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Institut Teknologi Sepuluh Nopember

THE PROCEEDINGS OF
THE 5TH INTERNATIONAL CONFERENCE ON MANAGEMENT OF TECHNOLOGY, INNOVATION, AND PROJECT

"INCLUSIVE TECHNOLOGY AND BUSINESS INNOVATION"

MOTIP 05

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The Proceeding of International Conference on Management of Technology, Innovation, and Project (MOTIP) 2022

"Inclusive Technology and Business Innovation"

July 23rd, 2022
Surabaya, Indonesia

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I Nyoman Pujawan
R. Haryo Dwito Armono
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Reny Nadlifatin
Gita Widi Bhawika

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International Conference on Management of Technology, Innovation, and Project (MOTIP) 2022
"Inclusive Technology and Business Innovation"

July 23rd, 2022
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Interdisciplinary School of Management and Technology
Institut Teknologi Sepuluh Nopember (ITS), Indonesia

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AGENDA

The conference will be held online on July 23rd, 2022 via Zoom platform. Kindly check your presentation schedule by looking for your paper ID (from Easy Chair) on the room in parallel session. The link of the zoom meeting for the webinar and each parallel room can be accessed to https://linkr.bio/motip2022

Time (GMT+7)	Agenda
08.30-08.55	**Opening** *(Link Zoom : https://bit.ly/ZoomOpeningMotip05)*
	Welcome Speech from Chair of MOTIP 05, Gita Widi Bhawika, S.ST., M.MT.
	Opening Speech from Dean of SIMT ITS, Prof. I Nyoman Pujawan, Ph.D, CSCP
08.55-09.45	**Keynote Speech** "Inclusive Technology and Business Innovation" **Speaker: Prof. Dr. Suhaiza Zailani, Professor of Supply Chain, Faculty of Business and Economics, University of Malaya** **Moderator: Niken Anggraini Savitri, ST, MT**
09.45-09.50	Break
09.50-11.50	**Parallel Sessions 1 (Room : A, B, C, D, E, F, G, H, I, J)**
	09.50-10.05: 1st Presenter
	10.05-10.20: 2nd Presenter
	10.20-10.35: 3rd Presenter
	10.35-10.50: 4th Presenter
	10.50-11.05: 5th Presenter
	11.05-11.20: 6th Presenter
	11.20-11.35: 7th Presenter
	11.35-11.50: 8th Presenter
11.50-12.45	Lunch Break
12.45-14.45	**Parallel Sessions 2 (Room : K, L, M, N, O, P, Q, R, S, T)**
	12.45-13.00: 1st Presenter
	13.00-13.15: 2nd Presenter
	13.15-13.30: 3rd Presenter
	13.30-13.45: 4th Presenter
	13.45-14.00: 5th Presenter
	14.00-14.15: 6th Presenter
	14.15-14.30: 7th Presenter
	14.30-14.45: 8th Presenter
14.45-14.50	Break
14.5 0-15.15	**Closing Ceremony and Best Papers Announcement** *(Link Zoom : https://bit.ly/ZoomMotip001)*
	Closing from Chair of MOTIP 05, Gita Widi Bhawika, S.ST., M.MT.

NOTES

General Rules

1. Dress code: formal or batik (no t-shirt).
2. Presenter should be use the virtual background download here. Thus, the video should be on during presentation.
3. Rename your zoom account with format: ID_full name, example: 150_Widya Kusumawardhani.
4. Kindly join the sessions using this link (https://linkr.bio/motip2022)
5. To obtain certificate of presenter, you must attend the whole session, from opening session, parallel sessions, giving presentation, until closing ceremony by accessing this link during the conference.
6. The proof of attendance can be a screen shoot of the webinar page, containing the material slide and/or the speaker, your face, and your name.
7. Please fill this attendance report by uploading your proof of attendance using this link (https://bit.ly/AttendanceMOTIP05)
8. Our staff will check your name anytime during conference for certificate eligibility.

Presentation Rules

1. The Session chairs will conduct the parallel session, they will be helped by an assistant as an administrator and a time keeper.
2. You must attend to the webinar at least 5 minutes before the opening session will be started. Kindly report to the session chair when you arrive at virtual meeting before the session is started.
3. The presentation time is 15 minutes per presenter, including question and answer. Session chair will interrupt and stop the presentation if the time is over.
4. Presentation slide and speech must be delivered in English, the presentation template can be downloaded here.
5. Question and answer must be delivered in English.

Technical Suggestions

1. Presentation using laptop/computer is preferable.
2. You should looking for comfortable and quite place to avoid any disturbance for the whole session.
3. Before the conference, make sure that your connection, audio, video, and any other technical function in your zoom application running properly.
4. Having back up/alternative internet connection is preferable.
5. For those who not familiar to present in the ZOOM Platform, we facilitate you to try it in our Practice Session which will held by request.

SCHEDULE SESSION 1

Room A
: Business Management

Topic : Business Management
Chair : Harisatul Agustin, S.AB., M.AB., MBA
Assistant : Nurul Fadillah
Link Zoom : https://bit.ly/ZoomMotip001

No	Time	ID Paper	Author	Affiliation	Title
1	09.50-10.05	3	Dirgahayu Miswar and Dony Abdul Chalid	Universitas Indonesia	Analysis On The Effect Of Muslim President Director Towards Company Decision To Use Islamic Financing In Indonesia
2	10.05-10.20	6	Aditya Putra Angkasa and Dony Abdul Chalid	Universitas Indonesia	Comparison Analysis Of Trading Behaviors Between Investors With Compulsive Gambling Symptoms And General Investors
3	10.20-10.35	14	Rumaisah Hidayatillah, Muhammad Ahsan and Nadya Eva Almira Wardani	ITS	Measurement Of Customer Dissatisfaction Using Attribute Control Chart Based On Customer Review: A Basis For Developing Service Improvement Recommendations
4	10.35-10.50	20	Thanthowie Jauharie and Eko Rizkianto	Universitas Indonesia	Effect Of Macroeconomic On Net Asset Value Of Equity Mutual Funds In Indonesia During Covid-19 Pandemic
5	10.50-11.05	26	Ary Amry and Avanti Fontana	Universitas Indonesia	Development Of Communication And Sales Channels At Pt Sampurna Rona Selaras
6	11.05-11.20	29	Pasthika Raras Pratita Sriyadi and Dr. Buddi Wibowo	Universitas Indonesia	The Impact Of Income Diversification On Profit And Risk In The Banking Industry (Multi Country Analysis)
7	11.20-11.35	31	Kevin Octareza	Universitas Indonesia	Business Feasibility Analysis Plan For The Acquisition Of Oil And Gas Block C In Country Senegal
8	11.35-11.50	72	Lukman Fadillah and I Ketut Gunarta	ITS	Business Feasibilty Analysis Of Renewable Wind Turbin Generator Projects In Banyuwangi

SCHEDULE SESSION 1

Room B
: Decision System Analysis

Topic : Decision System Analysis
Chair : Jerry Dwi T Purnomo, M.Si, Ph.D
Assistant : Indriani Puspitasari
Link Zoom : https://bit.ly/ZoomMotip002

No	Time	ID Paper	Author	Affiliation	Title
1	09.50-10.05	7	Hotmasterman Simbolon and Udisubakti Ciptomulyono	PT PLN (Persero) / ITS	Alternative Design Selection 150 Kv Transmission Line Holtekam – Angkasa Papua With MCDM TOPSIS Method Approach
2	10.05-10.20	19	Irfananda Setiadi Hutomo and Mohammad Arif Rohman	ITS	Critical Success Factor For Implementing Lean Construction In Indonesia
3	10.20-10.35	23	Al Fajri Rizqiqa Illahi Akbar and Maria Ulpah Ph.D	Universitas Indonesia	Fundamental Analysis Of Stocks in Determining Investment Decisions on Mergers and Acquisitions Company On The Indonesia Stock Exchange Using The Free Cash Flow To Equity Method In 2019–2021
4	10.35-10.50	39	Ali Akbar Baso and Udisubakti Ciptomulyono	ITS	Selection Of Shipyard Repair For Ferry Roro Ship Using The Integration Of The Delphi Method And Analitical Hierarchy Process (AHP)
5	10.50-11.05	65	Aditya Putrantono	ITS	Comparative Study Of Project Cost Performance at PT XYZ Using Dematel And ANP Methods
6	11.05-11.20	81	Rizka Shoumil Ilhami and Eko Budi Santoso	ITS	Analysis Of Service Quality On New PLN Mobile Using Integration Of E-S-Qual, Kano, and QFD Methods
7	11.20-11.35	97	Slamet Suryanto, Nurhadi Siswanto and Ahmad Rusdiansyah	ITS	The Implementation Of Entropy And Topsis Method For Rank Projects And Prioritizing Budget Allocation : A Case Study at PT.Vale Indonesia
8	11.35-11.50	124	Naura Firdausi and Mohammad Arif Rohman	ITS	Determination of Criteria in Social Sustainability Assessment of Construction Field Workers

SCHEDULE SESSION 1

Room C
: Organizational Behavior and Management

Topic : Organizational Behavior and Management
Chair : Ninditya Nareswari, S.M., M.Sc.
Assistant : Wahyu Aditya Rachman
Link Zoom : https://bit.ly/ZoomMotipW001

No	Time	ID Paper	Author	Affiliation	Title
1	09.50-10.05	8	Kuntodi Ambartomo and Riani Rachmawati	Universitas Indonesia	The Effect Of Meaningful Work And Sense Of Community On Intention To Stay: The Mediating Role Of Workplace Well-Being
2	10.05-10.20	9	Khaira Mareva	Universitas Indonesia	Family Ownership And The Proportion Of Professional Directors, Their Effect On Sustainability Report (Study In Banking Listed On Idx 2015-2021)
3	10.20-10.35	10	Adventia Mega Wardhani	ITS	Pengaruh Transformasi Digital Terhadap Performance Melalui Inovasi Digital Sebagai Variabel Mediasi Dalam Studi Kasus Penggunaan Program Contract Procurement Management System Di Ciputra Grup
4	10.35-10.50	11	Feris Subhan Dzaky Hidayat and Syarifa Hanoum	ITS	Workload Analysis As Allocation Of Optimal Workforces Evaluation On Unloading Coal Project Using Nasa-Tlx
5	10.50-11.05	13	Tengku Annisa Febrina and Riani Rachmawati Ph.D	Universitas Indonesia	Pengaruh Pengaturan Kerja Fleksibel, Cognitive Work To Home Spillover Dan Kepuasan Kerja Terhadap Kinerja Karyawan Pada Masa Pandemi Covid-19 Dengan Telecommuting Sebagai Variabel Mediator
6	11.05-11.20	15	Nadira and Erma Suryani	ITS	Analysis Of Factors That Affecting Companies And Employees' Intention In Indonesia To Use Earned Wage Access Services
7	11.20-11.35	22	Ilmidina Kamila and Dony Abdul Chalid	Universitas Indonesia	The Effect Of Social Responsibility On Financial Performance: Analysis Of Family Firms Listed On Indonesia Stock Exchange In 2013 – 2020
8	11.35-11.50	32	Bonipasius Sulo, Dyah Santhi Dewi and Adithya Sudiarno	ITS	Work Design In The Mining Industry With An Ergonomic Approach Considering Physical Demand Analysis (Case Study: Heavy Equipment Operators in PT. Vale Indonesia, Tbk)

SCHEDULE SESSION 1

Room D
: Risk Management/Analysis

Topic : Risk Management/Analysis
Chair : Mushonnifun Faiz Sugihartanto, S.T., M.Sc
Assistant : M. Kamil Hari Mulya
Link Zoom : https://bit.ly/ZoomMotipW002

No	Time	ID Paper	Author	Affiliation	Title
1	09.50-10.05	16	Rizki Raditia Nugraha	ITS	Risk Management Design in Project Management Of Maintenance With Ommp (Overall Measure Of Maintenance Performance) And MAFMA (Multi-Attribute Failure Analysis) Approach
2	10.05-10.20	24	Windy Anggraini Desinta Pandansari and Imam Baihaqi	ITS	Risk Management Planning Procurement Of Parts And Raw Materials at PT X
3	10.20-10.35	45	Brenda Adny Evelyne and Tri Joko Wahyu Adi	ITS	Quality Control Analysis Of Cosmetic Products Using Fault Tree Analysis Method
4	10.35-10.50	49	Muhammad Rifqi Shadiqin and Dr. Ir. Tatang A Taufik Msc Ipu	ITS	Risk Analysis And Mitigation Of Production Processes In Heavy Equipment Manufacture
5	10.50-11.05	52	Faizin Yusuf and Iwan Vanany	ITS	Risk Analysis To Evaluate Trucks Renewal Compared To Utilizing 3PL Services at PT. X Indonesia
6	11.05-11.20	58	Pihrin and I Putu Artama Wiguna	ITS	Risk Assessment Of Occupational Health, Safety And Environment In Shell Plate Installation Work On Sulphuric Acid Storage Tank Project at PT XYZ With Hirarc Method
7	11.20-11.35	86	Aulia Harumi Baharisa Tya and Ahmad Rusdiansyah	ITS	Risk Management Analysis On Cloud Kitchen: A Case Study Of A Cloud Kitchen in Surabaya
8	11.35-11.50	89	Catur Setio Budi and I Putu Artama Wiguna	ITS	Risk Analysis Of Execution Power Plant EPC Project – Case Study Of XYZ Project

SCHEDULE SESSION 1

Room E
: Operation Management

Topic : Operation Management
Chair : Dewanti Anggrahini, S.T., M.T.
Assistant : Yusra Nusaibah Noor
Link Zoom : https://intip.in/ZoomMotipAT001

No	Time	ID Paper	Author	Affiliation	Title
1	09.50-10.05	28	Davi Khoirun Najib and Moses Laksono Singgih	ITS	Coal Gasification Furnace (CGF) Performance Evaluation Using Integrated RCA-MLR (Root Cause Analysis-Multiple Linear Regression) Toward Sustainability Production Of Syngas
2	10.05-10.20	46	Helmi Lukman and Aab Dinariyana Dwi P	ITS	Optimization of Raw Material Supply To Consumer Demand Argoindustry Luwak Coffee (Civet Coffee) at PT. KLC, West Java
3	10.20-10.35	57	Risa Puripangestuti and Putu Dana Karningsih	ITS	Lean Implementation for Tender Process on Procurement Department in a Cement Company
4	10.35-10.50	59	Faisal Faisal and Nani Kurniati	ITS	Increasing Efficiency in Brewing Process By Applying Lean Manufacturing In PT XYZ
5	10.50-11.05	83	Reda Agung Abrianto	ITS	Lean Construction Implementation To Reduce Waste in Oil Replacement Project at The Rokan Area
6	11.05-11.20	99	Angelicha Aminah Zairuni Ussu and Iwan Vanany	ITS	ERP Module Design And Testing of Inventory and Warehouse in The Medical Industry to Improve Inventory Accuracy
7	11.20-11.35	154	Patdono Suwignjo, Zafira Khairunnisa and Moses Laksono Singgih	ITS	Evaluation of Power Plant Operation and Maintenance (O&M) Services Using Gap Analysis and Lean Smart Maintenance (LSM)
8	11.35-11.50				

SCHEDULE SESSION 1

Room F
Marketing Management

Topic : Marketing Management
Chair : Bahalwan Apriyansyah, S.T, MBA.
Assistant : Maulita Nahdiyah
Link Zoom : https://intip.in/ZoomMotipAT002

No	Time	ID Paper	Author	Affiliation	Title
1	09.50-10.05	17	Rijalul Fikri and Budi Santosa	ITS	Application of Marketing Strategy to Tenants at XYZ Airport Based on Market Basket Analysis
2	10.05-10.20	25	Ririn Novita Panggabean	Universitas Indonesia	The Effect of Social Media Influencer Characteristics on Purchase Intention Between Instagram And Tiktok
3	10.20-10.35	27	Anindita Larasati and Avanti Fontana	Universitas Indonesia	Social Media Strategy Implementation To Reach Customer Segmentation And Customer Relationship at Culinary MSMES
4	10.35-10.50	35	Adinda Aisya Zukhrufa and Muhammad Ahsan	ITS	Analysis Of Factors Influencing Skin Care Brand Selection Within Two-Stage Choice Process Framework
5	10.50-11.05	66	Saraswati Veda Pavita and Vita Ratnasari	ITS	Analysis of The Influence of Celebrity Advertising on Purchase Intention on Social Media With PLS-SEM Approach on The Sales of Fashion Accessories
6	11.05-11.20	82	Nimas Sefrida Andriaswuri and Jerry Dwi Trijoyo Purnomo	ITS	Continuance Intention to Health Center During The Covid-19 Pandemic
7	11.20-11.35	164	Primastha Jayawardhana and Ellya Zulaikha	ITS	User Persona Typology Analysis Of Customer Engagement on Bodycare B's Instagram Feed Content With a Design Thinking Approach
8	11.35-11.50	174	Adhi Priyanto Putro and Reny Nadlifatin	ITS	Strategy Of Building The Jakarta - Bandung High Speed Railway Brand Awareness

SCHEDULE SESSION 1

Room G
: Multidisciplinary Research

Topic : Multidisciplinary Research
Chair : Dawi Karomati Baroroh, M.Sc.
Assistant : Widya Kusumawardhani
Link Zoom : https://its-ac-id.zoom.us/j/98918352862

No	Time	ID Paper	Author	Affiliation	Title
1	09.50-10.05	98	I Made Indra Maha Putra	ITS	Analysis Reduction Non Revenue Water (NRW) for Mitigation Water Losses Using Root Cause Analysis Method
2	10.05-10.20	101/167	Muhammad Ahdal Masruhin and Christiono Utomo	ITS	Investment Financing Analysis PT Jasamarga Tollroad Maintenace
3	10.20-10.35	106	Deri Tialis Peristiawan and Udisubakti Ciptomulyono	ITS	FABA Utilization Strategy For Circular Business Model PT PLN (Persero) PLTU XYZ
4	10.35-10.50	108	Abdullah Ibnu Hasan and Mohammad Isa Irawan	ITS	Alternative Business Model For Rooftop PV in Indonesia
5	10.50-11.05	121	Adi Nugroho and Bagus Jati Santoso	ITS	Predictive Analytics Model Development To Evaluate Maintainability of Open Source Project In Github
6	11.05-11.20	135	Aswin Mushardiyanto and Eko Budi Santoso	ITS	Implementation of Otobos in The Framework Contract For The Maintenance of Offices and Official Residences at BUMN Energy Surabaya
7	11.20-11.35	153	Uruqul Nadhif Dzakiy, Sonny Yuliar, Togar Simatupang and Eko Agus Prasetio	ITB	Analysis Of Technology Commercialization In Indonesian Universities
8	11.35-11.50				

SCHEDULE SESSION 1

Room H
: Information System Management

Topic : Information System Management
Chair : Dr. Rizka Wakhidatus Sholikah, S.Kom.
Assistant : Sri Wahyuni
Link Zoom : https://its-ac-id.zoom.us/j/99288848669

No	Time	ID Paper	Author	Affiliation	Title
1	09.50-10.05	33	Hananta Adji	ITS	Analysis Of The Adoption And Commercialization Of XYZ Apps Using TRL, CRL, TRI2, And TAM2
2	10.05-10.20	36	Irfani Widya Pratidina, Riyanarto Sarno and Apol Pribadi Subriadi	ITS	Usage Model Analysis Of Internet Service Provider Customer Mobile Application in Millenial Generation
3	10.20-10.35	47	Sidik Kertapati and Erma Suryani	ITS	Risk Management Analysis For Information Technology Based on Cobit Framework In E-Procurement System (A Case Study Of PT.XYZ)
4	10.35-10.50	51	Narendro Ariwisnu and Erma Suryani	ITS	Information Security Management System In Cellular Operator Using ISO 27005 and NISTt SP 800-30
5	10.50-11.05	61	Dadin Dadin and Erma Suryani	ITS	Strategy for Increasing Customer Satisfaction in Making Payment at PLN Mobile Application With Using Extended TAM
6	11.05-11.20	67	Zainul Arifin and Hari Ginardi	ITS	IT Governance for Securing Management Information System in Industrial Estate Area Using ISO 27001:2013
7	11.20-11.35	71	M.Danang Mirza Zainurrachman and Erma Suryani	ITS	Evaluation of User Experience on Hand Gestures Touchless Computers
8	11.35-11.50				

SCHEDULE SESSION 1

Room I
: Project Management

Topic : Project Management
Chair : Rizki Revianto Putera, S.T., M.T.
Assistant : Titin Eriyanawati
Link Zoom : https://its-ac-id.zoom.us/j/94145670601

No	Time	ID Paper	Author	Affiliation	Title
1	09.50-10.05	37	Akbar Fauzan Syukroni and Farida Rachmawati	ITS	Conflict Causing Factor Identification on Public-Private Partnership Project in Indonesia
2	10.05-10.20	38	Dany Pramono Oentario	ITS	Identification Of Quality Decreasing Factors And Efforts to Increase The Quality Of House Building in The Citraland Utara Surabaya Project
3	10.20-10.35	42	Rafida Rahmah and Farida Rachmawati	ITS	Water Conservation Alternatives for Green Office Building in Indonesia
4	10.35-10.50	44	Leni Rizki Azzu Nafaro and Farida Rachmawati	ITS	Lean Construction Using Value Stream Mapping To Increase Efficiency in The Beam and Slab Construction Process
5	10.50-11.05	60	Ajenar Bhudri Kartika and Bambang Syariudin	ITS	Maturity Level Of Project Risk Management in Offshore Oil And Gas EPC Industry in Indonesia
6	11.05-11.20	64	Nur Huda and I Putu Artama Wiguna	ITS	Modeling of The Relationship Between Workplace Conflict And The Success of High-Rise Building Construction Project in Surabaya
7	11.20-11.35	70	Tan Ferdinand Christanto Sugiarto, Tri Joko Wahyu Adi & Farida Rachmawati	ITS	Green Building Feature Addition Model To Achieve Certain Sertification Level For an Apartment
8	11.35-11.50				

SCHEDULE SESSION 1

Room J
: Operation Management

Topic : Operation Management
Chair : Prahardika Prihananto, S.T., M.T.
Assistant : Indriyanti Nirmalasari
Link Zoom : https://its-ac-id.zoom.us/j/95572984003

No	Time	ID Paper	Author	Affiliation	Title
1	09.50-10.05	48	Arighi Geraudi and Nofrisel Nofrisel	Universitas Indonesia	Supply Chain Performance And Management Analysis Using Supply Chain Operational Reference (SCOR) 11.0 in Agriculture Sector: Case Study of PT Rajatani Agro Nusantara
2	10.05-10.20	50	Ervin Saputra, Dr. Ir. Mokh. Suef and Dr. Muhammad Ahsan	ITS	Assessment of Transmission Protection For Electricity Reliability in Kalimantan
3	10.20-10.35	55	Ramliah	ITS	Six Sigma Application to Improve Procurement Performance in The Nickel Processing Industry
4	10.35-10.50	73	Johanes Fudjainal Ferry Yanto, Imam Baihaqi and Benny Tjahjono	TDEM	Improving Inbound Logistics Cost Using Lean Approach – Practical Case of Automotive Manufacturing in Thailand
5	10.50-11.05	77	Louis Fernando A. Simanjuntak and Farida Rachmawati	ITS	Green Supply Chain Management Implementation Analysis in Construction Projects
6	11.05-11.20	96	Fadila Isnaini, Ahmad Rusdiansyah and Ratna Sari Dewi	ITS	The Development Of Refrigerated-Container Loading Problem Model For Ventilated Cargo Using Pallet
7	11.20-11.35	131	Annisa Aini	ITS	Modeling A Framework For Supply Chain Resilience Of Cosmetics Industry During Pandemic Covid-19 Using Best-Worst Method
8	11.35-11.50	157	Winda Puspitasari, Moses Laksono Singgih and Patdono Suwignjo	ITS	Lean Maintenance Management For The Selection Of Alternative Efficiency Maintenance Activities In Steel Smelting Factories

SCHEDULE SESSION 2

Room K
: Strategic Management

Topic : Strategic Management
Chair : Dr. Ir. Tatang Akhmad Taufik M.Sc.
Assistant : Erwina Adhyarini
Link Zoom : https://bit.ly/ZoomMotipW001

No	Time	ID Paper	Author	Affiliation	Title
1	12.45-13.00	53/199	Suti'Ah S.Tr.T	PLN / ITS	Management Strategy Distribution & Services PT PLN Persero
2	13.00-13.15	54/50	Doni Budiono	ITS	Digital Transformation Of Gate Automation Service With Weigh In Motion Technology At The Container Terminal PT XYZ
3	13.15-13.30	56	Hamzah Muslim and Arman Hakim Nasution	ITS	Competitive Strategy Development With Performance Management System Approach Based On Balanced Scorecard PT XYZ
4	13.30-13.45	62	Setyani Hardiana Sunardi and Ellya Zulaikha	ITS	Service Design Strategy For Indonesian Footwear Network Platform Development
5	13.45-14.00	87	Bagyo Widodo	ITS	Modeling Of Surabaya's Municipal Solid Waste
6	14.00-14.15	103	Yulia Margiati and Udisubakti Ciptomulyono	ITS	Dematel And ANP Approach For Development Of Supply Chain Performance Assessment in Garment Industry With Lean Paradigm Consideration
7	14.15-14.30	129	Prasetyo Arie Hatmoko and Imam Baihaqi	ITS	Applying Blue Ocean Strategy For Business Development: A Case Study Of Engineering Construction Company
8	14.30-14.45				

SCHEDULE SESSION 2

Room L

: Organizational Behavior and Management

Topic : Organizational Behavior and Management
Chair : Reny Nadlifatin, S.Kom., MBA., Ph.D
Assistant : Ahmad Enggal Maossyara
Link Zoom : https://bit.ly/ZoomMotipW002

No	Time	ID Paper	Author	Affiliation	Title
1	12.45-13.00	68	Ardhitya Dwi Syahputri and Vita Ratnasari	ITS	The Influence Of Work Environment, Management Support, Corporate Culture And Employee Engagement On Job Satisfaction And Employee Performance: A Sampling In SEM AMOS Modelling
2	13.00-13.15	91	Farrel Naufal and Sri Gunani Partiwi	ITS	Measurement Of Organizational Readiness Using Improvisation Readiness Index Score (Iris) Framework At University X In Crisis Situation
3	13.15-13.30	104	Mochamad Naufal Laudza Banin and Eko Budi Santoso	ITS	Effect Of Profitability, Liquidity, And Solvency Ratio On Stock Return Case Study On Sharia Companies During Covid-19 Pandemic Q1 2020 – Q3 2021
4	13.30-13.45	142	Ilham Trilaksono and Vita Ratnasari	ITS	Employees Performance And Loyalty Modeling On The Powerplant Industry Using Structural Equation Modeling-Partial Least Square Approach
5	13.45-14.00	145/169	Atikasita Armin Putri and Bambang Syairudin	ITS	Analysis Of The Influence Of Workload On Work Motivation And Loyalty And The Impact On Employee Performance BPJS Ketenagakerjaan Branch Office Sidoarjo
6	14.00-14.15	156	Patdono Suwignjo, Anisah Amalia Nur Ibrohim and Moses Laksono Singgih	ITS	Coaching Model As A Team Management Building Strategy To Increase Startup Success: A Literature Review
7	14.15-14.30	173	Guruh Adi Darma and Reny Nadlifatin	ITS	The Effect Of Service Quality, Outlet Atmosphere, And Discount On Customer Satisfaction And Intention To Repurchase With Case Study: Foresthree Coffee Ragunan
8	14.30-14.45				

SCHEDULE SESSION 2

Room M

: Innovation Design Management

Topic : Innovation Design Management
Chair : Sri Yayu Ninglasari, S.E., M.SEI
Assistant : Sri Wahyuni
Link Zoom : https://its-ac-id.zoom.us/j/98918352862

No	Time	ID Paper	Author	Affiliation	Title
1	12.45-13.00	2	Dedy Marsetioadi and Agus Windharto	ITS	Collaboration Of Design Thinking Approach With Business Model Canvas For Expertise Product Innovation Design
2	13.00-13.15	74	Irbah Mufidah and Ellya Zulaikha	ITS	User Experience Development Visitors Of Residential Offshore Marine Tourism "Ocean Farm ITS" Using Design Thinking Methods
3	13.15-13.30	75	Reno Bahelwan Miazaki, Ellya Zulaikha and Oktaviyanti Dwi Wahyurini	ITS	User Experience Development Of Local Brand Footwear Post Pandemic On The "Indonesia Footwear Network" Platform Using Design Thinking
4	13.30-13.45	79	Fariz Rizky Wijaya	ITS	Multi-Information Display (Mid) Innovation For E-Scooter In User Convenience Perspective
5	13.45-14.00	92	Yuni Niami and Ellya Zulaikha	ITS	Digital Marketing Innovation For Batik UMKM Development in Surabaya
6	14.00-14.15	110	Yuanita Christanti, Agus Windharto and Tatang Akhmad Taufik	ITS	Omnichannel Marketing Strategy Toward Suzuki Passenger Car With Design Thinking Process
7	14.15-14.30	138	Nuke Yulnida Aden Faradhillah, Tatang Akhmad Taufik and Kriyo Sambodho	ITS	Information System Concept Design Of ICT And Robotics Cluster At DIKST ITS
8	14.30-14.45				

SCHEDULE SESSION 2

Room N

: Information System Management

Topic : Information System Management
Chair : Andre Parvian Aristio, S.Kom., M.Sc
Assistant : Wahyu Aditya Rahman
Link Zoom : https://its-ac-id.zoom.us/j/99288848669

No	Time	ID Paper	Author	Affiliation	Title
1	12.45-13.00	21	Budi Suwanto and Dr. Ir. Tatang Akhmad Taufik Msc Ipu	ITS	Measuring The Level Of Community Readiness And Satisfaction With The Implementation Of The E Lampid Application
2	13.00-13.15	85	Eko Yuwono and Erma Suryani	ITS	Interest Analysis of Using EV Charging Platform Charge.In By Using A Modified Technology Acceptance Model
3	13.15-13.30	88	Faisal Arif Rahmawan and Raden Venantius Hari Ginardi	ITS	Penyelarasan Kinerja Manajemen Sumber Daya Dan Teknologi Informasi Dengan Menggunakan Cobit 2019 (Studi Kasus: Pt XYZ)
4	13.30-13.45	112	Afifa Filiani Sehato and Raden Venantius Hari Ginardi	ITS	Development Of E-Government Process Model Based On Specific Characteristics Of Local Government Organizations
5	13.45-14.00	125	Risas Ridhoh and Tri Wahyu	ITS	Monitoring System And Multi Controling Project Construction Using Android-Based House Of Quality Method
6	14.00-14.15	126	Wungu Shofrina Wijaya Putri and Tatang Akhmad Taufik	ITS	Study Of Research Impact Information System In The Directorate Of Innovation And Science Techno Park - ITS
7	14.15-14.30	141	Rizki Wardhani and Erma Suryani	ITS	Customer Behavioral Analisys To Identify Customer Product Choice Using UTAUT2 Model Implementation
8	14.30-14.45				

SCHEDULE SESSION 2

Room O
: Project Management

Topic : Project Management
Chair : Nabila Silmina Hakim, S.T., MBA.
Assistant : Nurul Fadillah
Link Zoom : https://bit.ly/ZoomMotip001

No	Time	ID Paper	Author	Affiliation	Title
1	12.45-13.00	93	Riski Nugrahaning Gusti and I Putu Artama Wiguna	ITS	Work Accident Risk Analysis With Probability Based Fault Three Analysis Method On Multi-Storey Building Construction Project
2	13.00-13.15	94	M. Syaifuddin Zuhri, I Putu Artama Wiguna and Mudjahidin	ITS	Establishment Of Causal Loop Diagram Model On Flexible Pavement Road Projects Delay
3	13.15-13.30	100	Achmad Helmi and I Putu Artama Wiguna	ITS	Factors Analysis Of Preventing The Spread Of Covid-19 On Exposure Of Construction Workers
4	13.30-13.45	102	Herdira Dita Ramadhani and Farida Rachmawati	ITS	Delay Risk Identification For Maintenance Project In Gas Engine Power Plant (PLTMG)
5	13.45-14.00	105	Safira Yulia Rizqi, Tri Joko Wahyu Adi and Farida Rachmawati	ITS	Factors Affecting The Duration Of Construction Project Activities
6	14.00-14.15	113	Yulfia Ayu Dwiputri	ITS	Project Management Application Analysis On Ship X Project In PT. ABC
7	14.15-14.30	114	Ni Luh Pujiyanti Widhiastuti and A.A.B Dinariyana Dwi P	ITS	Small Scale LNG Distribution Design For Power Plants In The Bali And Nusa Tenggara
8	14.30-14.45				

SCHEDULE SESSION 2

Room P
: Risk Management/Analysis

Topic : Risk Management/Analysis
Chair : R. Haryo Dwito Armono S.T., M.Eng., Ph.D
Assistant : Indriani Puspitasari
Link Zoom : https://bit.ly/ZoomMotip002

No	Time	ID Paper	Author	Affiliation	Title
1	12.45-13.00	43	Mario Frankista Suroso	ITS	Risk Analysis of The Jakarta-Bandung High Speed Train Project In A State-Owned Construction Company PT XYZ
2	13.00-13.15	111	Alvinura Fajrin and Adithya Sudiarno	ITS	Project Risk Analysis Of Pipeline Construction Planning in Oil & Gas Company in Sidoarjo
3	13.15-13.30	118	Tamrin Sattung, Nani Kurniati and Bambang Syairudin	ITS	Procurement Risk Management Of Mining Services in a Mining Company Using House Of Risk (HOR) Method
4	13.30-13.45	130	Binta Tamara and Udisubakti Ciptomulyono	ITS	Development Of Risk Management On Powered Rolling Stock Project Delay Of XYZ
5	13.45-14.00	150	Patdono Suwignjo, Tri Andi Setiawan, Moses Laksono Singgih, Anda Iviana Juniani and Priyo Agus Setiawan	ITS	A Study Of Risk Management Using FMEA Approach And Mean Time To Failure
6	14.00-14.15	155	Mario Hartono and I Putu Artama Wiguna	ITS	Risk Management On The Construction Project Of The High Voltage Transmission Network 150 Kv Bangkalan
7	14.15-14.30	163	Taslim Maulana and Tri Joko Wahyu Adi	ITS	Financial Feasibility Analysis Of Clay Mining Project Based On Probabilistic NPV at Risk
8	14.30-14.45				

SCHEDULE SESSION 2

Room Q

: Business Analytics

Topic : Business Analytics
Chair : Dr. Eng. Dhimas Widhi Handani, ST, M.Sc.
Assistant : Yusra Nusaibah Noor
Link Zoom : https://intip.in/ZoomMotipAT001

No	Time	ID Paper	Author	Affiliation	Title
1	12.45-13.00	30	Essa Abubakar Wahid and Bagus Jati Santoso	ITS	Comparison Of Predictive Maintenance Model By Using Machine Learning Approach On Cement Plant Operational Data (Case Study Of PT XYZ)
2	13.00-13.15	121	Adi Nugroho and Bagus Jati Santoso	ITS	Predictive Analytics Model Development To Evaluate Maintainability Of Open Source Project In Github
3	13.15-13.30	140	Safitri Akbar Ardianto	ITS	Implementation Of Value Based Decision On Elevator Design System Selection
4	13.30-13.45	143	Ardo Fachrizal Ilmy and Achmad Choiruddin	ITS	Customer Churn Analysis of Telecommunication Services Using Logistic Regression Methods
5	13.45-14.00	151	Novemi Uki Andreas, Rio Indralaksoo, Muhammad Abdul Wakhid, Diana Purwitasari and Agus Budi Raharjo	PLN/ITS	Peramalan Jangka Pendek Beban Listrik Pada Hari Libur Di Jawa Tengah Dengan Metode Long Short Term Memory
6	14.00-14.15	152	Aznovri Kurniawan and Achmad Choiruddin	ITS	Recommendations On Post-Pandemic Financing Strategy For Islamic Banks In Indonesia Using Vector Autoregression And Financial Analysis
7	14.15-14.30	162	Taufik Brillian Nur and Wahyu Wibowo	ITS	Analysis Of Service Quality In Health Applications (M-Health) Using Text Mining Method And Support Vector Machine (SVM) Algorithm: Alodokter And Halodoc
8	14.30-14.45				

SCHEDULE SESSION 2

Room R
: Operation Management

Topic : Operation Management
Chair : Gita Widi Bhawika, S.ST., M.MT., CSCA
Assistant : Mizati Dewi Wasdiana
Link Zoom : https://intip.in/ZoomMotipAT002

No	Time	ID Paper	Author	Affiliation	Title
1	12.45-13.00	76	Ichwan Ibrahim and Udisubakti Ciptomulyono	ITS	A Proposed Model For The Investigasion Of Relationship Among Supply Chain Integration, Supply Chain Resilience And Operational Performance
2	13.00-13.15	95	Maulina Maharani and Tatang Ahmad Taufik	ITS	Application Of The Dematel-ANP-TOPSIS Method In The Selection Of Trucking Vendors in 3PL Company
3	13.15-13.30	157	Winda Puspitasari, Moses Laksono Singgih and Patdono Suwignjo	ITS	Lean Maintenance Management For The Selection Of Alternative Efficiency Maintenance Activities In Steel Smelting Factories
4	13.30-13.45	161	Dessy Ahadian and Moses Laksono Singgih	ITS	Improving Manufacturing Excellence Through Lean Six Sigma (Case Study In PBR Company)
5	13.45-14.00	165	Subali Ali and I K Gunarta	ITS	Determination Of The Rental And Purchase Scheme Of Heavy Equipment Using The Monte Carlo Simulation By Considering Fluctuations In The Need For Loading And Unloading Cargo (Case Study: Solid Port Operations)
6	14.00-14.15	175	Aida Aidil and Mokh Suef	ITS	Integration Of Lean And Taguchi In Eliminate Waste And Increase Quality In Bagea Cake Production Process
7	14.15-14.30	176	Bagas Mardiasyah Prakoso and Erma Suryani	ITS	XYZ Digital Banking Application Service Quality Improvement Strategy By Implementing Integration of E-Servqual, Kano Method and Quality Function Deployment (QFD)
8	14.30-14.45				

THE 5TH INTERNATIONAL CONFERENCE ON MANAGEMENT OF TECHNOLOGY, INNOVATION, AND PROJECT (MOTIP 05)

A New Landscape of Reverse Logistics and Green Logistics in Malaysia towards Digitalization



Professor Datin Sri Dr Suhaiza Hanim Dato Mohamad Zailani
Faculty Of Business and Economics
University Of Malaya
Malaysia

23 July 2022

Agenda



01
Introduction



Burning platform for Digitizing Reverse Logistics and Green Logistics

02
Key Findings



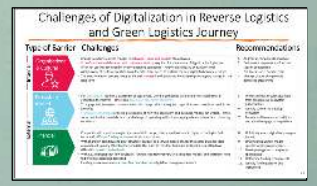
Industries' views

03
Emerging Opportunities



Digitalization of Reverse Logistics and Green Logistics

04
Way Forward



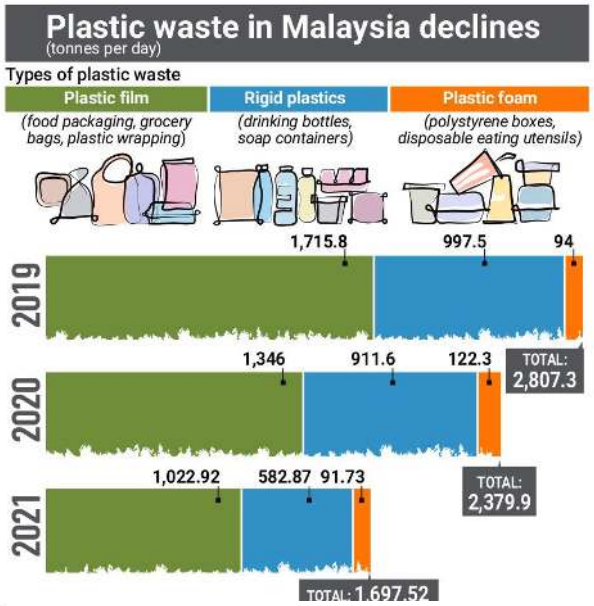
Way forward enabling digitalization in Reverse Logistics and Green Logistics Initiatives in Malaysia

Current Issues in Malaysia

- **Malaysia** has been continuously facing incremental solid waste management challenges.
- **2 major industries** contributing to solid waste are plastic & resins and food & beverages industry.
- In terms of the plastic and resins industry, Malaysia is gradually becoming a lead player in the consumption of **single-use plastics and resins**.
- The Malaysian government released “Roadmap Towards Zero Single-use Plastics 2018-2030”, announcing its policy to eliminate plastic straws and plastic bags by 2030.

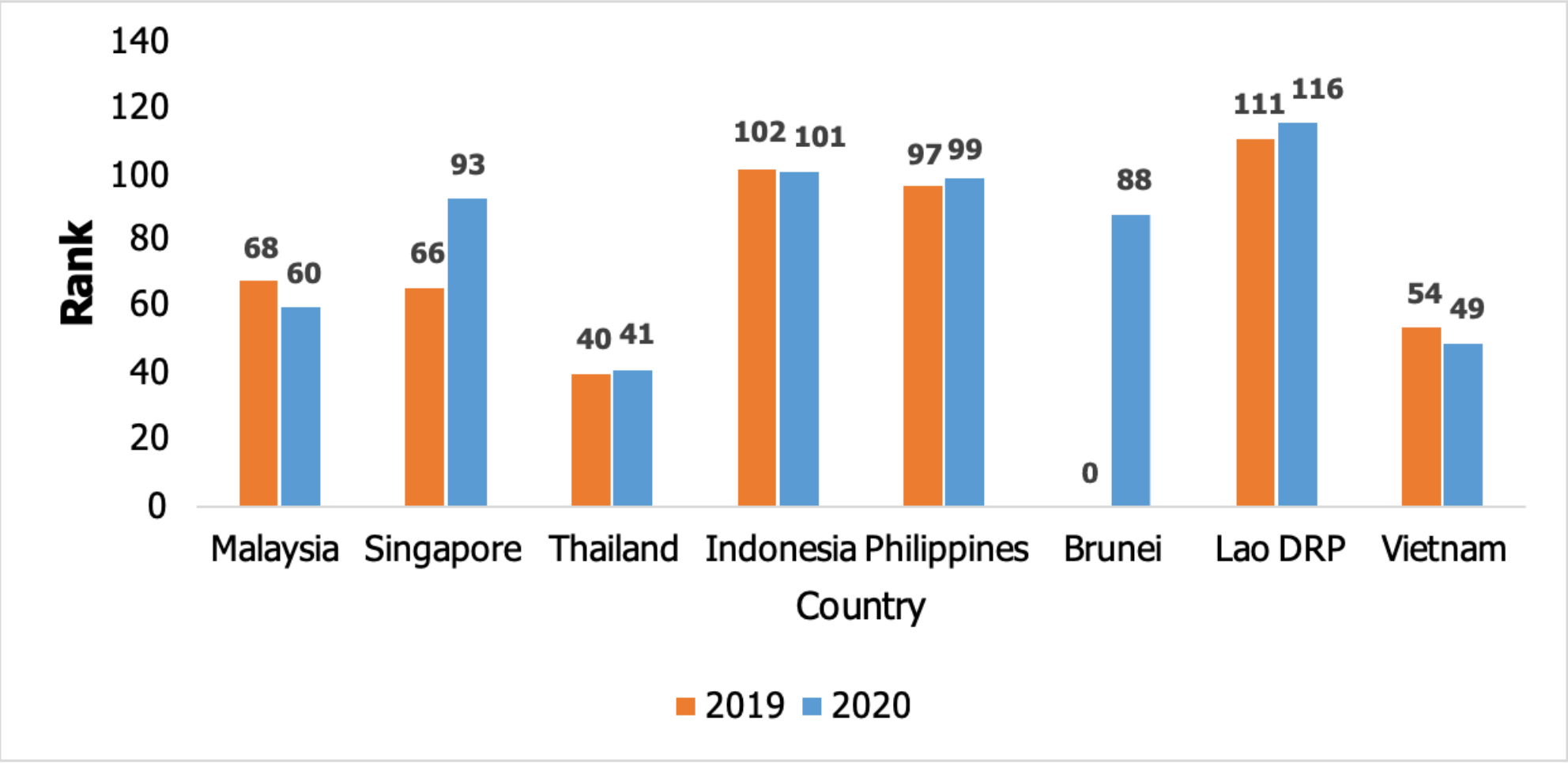


Source: The Star Newspaper, 20 Jan 2020



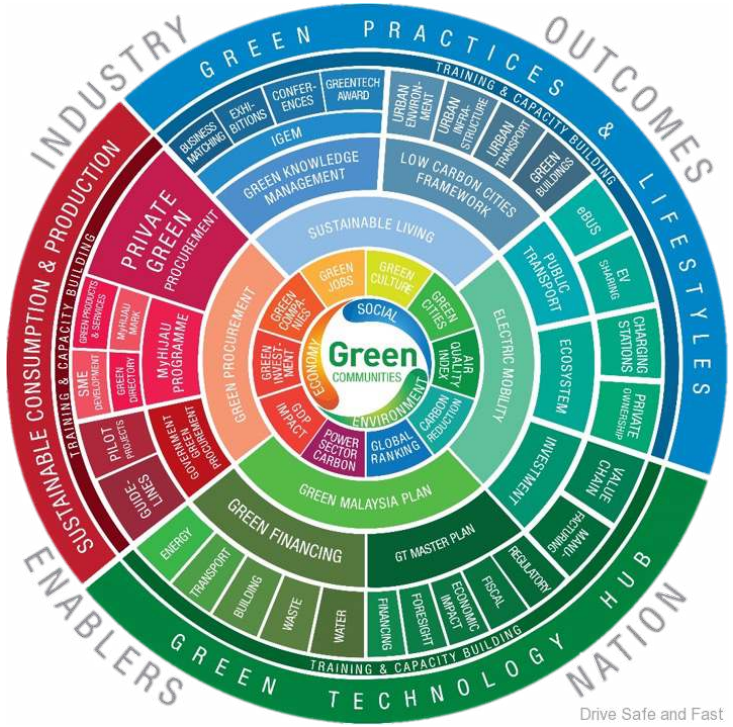
Source: The Star Newspaper, 1 May 2022

Malaysia's SDG Performance Relative to Other ASEAN Between 2019 - 2020



Sustainable Development in Malaysia

Green Economy



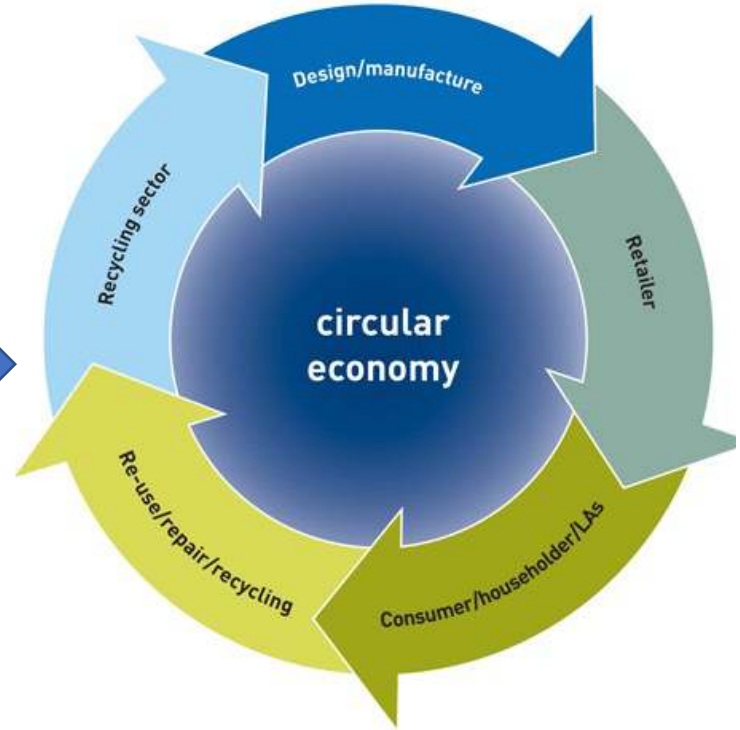
Source:
https://www.dsf.my/2017/03/greentech-malaysia-redefining-the-green-game/

SDGS 12 : Sustainable Consumption and Production



Source:
http://www.unep.org/resourceefficiency/Home/WhatisSCP/tabid/105574/Default.aspx

Circular Economy



Source:
http://www.wrap.org.uk/about-us/about/wrap-and-circular-economy

Sustainable Consumption and Production





Resource depletion



Forest area reduction



Greenhouse gas



Pollution



Hazardous substances



Lack of final disposal site

Extraction | Production | Access | Consumption | Disposal

Production-side

Consumption-side

"There is no way around sustainable logistics in the future. We are deciding today what kind of world we and our children will live in 30 years from now. And our aspiration is to make a substantial contribution to ensure that this will be an even better world."

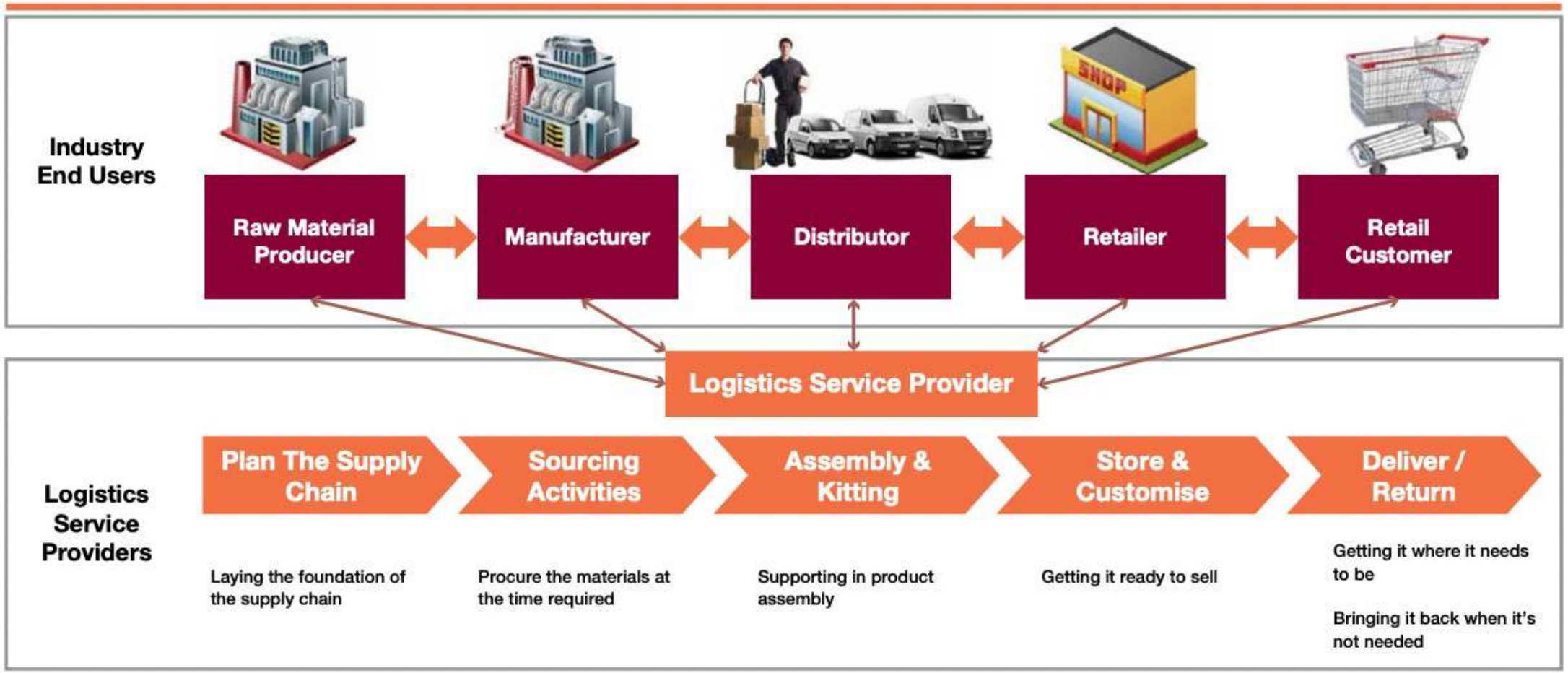
Dr. Frank Appel, CEO of Deutsche Post DHL Group



Logistics Output Impact to Economy

Increased cargo volume in key transportation modes	Higher productivity in transportation and storage sub-sector
1. Cargo volume CAGR	**1. Labour productivity CAGR**
 **8%** (2014-2020) *Total cargo volume is estimated **to reach 0.88 billion tonnes** by 2020.* 5.45% (Current CAGR 2006-2013)	 **5%** (2014-2020) *Labour productivity is estimated **at RM149,711** by 2020.* 3.64% (Current CAGR 2008-2013)
• Cargo volume under normal growth is expected to reach 0.74 billion tonnes by 2020 (5.5% CAGR 2014-2020)	• Labour productivity under normal growth is expected to reach RM136,021 by 2020 (3.6% CAGR 2014-2020)
"Every one tonne increase in cargo volume increases the transportation and storage sub-sector's contribution to GDP by RM45,010"	*"For every RM1,000 increase in labour productivity, Transportation and Storage sub-sector contribution to GDP increases by RM280 million"*
2. Cargo volume increase of CAGR 8%, will result in an	**2. An expected productivity increase of CAGR 5%, will result in an estimated contribution of an**
 **additional RM5.90 billion to National GDP by 2020** (Constant 2005 Price)	 **additional RM3.88 billion to GDP by 2020** (Constant 2005 Price)

Transportation and Storage sub-sector contribution to National GDP is expected to reach 4.3% (RM50.8 billion) by 2020 from the current 3.6%.



Logistics and Trade Facilitation Support and Services


Inbound Transport by Sea, Air and Land


Outbound Transport by Sea, Air and Land


Warehousing Services


Distribution Services

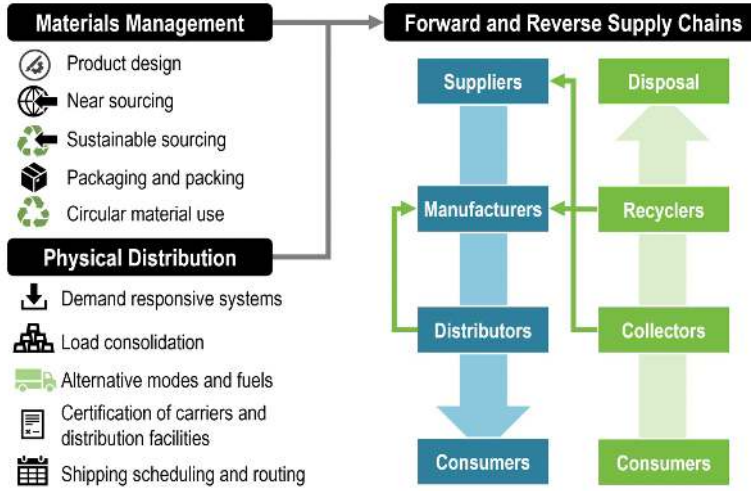


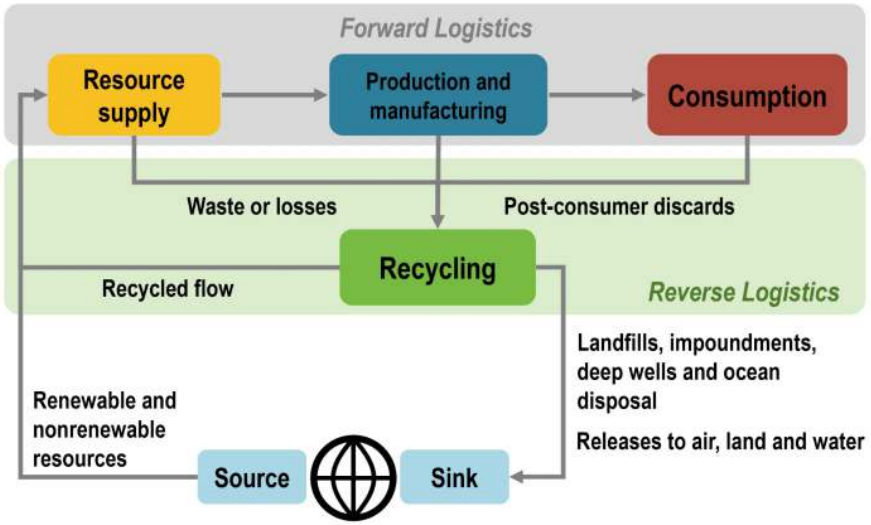
Finance and Insurance Services

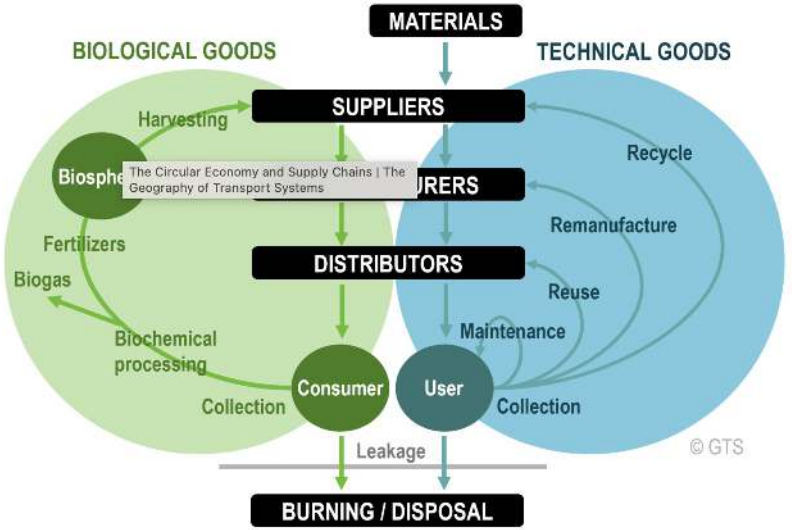

Customs Declaration & Clearance


Government Agencies Policies & Acts

Green Logistics + Reverse Logistics = Circular Economy





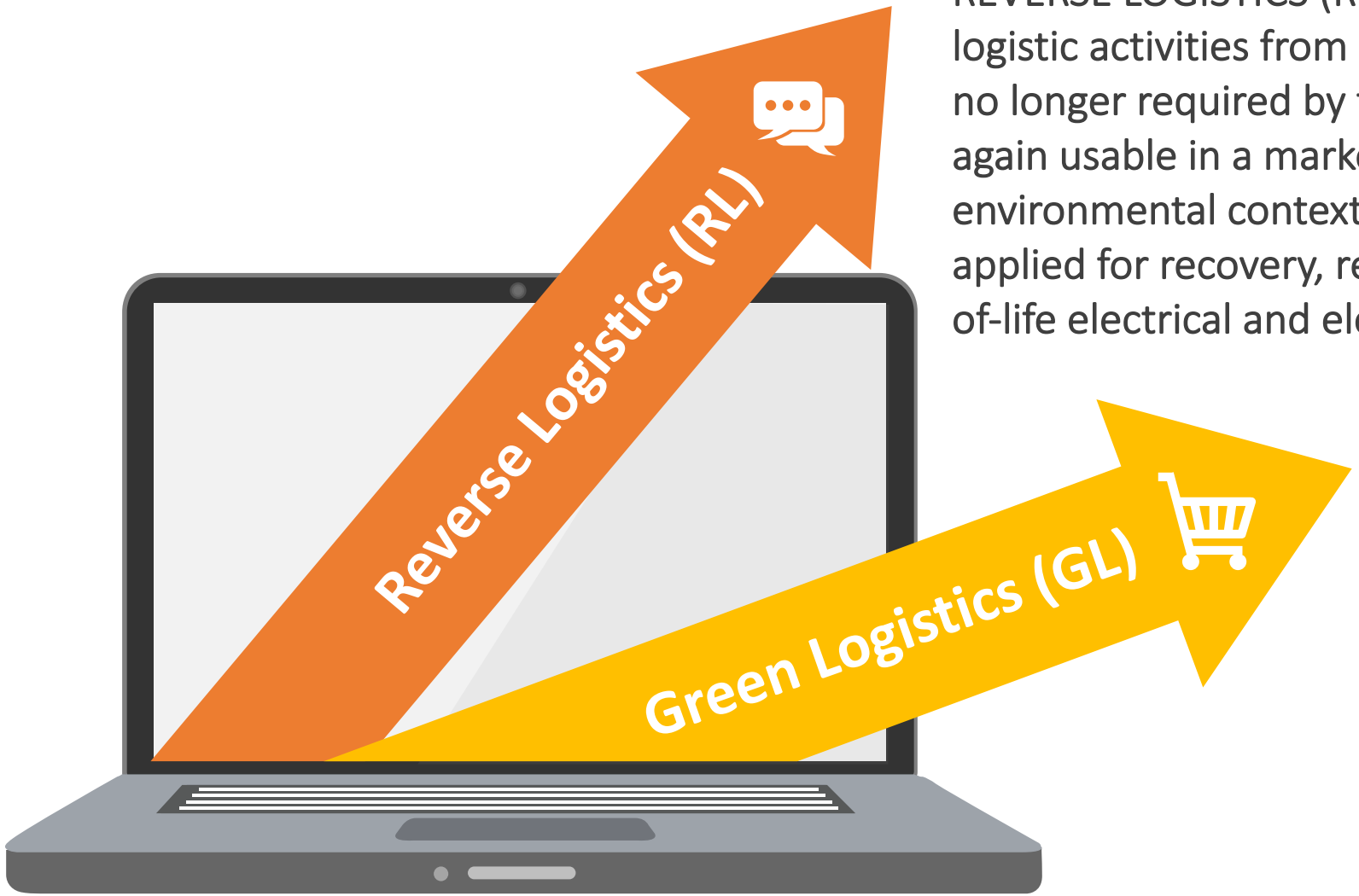


GREEN LOGISTICS practices and strategies that reduce the environmental and energy footprint of freight distribution.

While traditional logistics seeks to organize forward distribution, that is, the transport, warehousing, packaging, and inventory management from the producer to the consumer, REVERSE LOGISTICS is with environmental considerations opened up markets for recycling and disposal.

CIRCULAR ECONOMY, which is inserting logistics into reuse, remanufacturing, recycling, and waste disposal into a feedback loop.

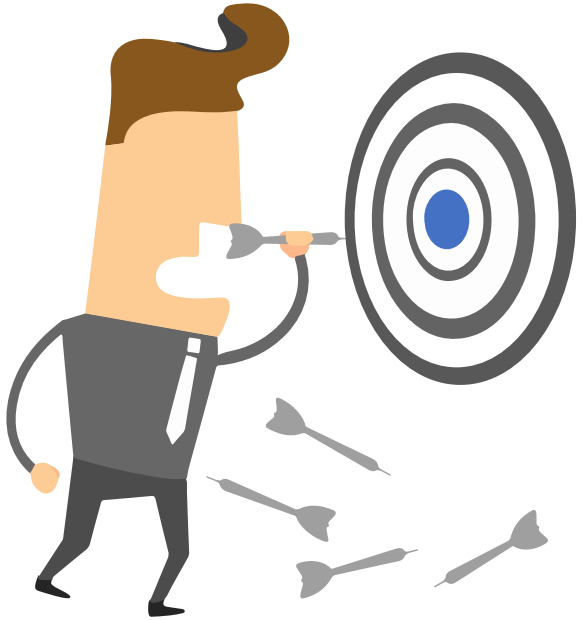
Reverse Logistics and Green Logistics



REVERSE LOGISTICS (RL) encompasses all the logistic activities from used products which are no longer required by the users to products again usable in a market. Within the environmental context, RL has been successfully applied for recovery, recycling and reuse of end-of-life electrical and electronic equipment.

GREEN LOGISTICS (GL) is focused on restricting damage to environment during the process of Logistics. It is based on the global environment maintenance and sustainable development.

Reverse Logistics and Green Logistics as a Competitive Tool



Create customer value by providing a clean environment without any extra cost to the customer through green logistics and reverse logistics services.

- Replacing defective goods
- Repairing of used products
- Refurbishing the returned products
- Calling back sub-standard or harmful goods
- Disposing-off product waste
- Reducing the environmental and energy footprint of freight distribution
- Sourcing ethically, material handling, waste management, packaging, and transport

Reverse Logistics

- If no goods or materials are being sent “backwards”, the activity probably is not a reverse logistics activity.
- **Reverse logistics** includes processing returned merchandise due to damage, seasonal inventory, restock, salvage, recalls, and excess inventory. It also includes recycling programs, hazardous material programs, obsolete equipment disposition, and asset recovery.
- Unfortunately, a lot of product returns end up being incinerated or in landfill as companies are hesitant to sell into secondary markets based on a belief it may devalue their brand.

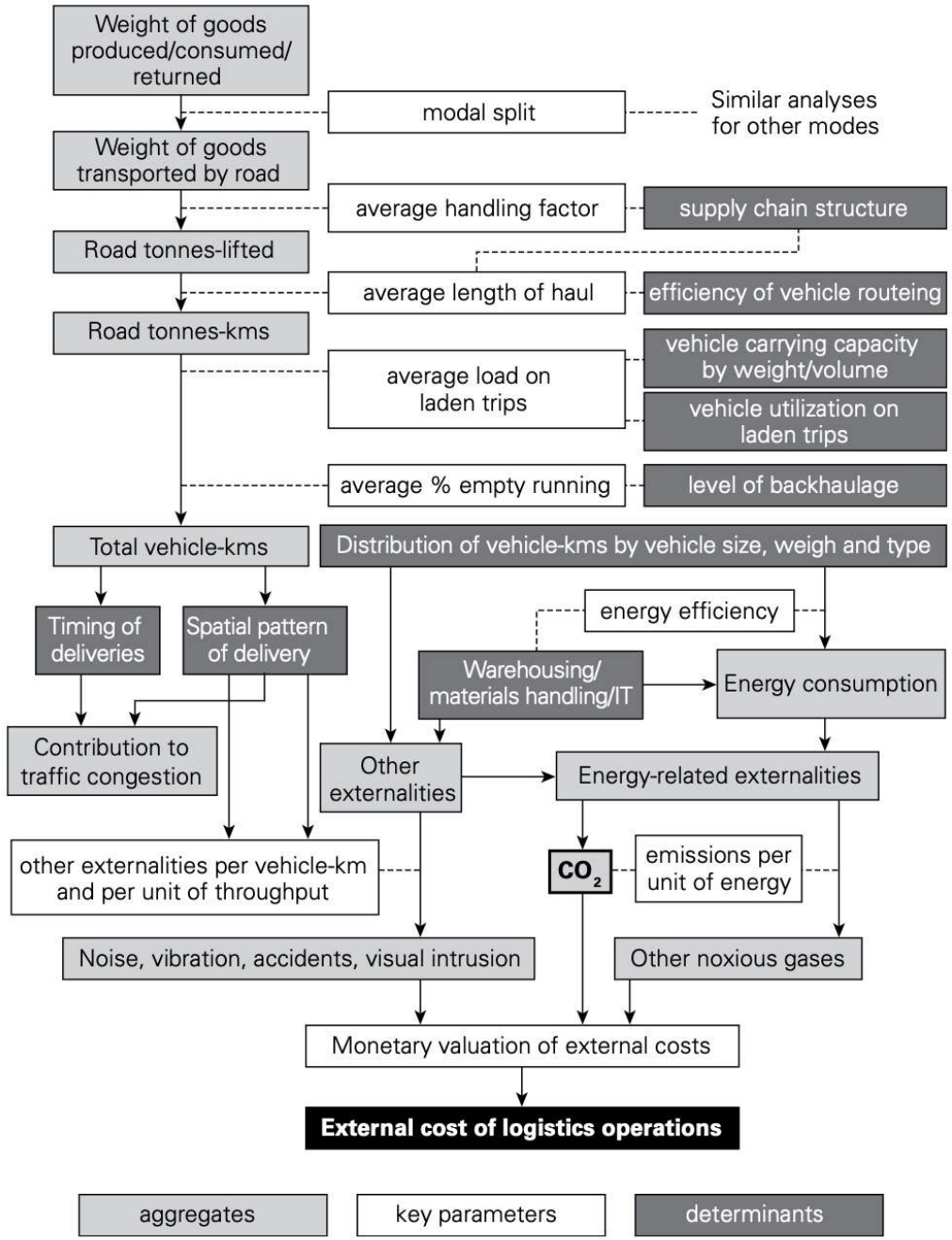




Reverse Logistics Process



- Resell
- Reuse
- Remanufacture
- Repair
- Refurbish
- Recover
- Recyclable Materials
- Dispose

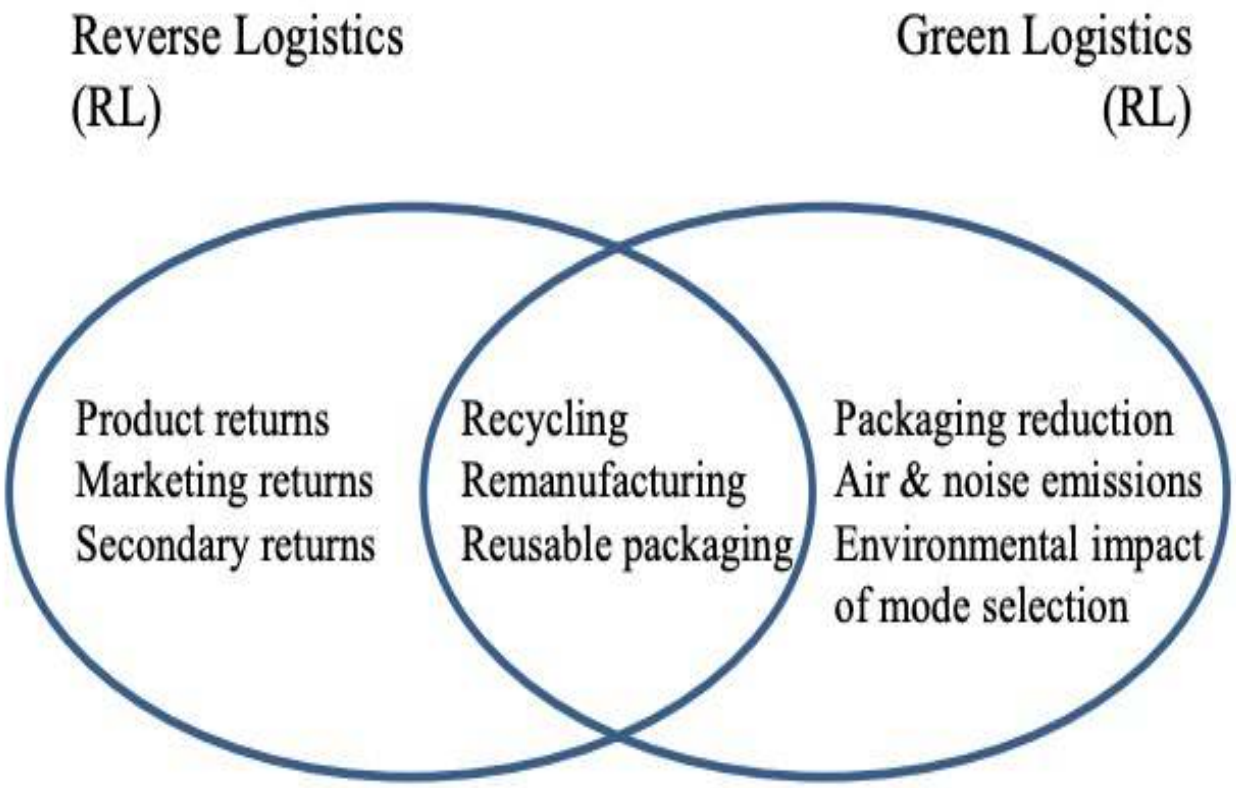


Green Logistics

- Green logistics describes all attempts to measure and minimize the ecological impact of logistics activities. This includes all activities of the forward and reverse flows of products, information and services between the point of origin and the point of consumption.
- It is the aim to create a sustainable company value using a balance of economic and environmental efficiency. Green logistics has its origin in the mid 1980s and was a concept to characterize logistics systems and approaches that use advanced technology and equipment to minimize environmental damage during operations.


Extraction of raw materials
Raw material transport
Refinement of raw materials/ Feedstock production
Feedstock transport
Component transport to manufacturing sites
Manufacture of final product
Warehousing & distribution
Component manufacture
Retail & industrial sales
Product use
Product & packaging disposal

Reverse Logistics and Green Logistics



The term GL is often used interchangeably with RL. However, in contrast to RL, GL resumes logistic activities that are primarily motivated by environmental considerations. RL focuses on saving money and increasing value by reusing or reselling materials to recover lost profits and reduce operating costs; in turn, GL focuses on the transportation.

GL looks for alternatives so that the transport factor is favorable and the related costs are reduced, in addition to providing a green image for the company. The activities considered are designed to measure environmental impacts on transportation, reduce energy consumption and reduce the use of materials.

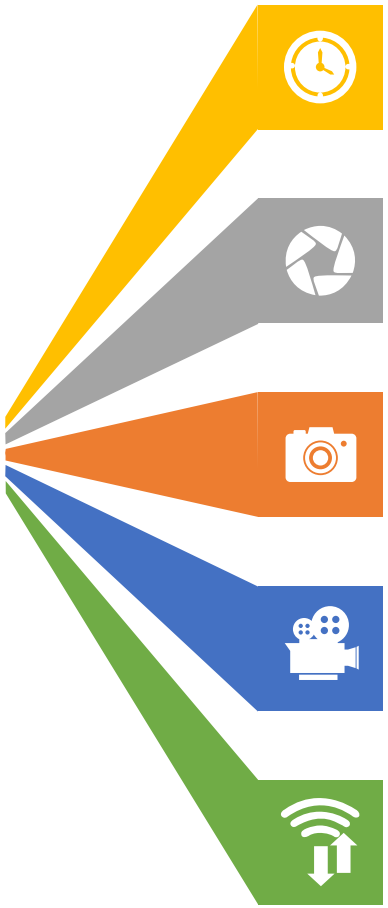
Recycling, remanufacturing, and reusable packaging are the common processes that contribute to GL and RL and these processes have the most significant negative impacts on sustainability.

Digitalization

- Today in the digitalisation era the logistics industry has plenty of potential to be transformed.
- Digitalization is defined as “the use of digital technologies to change a business model and provide new revenue and value-producing opportunities”. Digital transformation does not only mean to use technological devices and to push paperless processes. It implies a variety of changes in a company’s strategy, processes and organisational culture through the usage of technology.



FIVE Key Digital Themes



Information Services

Digitally enabled information services will put data at the heart of logistics business through initiatives such as reverse logistics and green logistics, and help in reducing operating costs while improving efficient of operations.

Shared Logistics Capabilities

Share logistics capabilities, through shared warehouse and shared transport capabilities, are expected to increase asset utilization.

Circular Economy

Circular economy will foster a more sustainable product life cycle, helping to lessen the logistics industry's environmental footprint by reducing carbon dioxide emission, air pollution and waste material.

Logistics Services

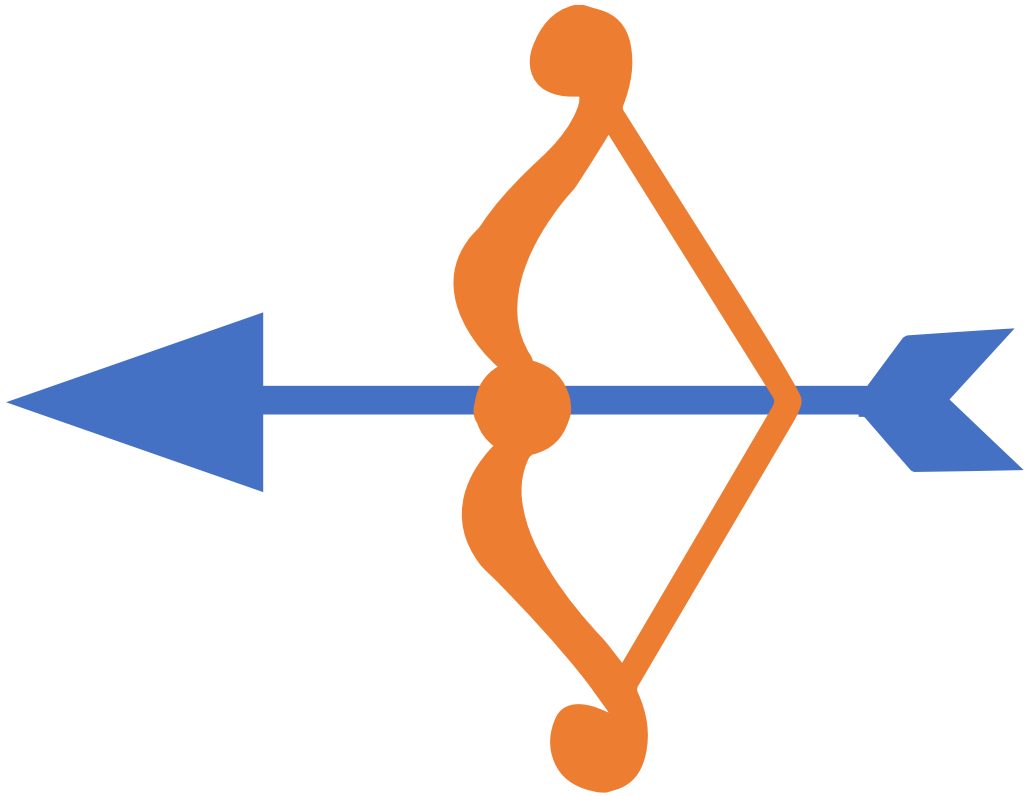
Digitally enabled logistics services will help in trade growth through the creation of digitally enhanced sustainability platforms. It will also allow logistics companies to satisfy the growing need of customers on sustainability, and at the same time promote same day deliveries.

Delivery Capabilities

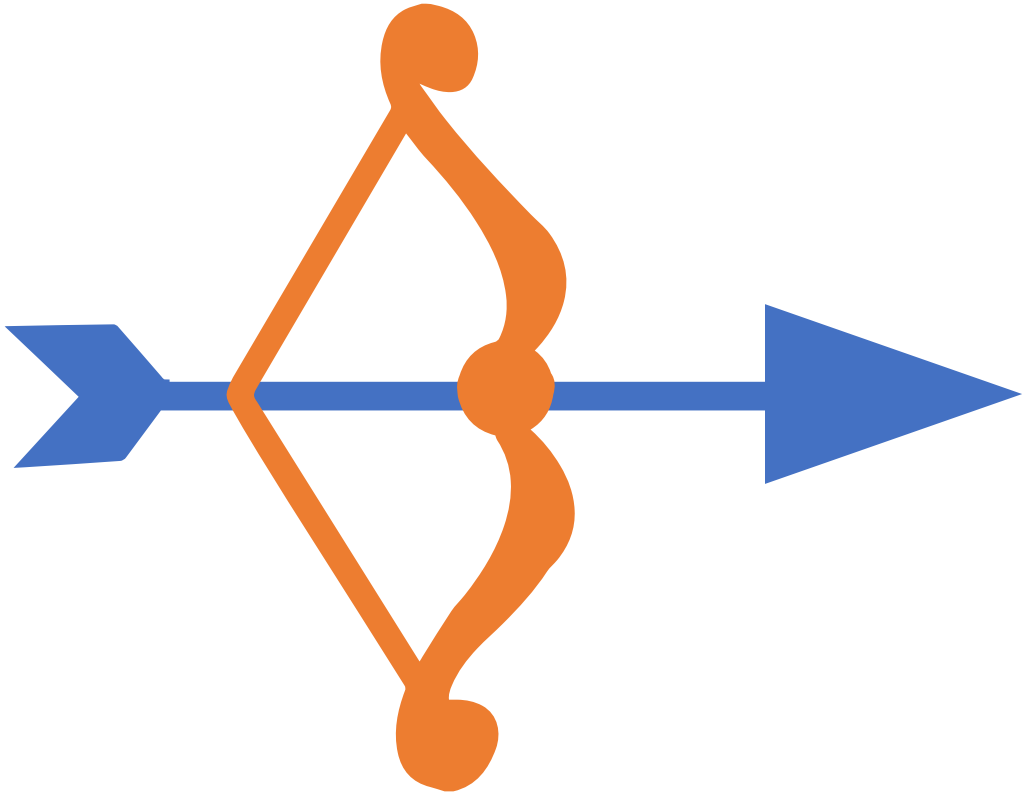
New delivery capabilities will allow logistic to harness technologies such as digital trucks and drones to for more efficient ways to deliver shipments, while 3D printing and iClouds offer new ways to think of logistics processes.

Green Logistics Digitalization

Internet of Things, artificial intelligence, cloud-connected sensors and smart tracking systems make green logistics achievable. Sustainably-focused last-mile delivery service e.g. fossil-free line-hauls and drones with large formats and capacities for efficient cargo delivery. 3D-printing biodegradable thermoplastic and runs on a battery with zero carbon dioxide.

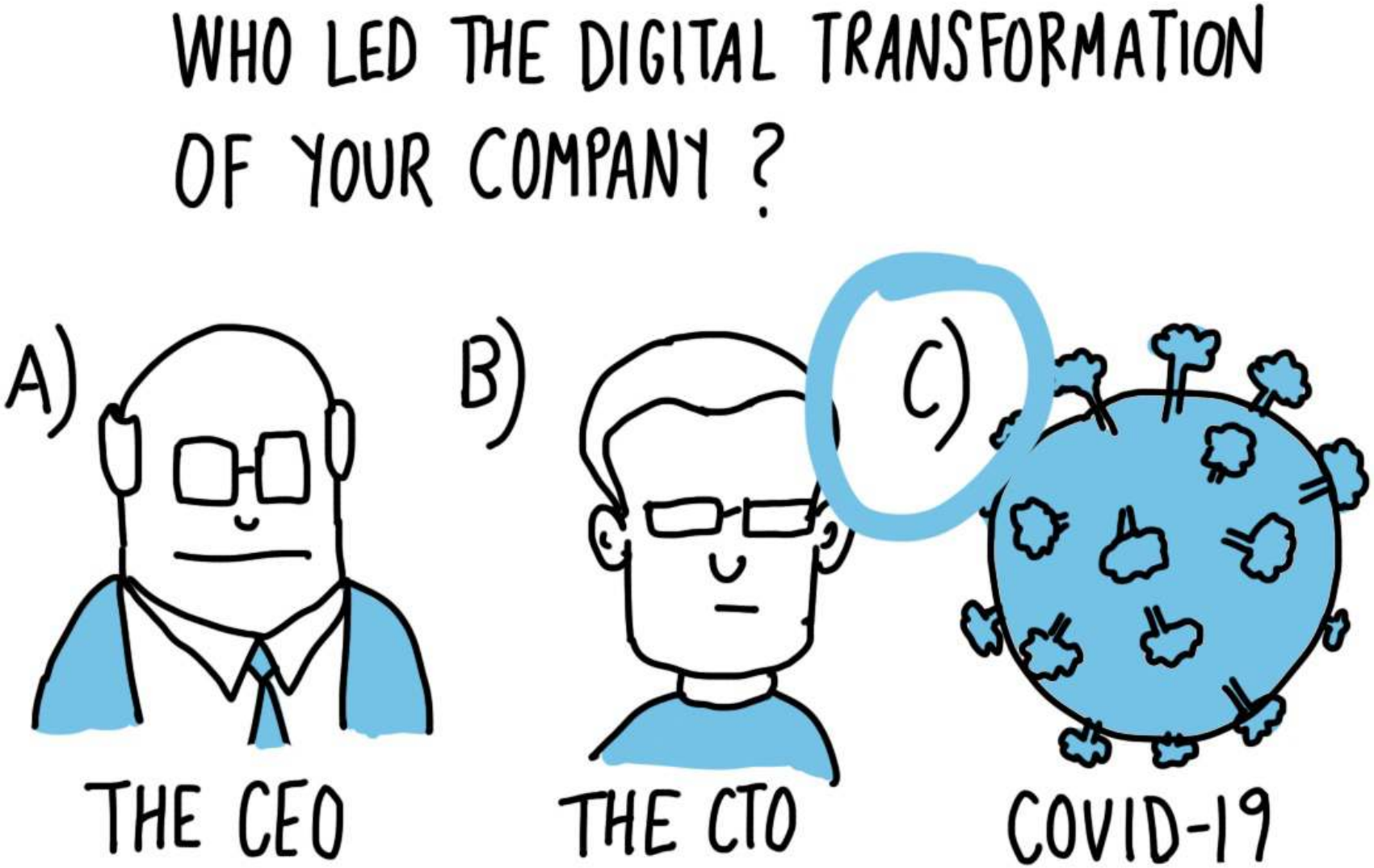


Reverse Logistics Digitalization

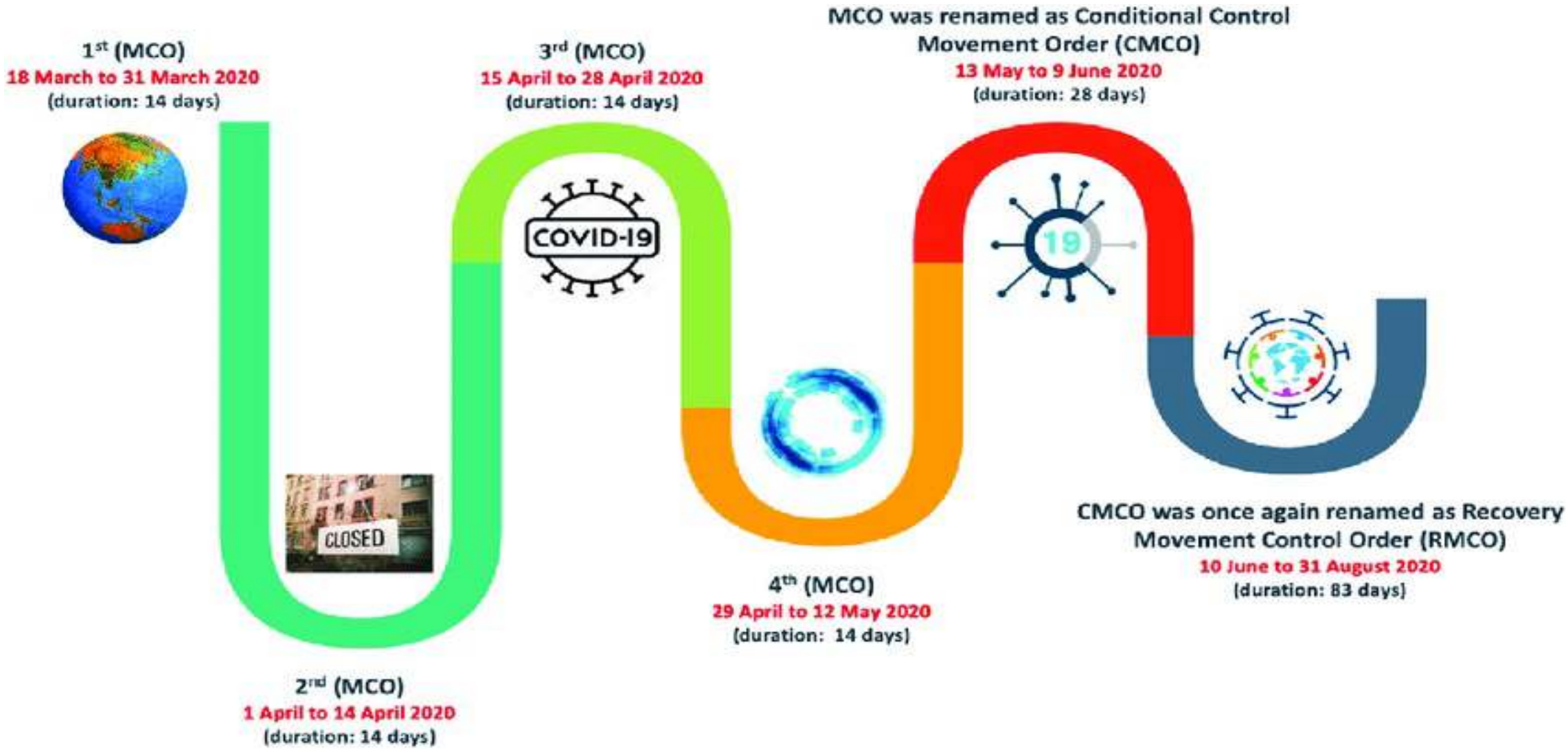


Sensors and monitoring devices, asset inventory management, the Internet of Things (IoT), and big data all present solutions that make it easier to identify, locate, track and communicate with the products and components that, at some point, require maintenance, repair or replacing.

Why is Digitalization Important?



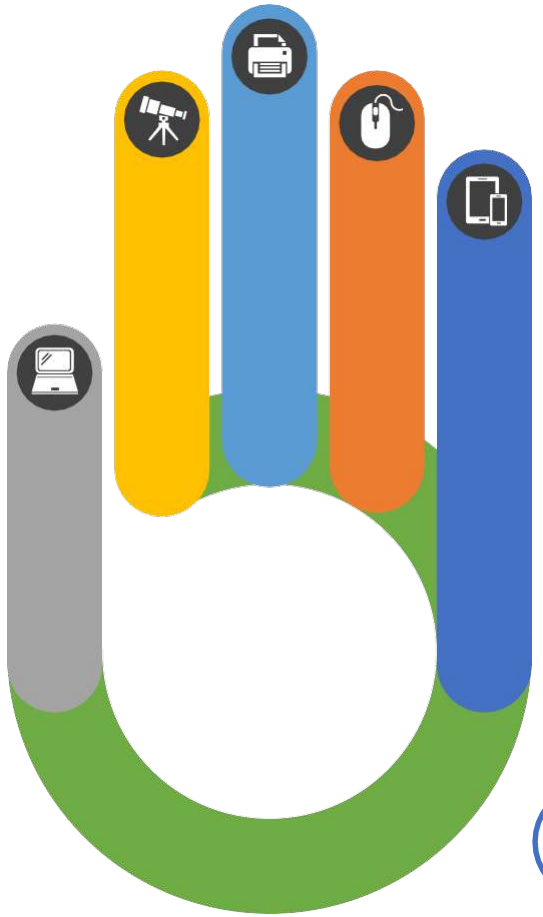
Covid-19 in Malaysia



Impact of Covid-19 to Malaysia

Malaysia is enduring its **worst economic recession** in its history just as other developed nations are facing deep downturns due to Covid-19 pandemic and MCO.

The economic recession has **impacted the nation's income**, with the country losing RM2.4 billion (USD553.3 million) daily.



The country economic growth to be between -0.2% and 0.5% in 2020 from 4.3% in 2019 within 5 weeks of MCO. **GDP is expected to decline between 3-4%.**

Industrial output is estimated to reduce between 40% and 70% during MCO and projected negative growth of -8.6% of the manufacturing sector.

Unemployment rate, which stood at 3.3% in 2019, is hit 4.0% this year, higher than during the Global Financial Crisis (GFC) in 2009 and Asian Financial Crisis 1998 at 3.7% and 3.2% respectively

Impact of Covid-19 to Businesses

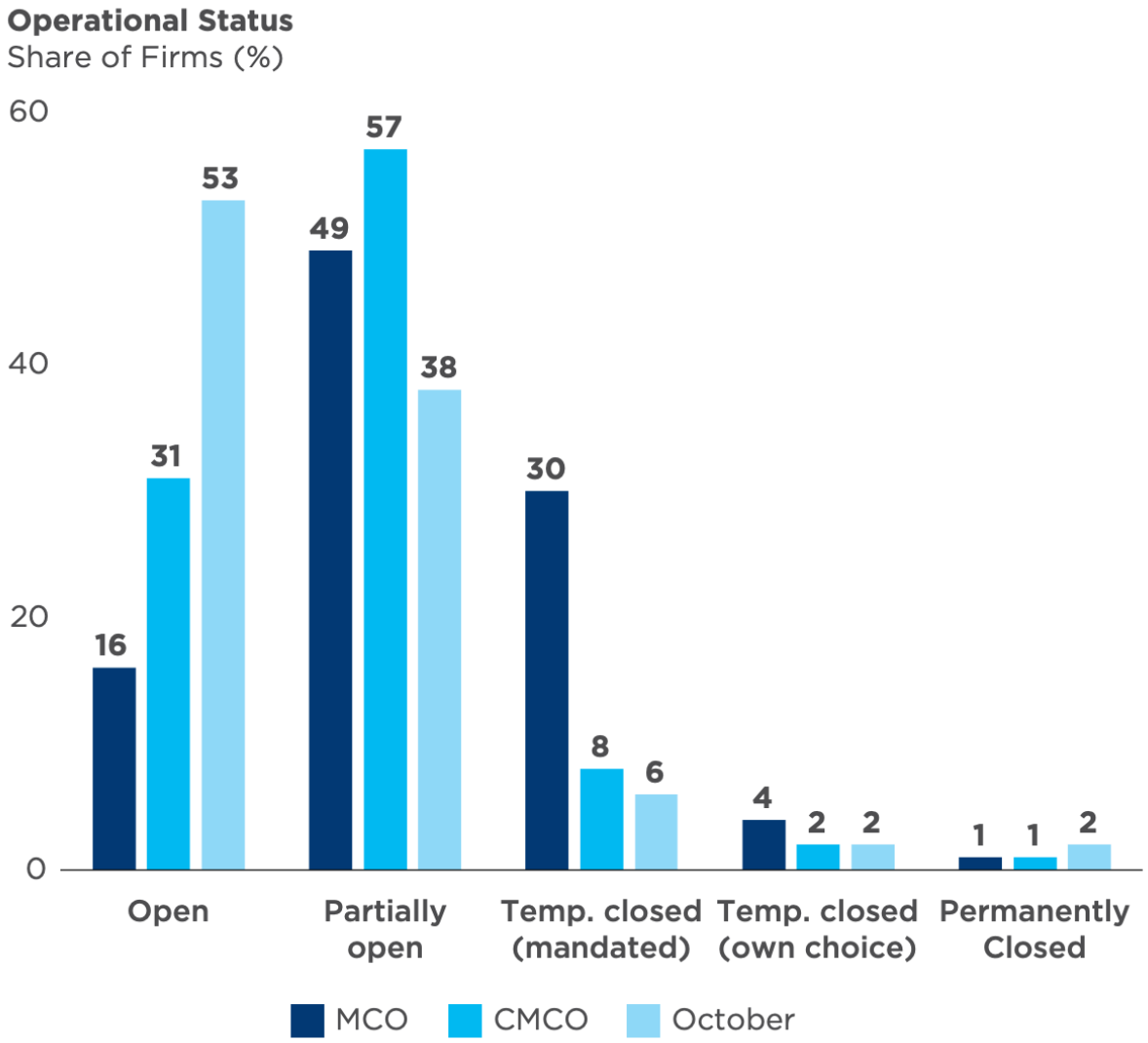
E-retail logistics, on-demand and last mile delivery sectors are amongst the highest growth sectors as a result of the coronavirus crisis.

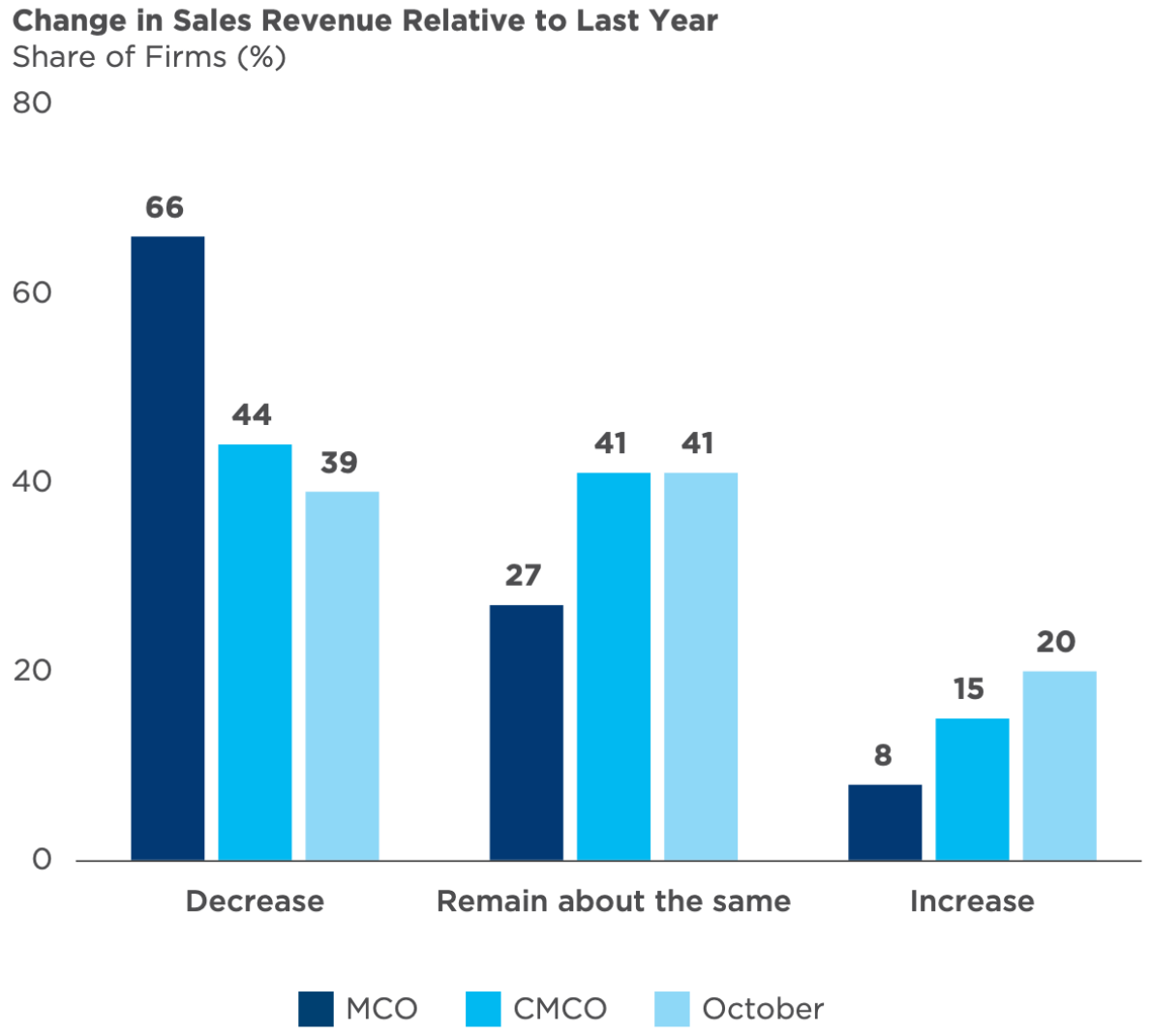
SMEs and MNCs are facing severe disruptions to production, being unable to receive the necessary inputs and raw material from suppliers to continue producing.

A survey of Malaysian supply chain executives conducted between December 2020 and February 2021 found that 39% of those polled claimed the COVID-19 epidemic has harmed their supply networks. In contrast, 18% of supply chain executives stated the epidemic enhanced their company's income.

The pandemic's inception and spread have had a profound impact on the supply chain and logistics on the primary industries.

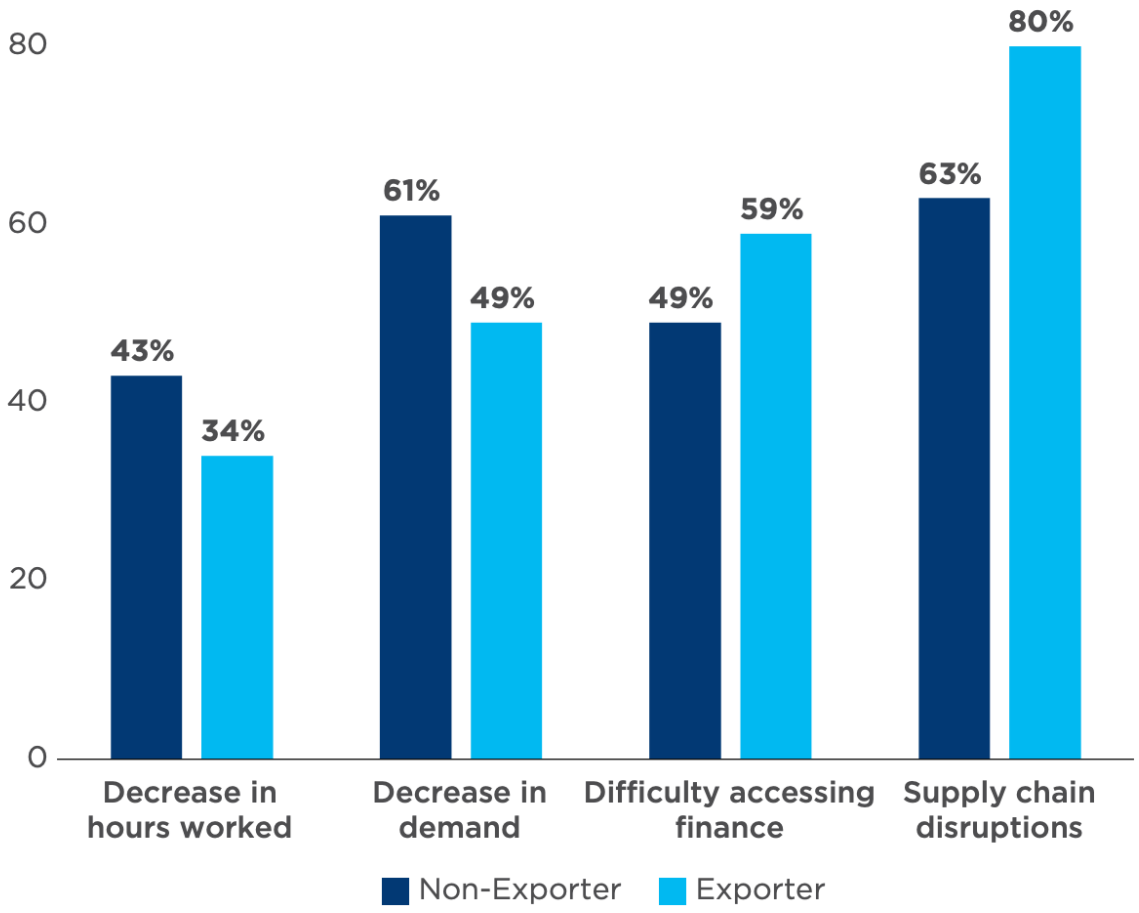




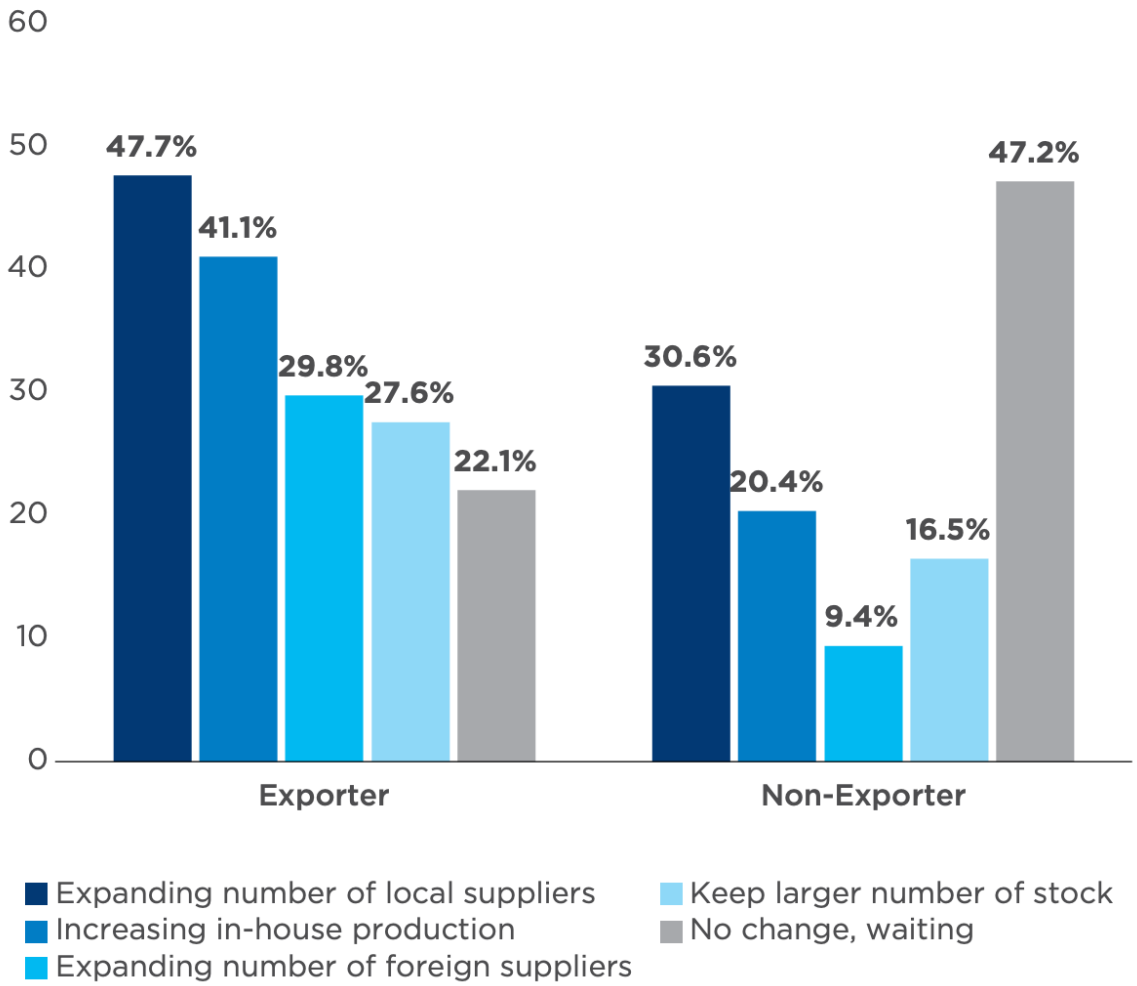


Source: COVID-19 Business Pulse Surveys: Impacts of COVID-19 on Firms in Malaysia in December 2020 (Would Bank Group, 2020)

Channels Affecting Operations in October Relative to Last Year
Share of Firms (%)

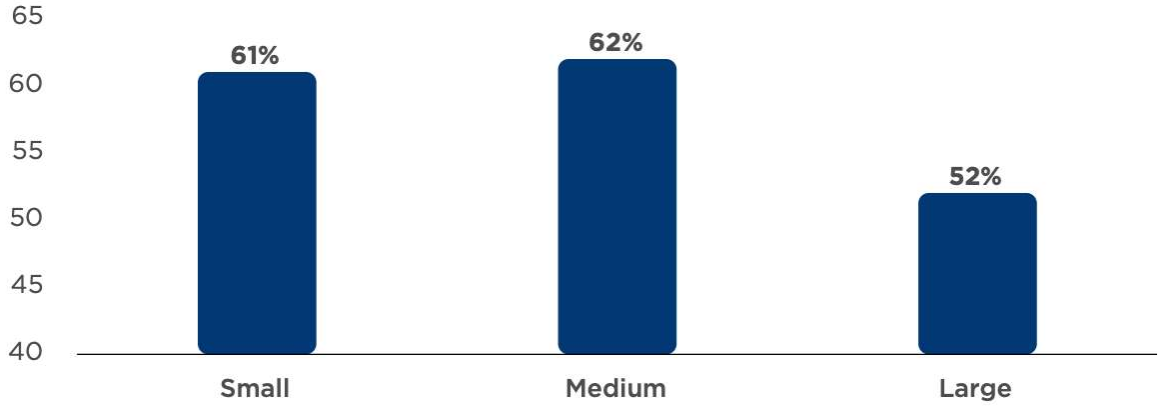


Adjustments Made or Planning to Make to Deal with Supply Chain Disruptions
Share of Firms (%)

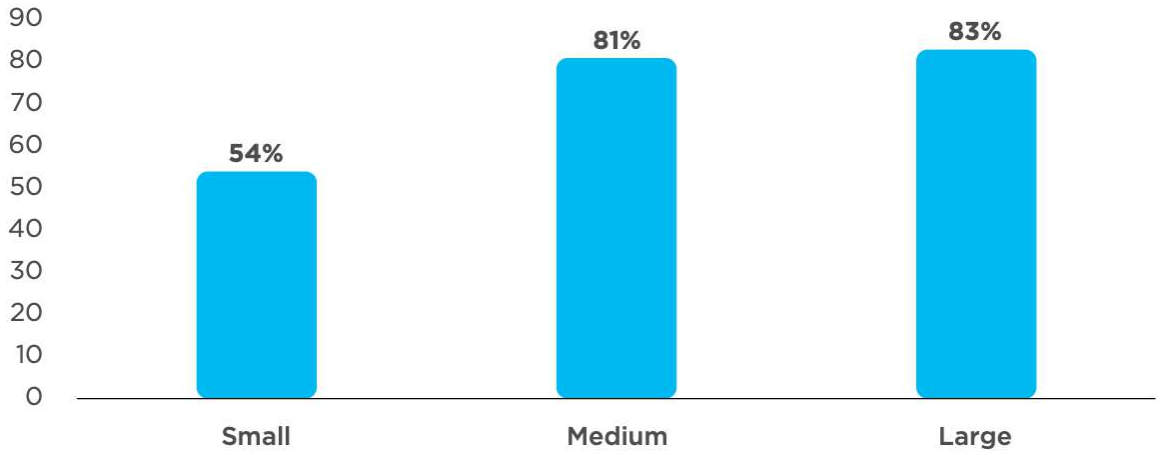


Source: COVID-19 Business Pulse Surveys: Impacts of COVID-19 on Firms in Malaysia in December 2020 (Would Bank Group, 2020)

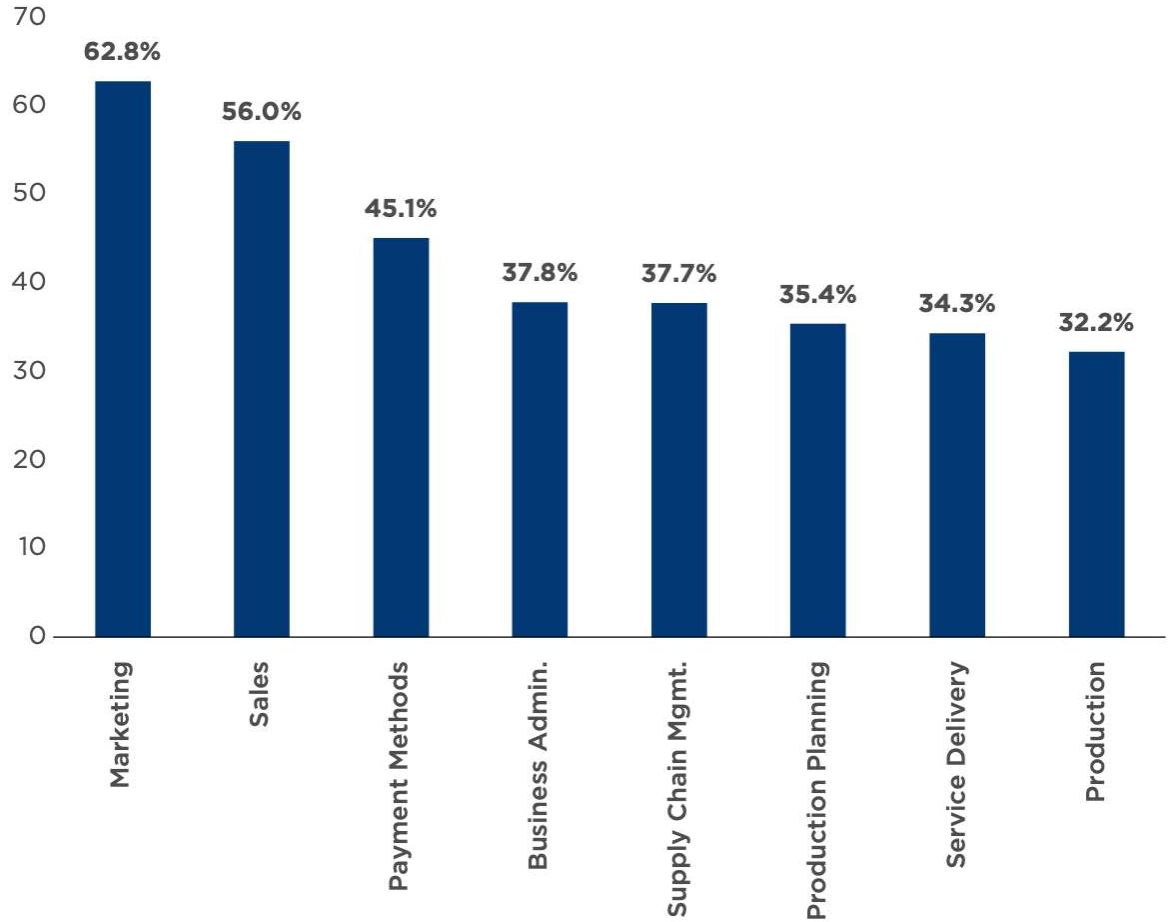
Increased use of Digital Platforms
Share of Firms (%)



Invested in Digital Solutions
Share of Firms (%)



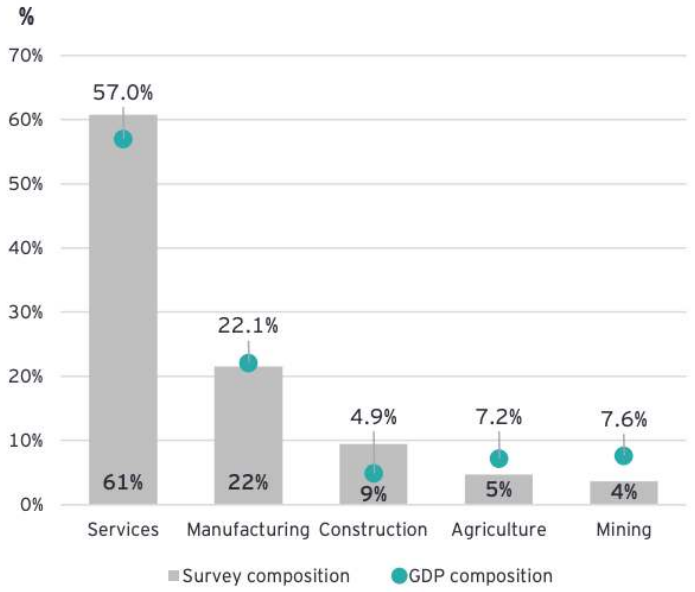
Use of Digital Platforms by Business Functions
Share among Firms that Started or Increased Use in Digital Platforms (%)

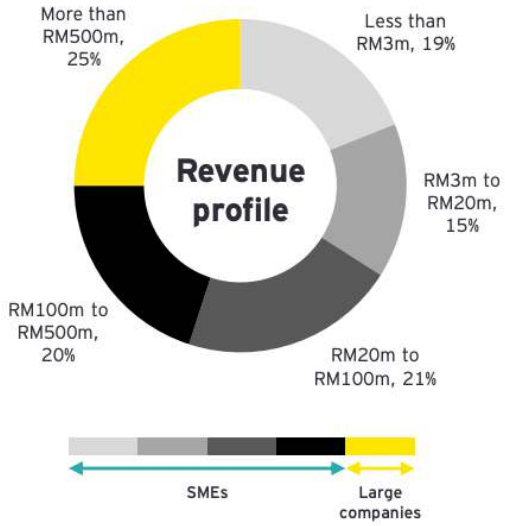


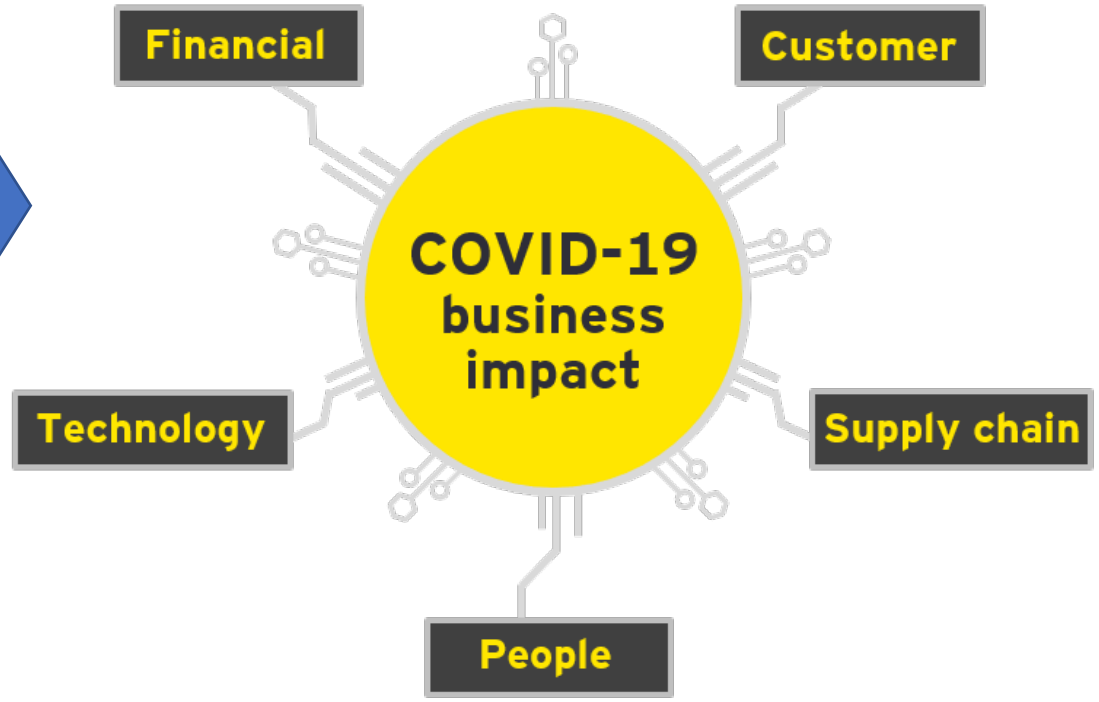
Source: COVID-19 Business Pulse Surveys: Impacts of COVID-19 on Firms in Malaysia in December 2020 (Would Bank Group, 2020)

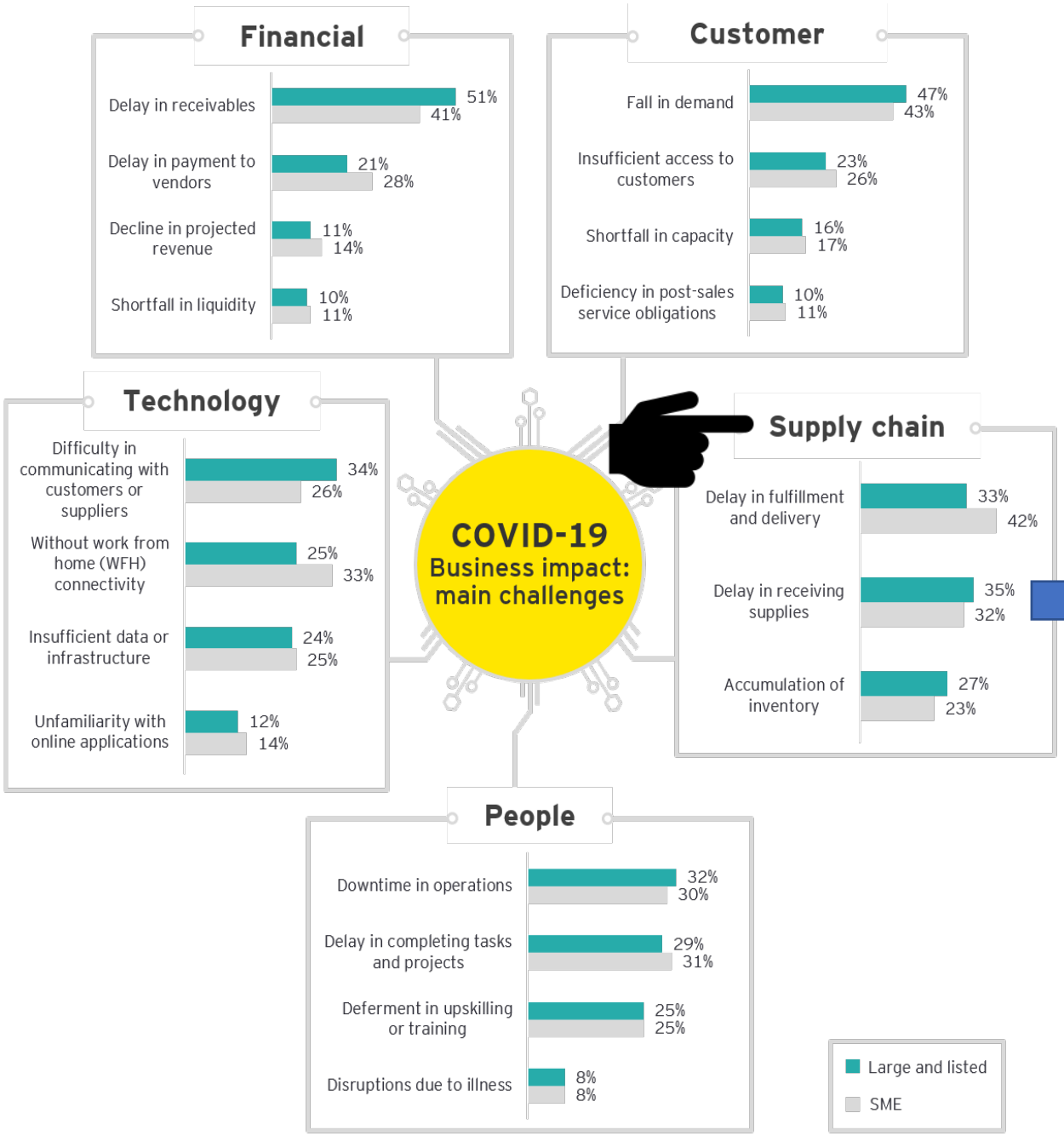
Covid-19 Business Impact

The online survey conducted over 670 responses from large and listed companies and SMEs in Jun 2021 to understand the impact of COVID-19 on Malaysian businesses.









Financial

Large and listed

- Restoring financial strength and liquidity will be essential first steps, after which companies will reconsider investment and development priorities, including digital transformations.

SME

- Restoring customer cashflow, managing delayed receivables and upgrading systems will add financial burdens in the short run.

Customer

Large and listed

- Large companies are also seeking a rapid transition to the new normal, which will include significant investments in "contactless" digital infrastructure.

SME

- Aim for a rapid move to the new normal, while adapting to new customer preferences and expectations in terms of connectivity and digital transformation

Technology

Large and listed

- While most large companies have IT support staff, coping with changes in communication processes and new digital system designs and implementation will be key.

SME

- Need for better digital connectivity with staff, including implementation of communication and co-working tools; training can help rapid adoption.



Supply chain

Large and listed

- Businesses will require improved connectivity and greater capabilities in managing more complex and diverse supply chains.

SME

- Renewing supply of parts and materials is the first priority – digital systems may help to manage more complex inventory management.

People

Large and listed

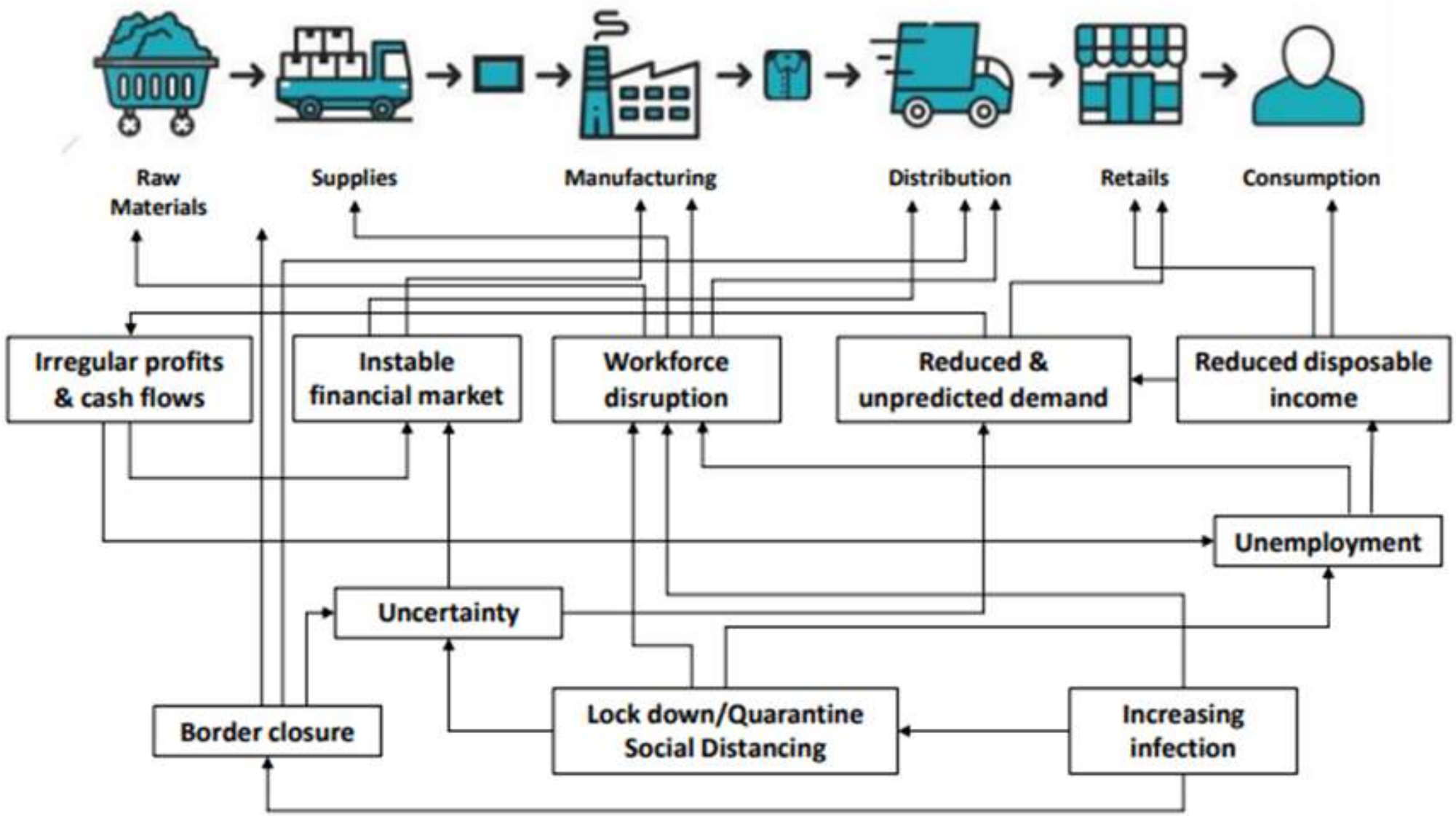
- Adjusting capacity to meet new demand will be a priority, along with maximizing productivity and transitioning staff to new ways of working

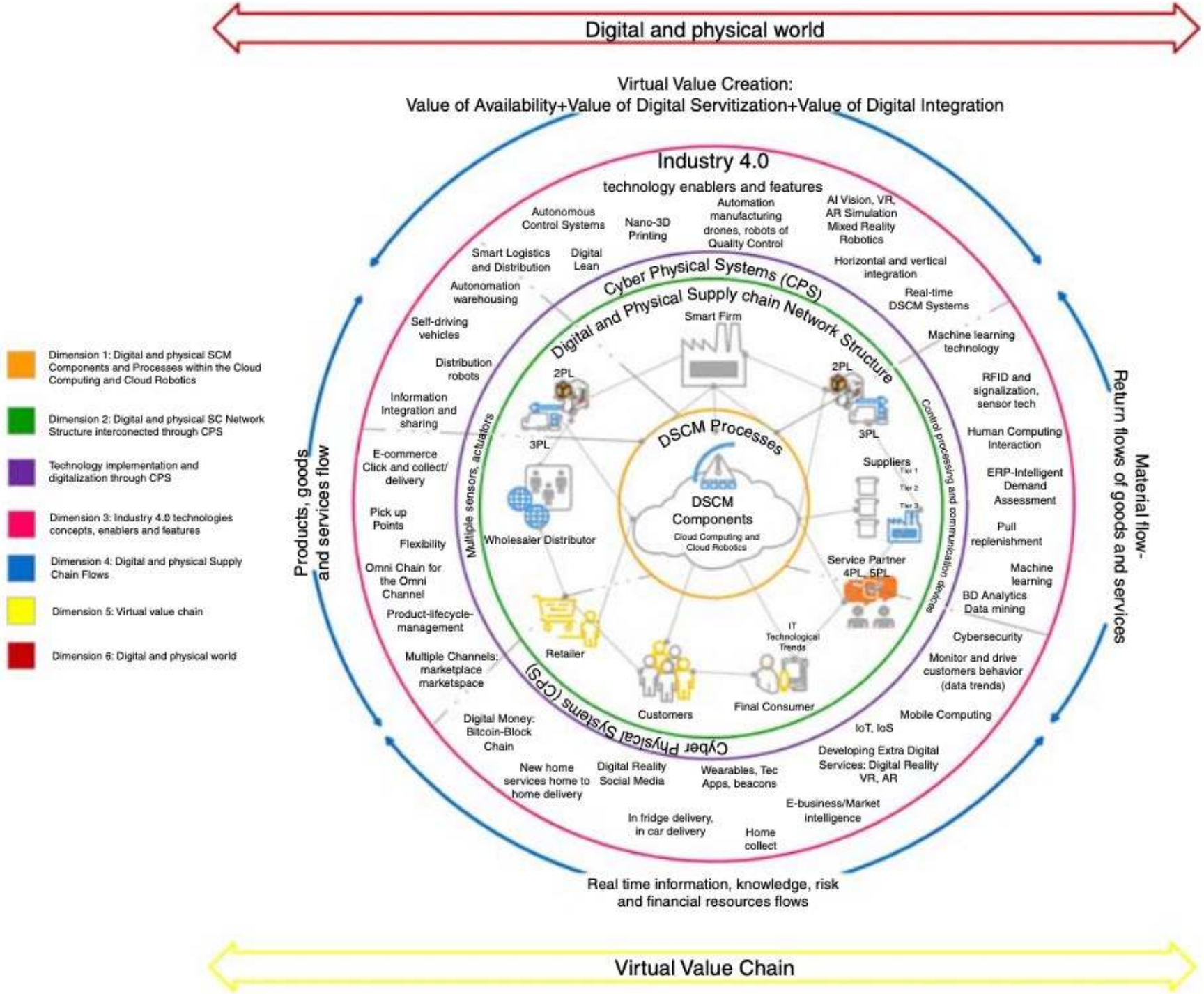
SME

- Main task is to restore project timelines amid new work arrangements and processes designed to manage employee and customer safety.

Note: Percentages do not sum to 100% due to the exclusion of "Other challenges".

Supply Chain Disruptions




Digital and physical world
Virtual Value Creation:
Value of Availability+Value of Digital Servitization+Value of Digital Integration
Industry 4.0
technology enablers and features
Cyber Physical Systems (CPS)
Digital and Physical Supply chain Network Structure
DSCM Processes
DSCM Components
Cloud Computing and Cloud Robotics
Smart Firm
2PL
3PL
Wholesaler Distributor
Retailer
Customers
Final Consumer
Suppliers
Tier 1
Tier 2
Tier 3
Service Partner 4PL, 5PL
IT Technological Trends
Multiple sensors, actuators
Control processing and communication devices
Cyber Physical Systems (CPS)
Autonomous Control Systems
Nano-3D Printing
Automation manufacturing drones, robots of Quality Control
AI Vision, VR, AR Simulation Mixed Reality Robotics
Smart Logistics and Distribution
Digital Lean
Horizontal and vertical integration
Autonomation warehousing
Real-time DSCM Systems
Self-driving vehicles
Machine learning technology
Distribution robots
RFID and signalization, sensor tech
Information Integration and sharing
Human Computing Interaction
E-commerce Click and collect/ delivery
ERP-Intelligent Demand Assessment
Pick up Points
Pull replenishment
Flexibility
Machine learning
Omni Chain for the Omni Channel
BD Analytics Data mining
Product-lifecycle-management
Cybersecurity
Multiple Channels: marketplace marketspace
Monitor and drive customers behavior (data trends)
Digital Money: Bitcoin-Block Chain
Mobile Computing
IoT, IoS
Developing Extra Digital Services: Digital Reality VR, AR
New home services home to home delivery
Digital Reality Social Media
Wearables, Tec Apps, beacons
E-business/Market intelligence
In fridge delivery, in car delivery
Home collect
Products, goods and services flow
Material flow- Return flows of goods and services
Real time information, knowledge, risk and financial resources flows
Virtual Value Chain
Dimension 1: Digital and physical SCM Components and Processes within the Cloud Computing and Cloud Robotics
Dimension 2: Digital and physical SC Network Structure interconnected through CPS
Technology implementation and digitalization through CPS
Dimension 3: Industry 4.0 technologies concepts, enablers and features
Dimension 4: Digital and physical Supply Chain Flows
Dimension 5: Virtual value chain
Dimension 6: Digital and physical world

Problem Statement



LOW TECHNOLOGY ADOPTION

- Malaysia is ranked 60th out of 144 economies in the category of Technological Readiness in the Global Competitiveness Index Report 2014-2015, highlighting the country's low technology adoption rate.
- Logistics service providers state that their adoption of advanced technology is minimal due to limited expertise and high upgrading costs.
- With the dawn of Industry 4.0 and increased trust in digital services such as analytics, cloud and marketing, merchants, transhippers, warehouses, and ports authorities are increasingly exploring digital transformation to stay ahead of the regional and global logistics competition while keeping costs low.

LOW GREEN INITIATIVES ADOPTION

- Logistics companies have been urged to adopt green strategies to lower their carbon footprint.
- The logistics sector now accounts for 21%, the second largest proportion of total carbon emissions in the country.
- Industry players should consider the environmental impact by reducing carbon emissions.
- Green logistics include strategies to reduce bottlenecks, simplify processes and procedures as well as consolidate partnership with the private sector.
- The green logistics strategy is in line with Malaysia's commitment to reduce greenhouse gas emissions by 45% by 2030 under the Paris Agreement.
- Green logistics is an important component of the Logistics and Trade Facilitation Masterplan 2015 — 2020.

LOW SUSTAINABLE DEVELOPMENT GOALS (SDGs)

- All sectors must work together to achieve the sustainability goals including the logistics industry.
- Federation of Malaysian Freight Forwarders president Chua Seng Wah said certain policies had to be reviewed to enable green and reverse logistics.
- E.g., when cargo trucks unload at their destinations, they must return empty because they are not licensed to carry containers even though they are equally capable of transporting containers. As a result, the number of trucks on the roads rises, thereby widening their carbon footprint.

Objectives

The awareness levels and indicators towards effective RL and GL

The current RL and GL in Malaysian is still low

The links between digitalization with RL and GL is not well understood by the industry players

- to investigate the awareness level of digitalization on the reverse logistics and green logistics activities.
- to examine the views of reverse logistics and green logistics activities that commonly adopted by the firms
- to identify the links between digitalization that are relevant to reverse logistics and green logistics principles

Agenda



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Burning platform for Digitizing Reverse Logistics and Green Logistics

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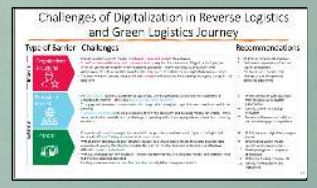
Industries' views

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Digitalization of Reverse Logistics and Green Logistics

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Way Forward



Way forward enabling digitalization in Reverse Logistics and Green Logistics Initiatives in Malaysia

Who We Talked to for the Industry

SECTORS:
8 main sectors were participated

PURPOSE

The survey was conducted to understand the starting point of Malaysian firms in adopting digitalization for RL and GL principles.

CONTENT

Respondents were asked to assess their current adoption level of the RL and GL with the the impact from technology.

TOTAL FIRMS:
The 500 total samples of firms were randomly selected, and data were collected through an online survey in April – Jun 2020.

YEARS IN COMPANY

74% were less than 10 years and 21% between 11-30 years.

TOTAL RESPONDENTS:

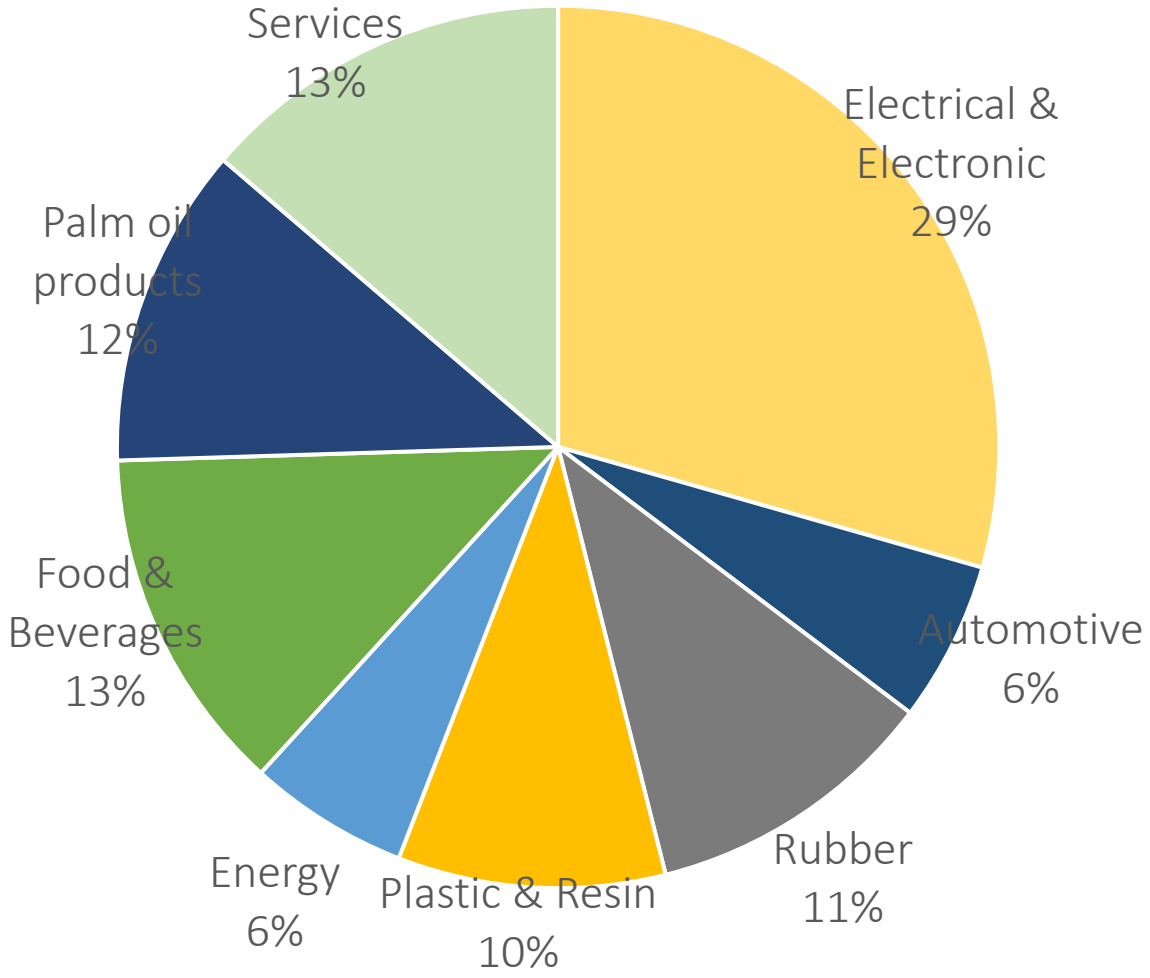
From 500 samples, only 102 responded to the survey with 20,4% response rate.

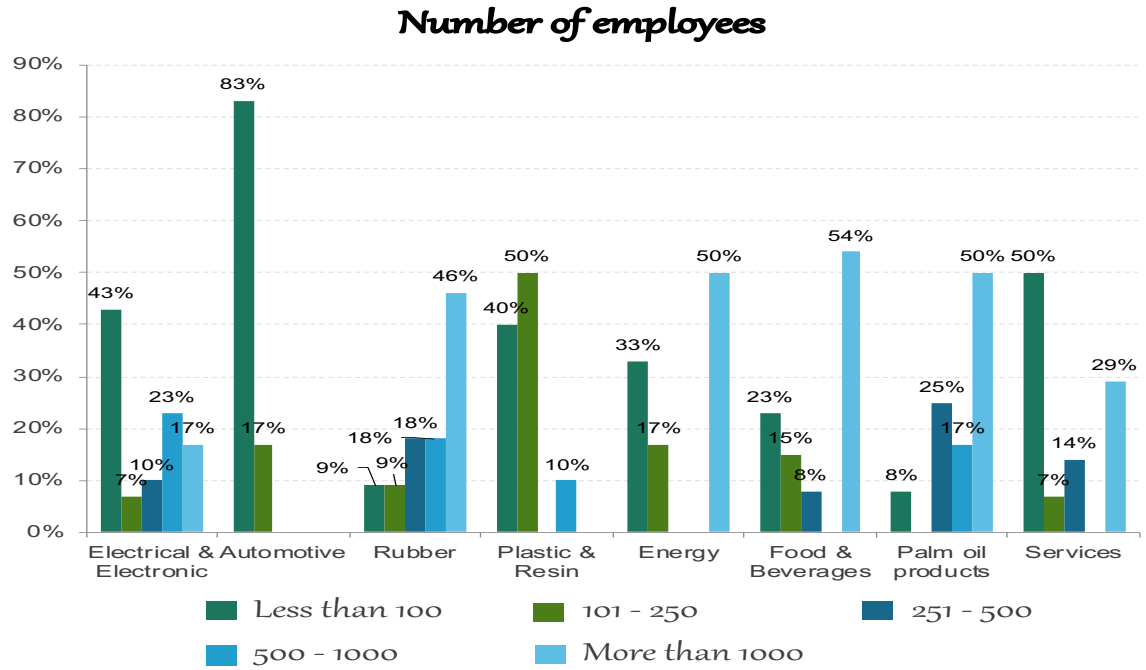
JOB ROLE:
40% were directors and MD, 23% were managers and 12% were executives.

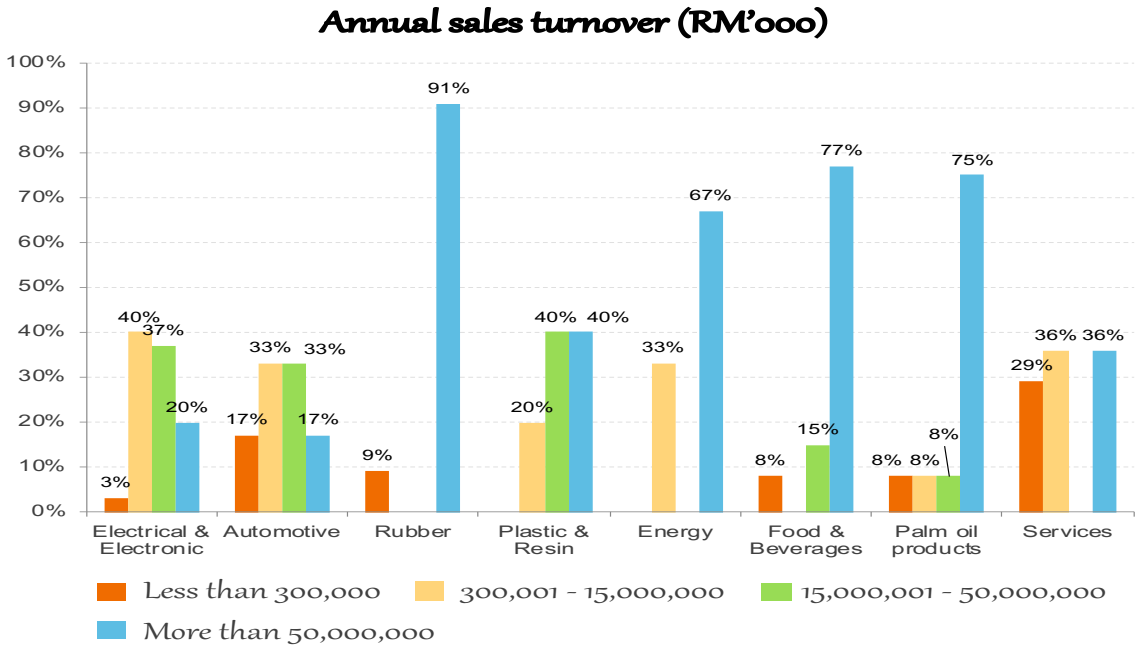
GENDER

68% were males 32% were females.

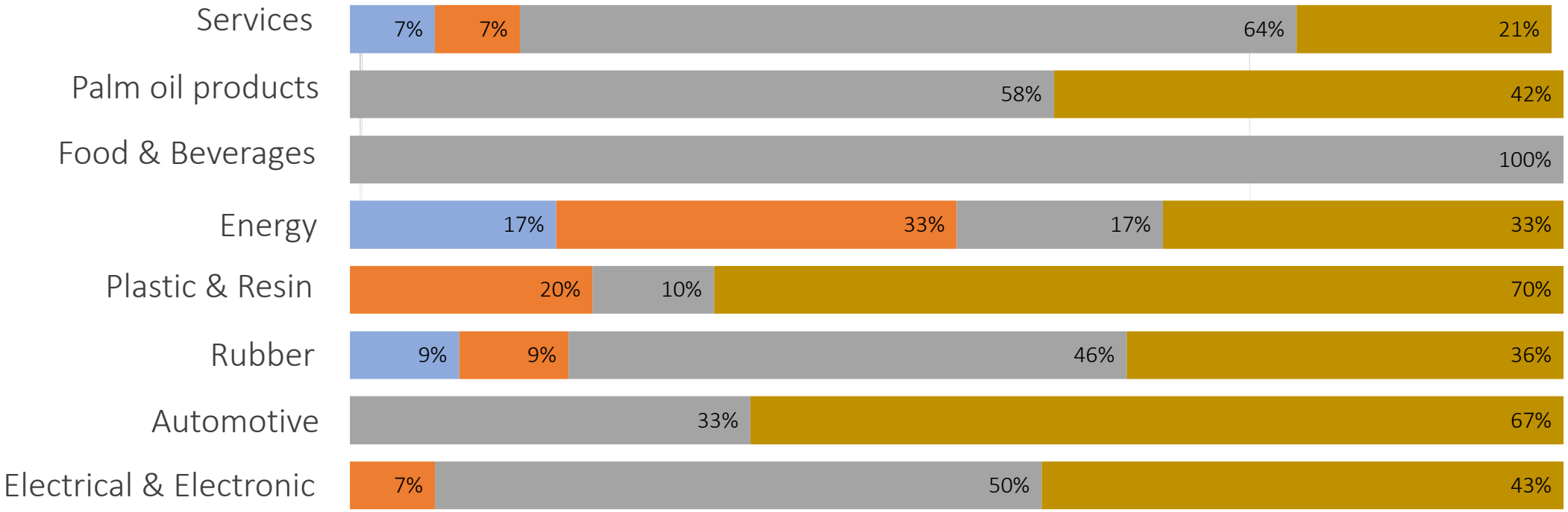
Profiles of the Firms





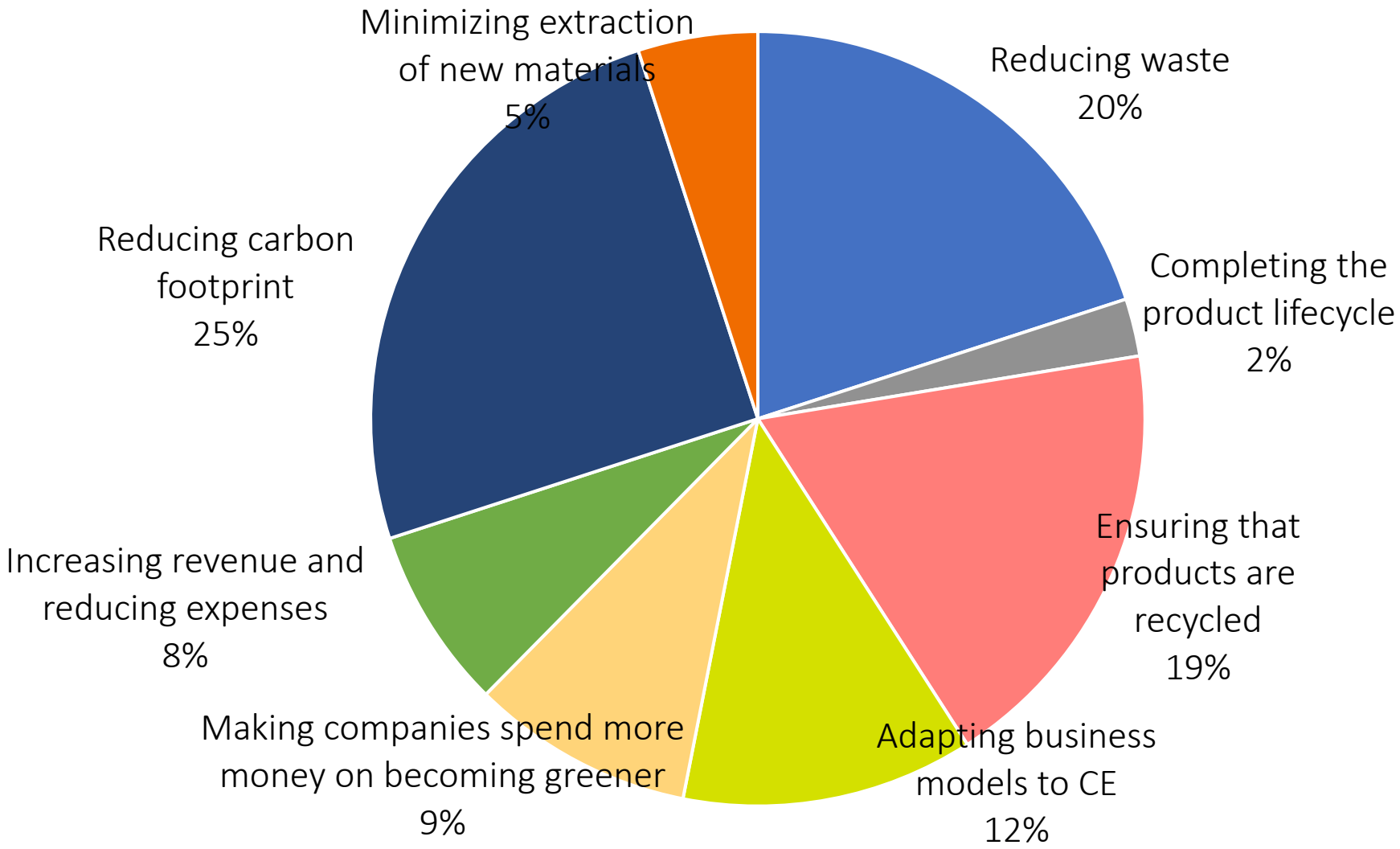


Awareness Level on the Impact of Digitalization on Reverse Logistics and Green Logistics Activities

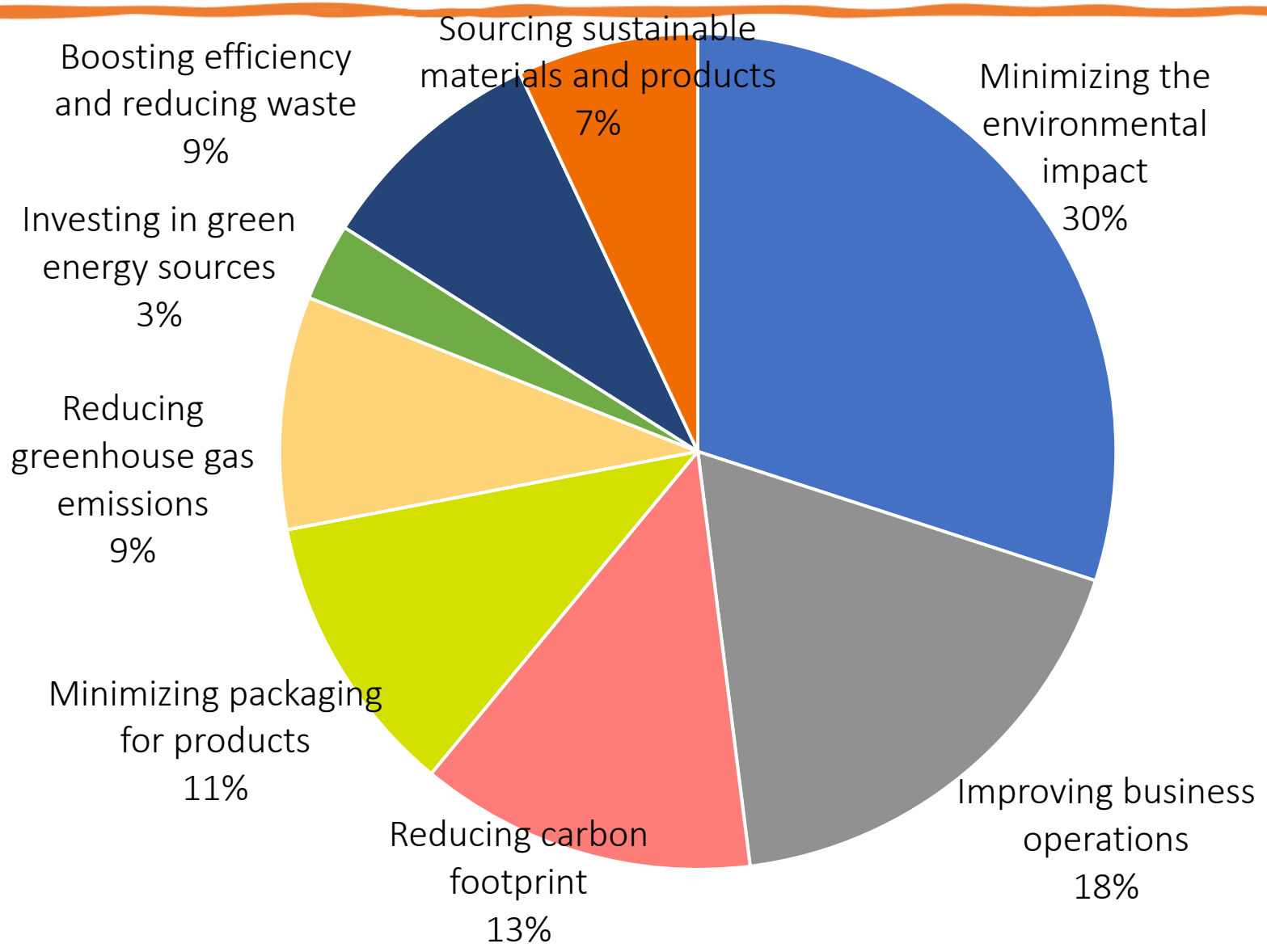


	Electrical & Electronic	Automotive	Rubber	Plastic & Resin	Energy	Food & Beverages	Palm oil products	Services
Minimal influence			9%		17%			7%
Moderate	7%		9%	20%	33%			7%
Some influence	50%	33%	46%	10%	17%	100%	58%	64%
Strong influence	43%	67%	36%	70%	33%		42%	21%

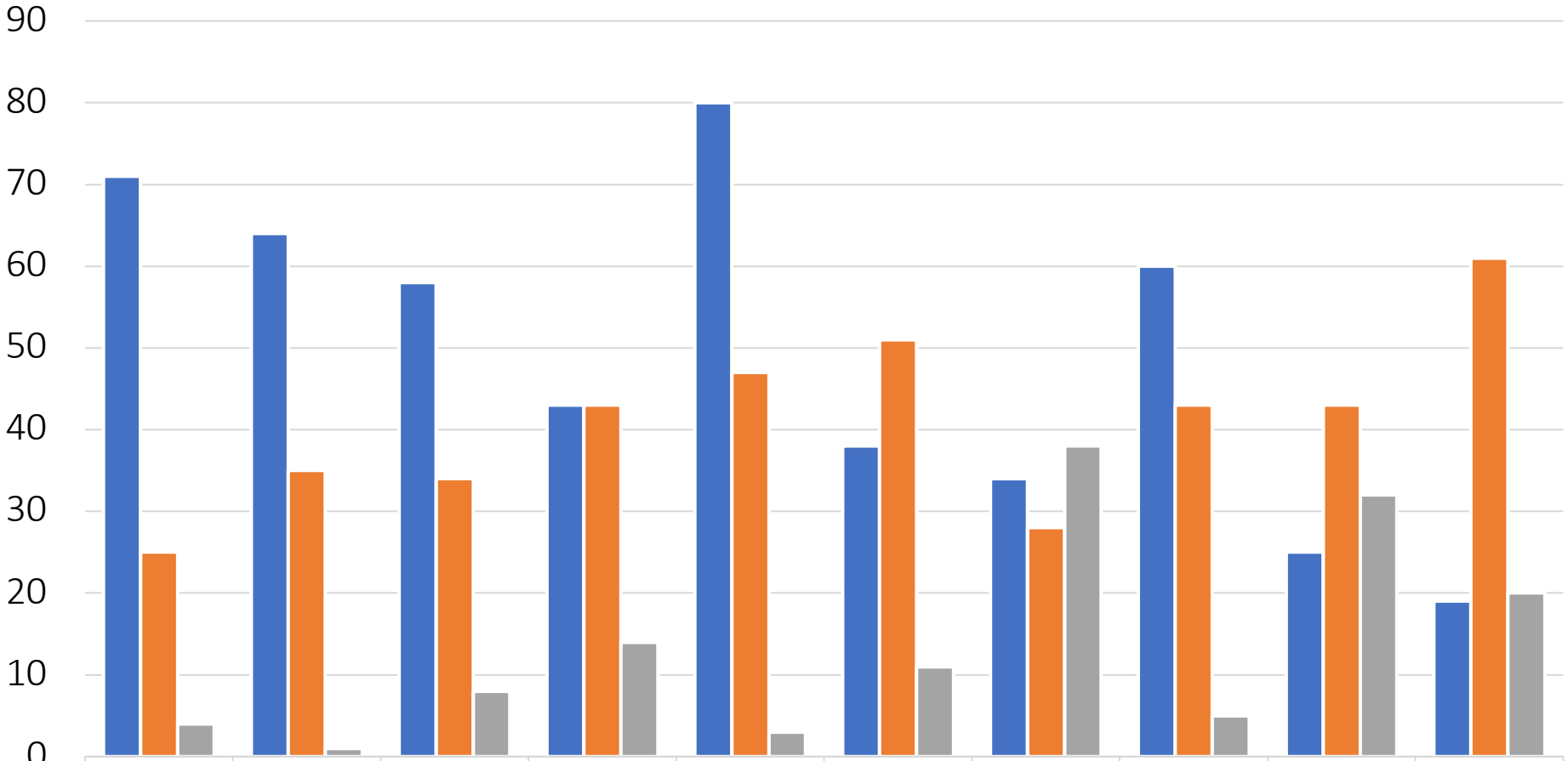
Views on Reverse Logistics



Views on Green Logistics

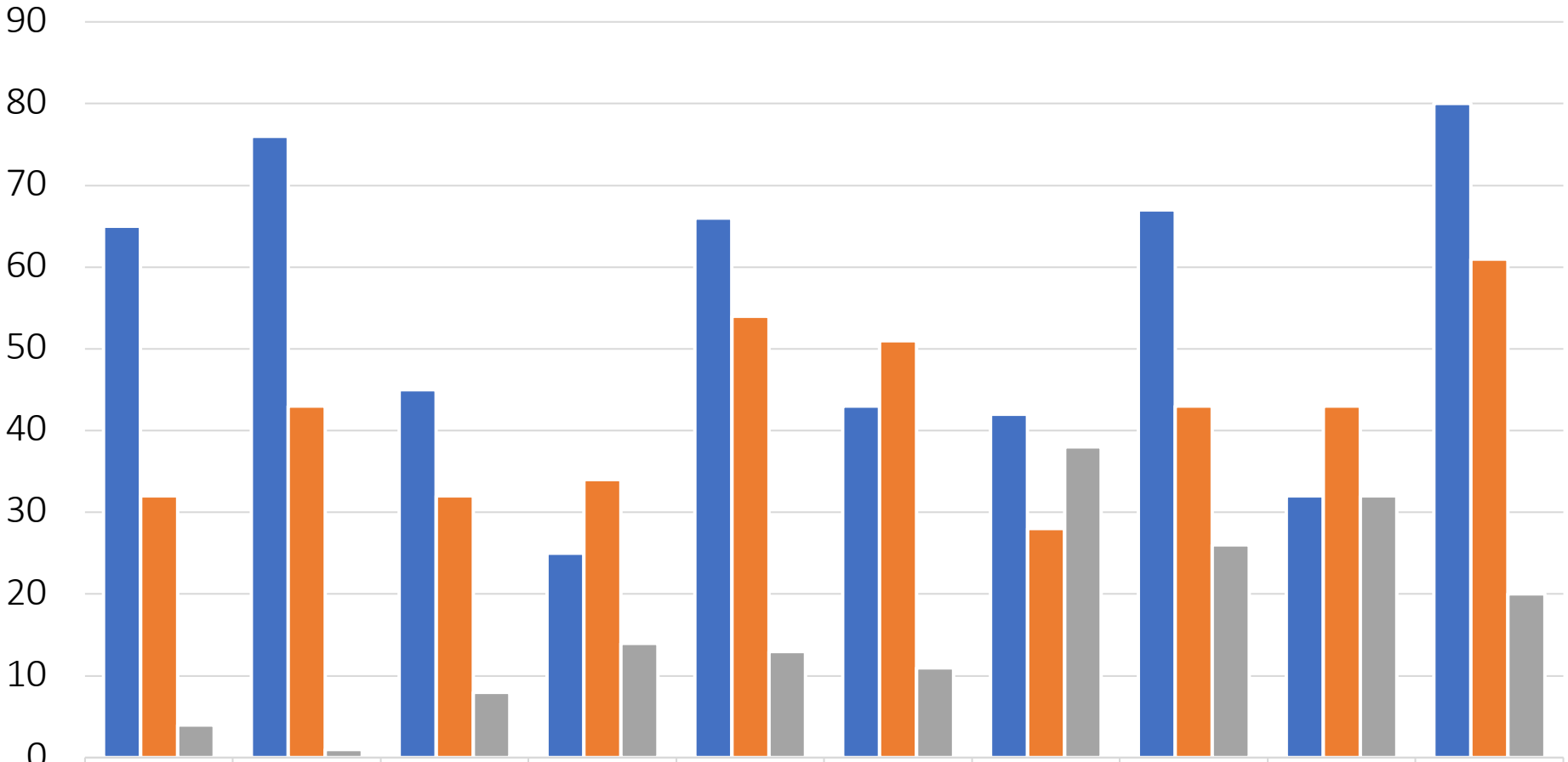


Types of Digitalization in Reverse Logistics (%)



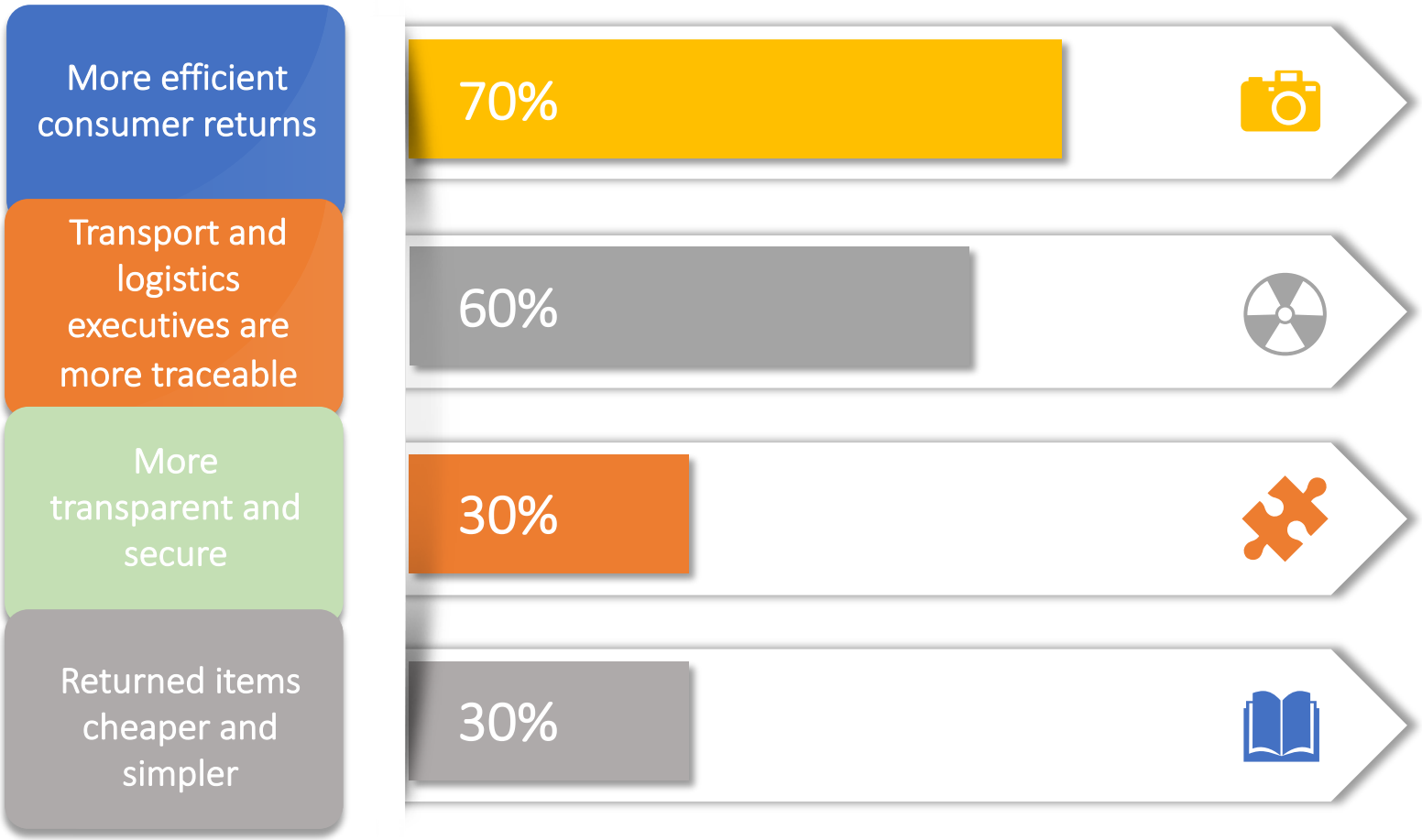
	Data Analytics	Cloud Computing	ERP	Robotic Process Automation	Internet of Things	Arificial Intelligence (AI) / Machine Learning	3D Printing	Blockchain	Virtual Augmented Reality	5G
Currently Deploying	71	64	58	43	80	38	34	60	25	19
Plan to Deploy	25	35	34	43	47	51	28	43	43	61
No Plan	4	1	8	14	3	11	38	5	32	20

Types of Digitalization in Green Logistics (%)

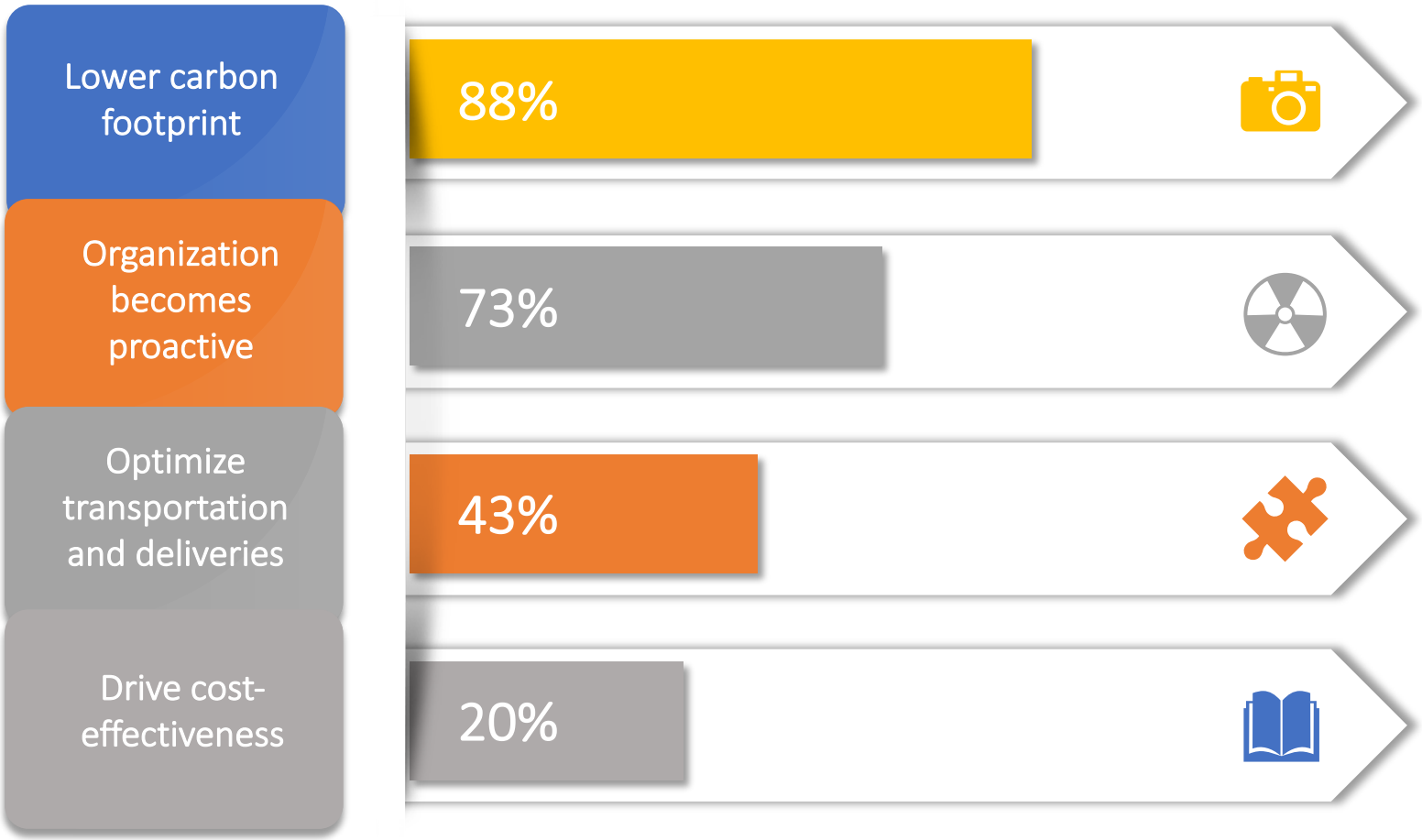


	Data Analytics	Cloud Computing	Data Warehouse	Robotic Process Automation	Internet of Things	Arificial Intelligence (AI) / Machine Learning	3D Printing	Blockchain	Virtual Augmented Reality	Online Quoting
Currently Deploying	65	76	45	25	66	43	42	67	32	80
Plan to Deploy	32	43	32	34	54	51	28	43	43	61
No Plan	4	1	8	14	13	11	38	26	32	20

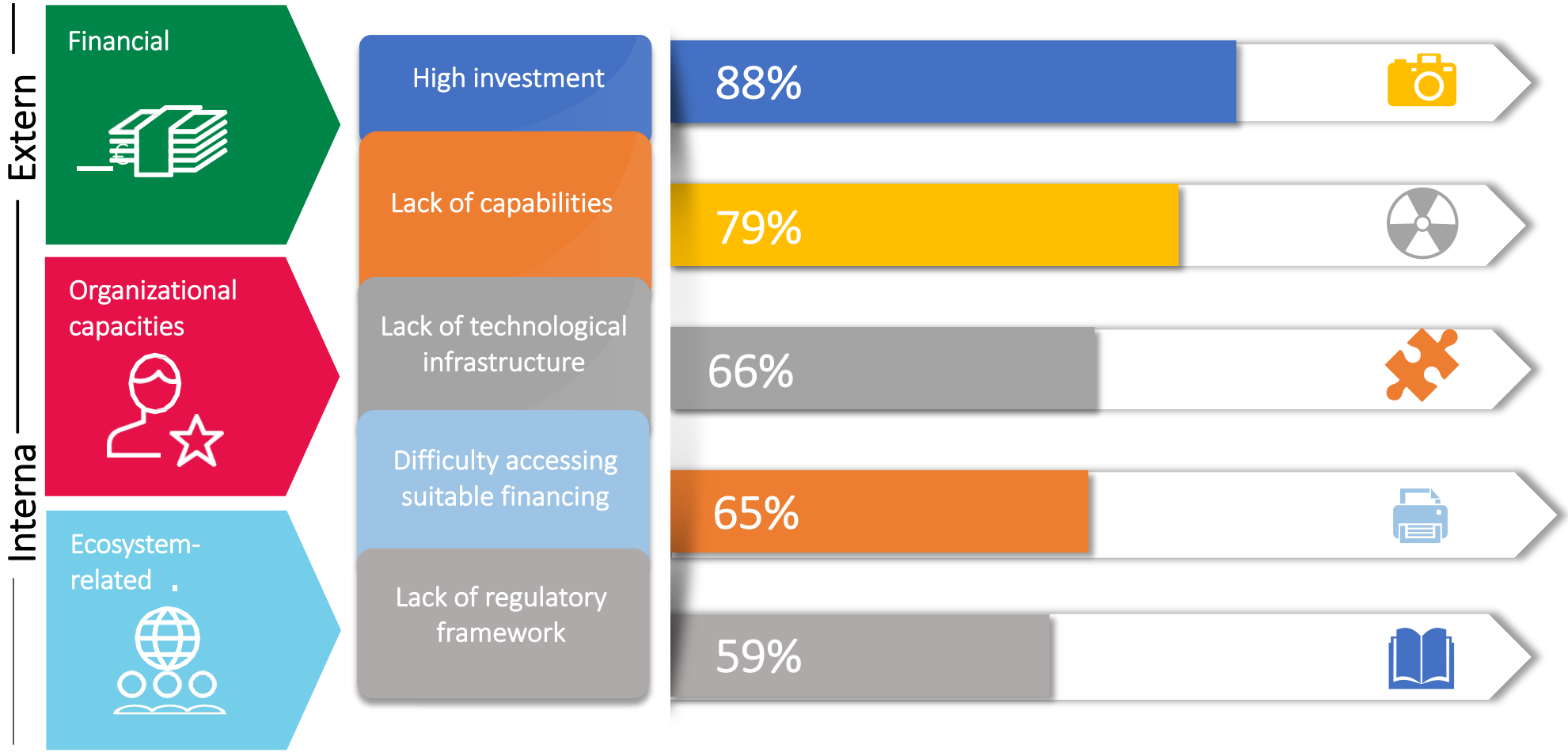
The Top Four How Digitalization Driving Reverse Logistics



The Top Four How Digitalization Driving Green Logistics



The Top Four Barriers of Digitalization



The Impacts of Digitalization

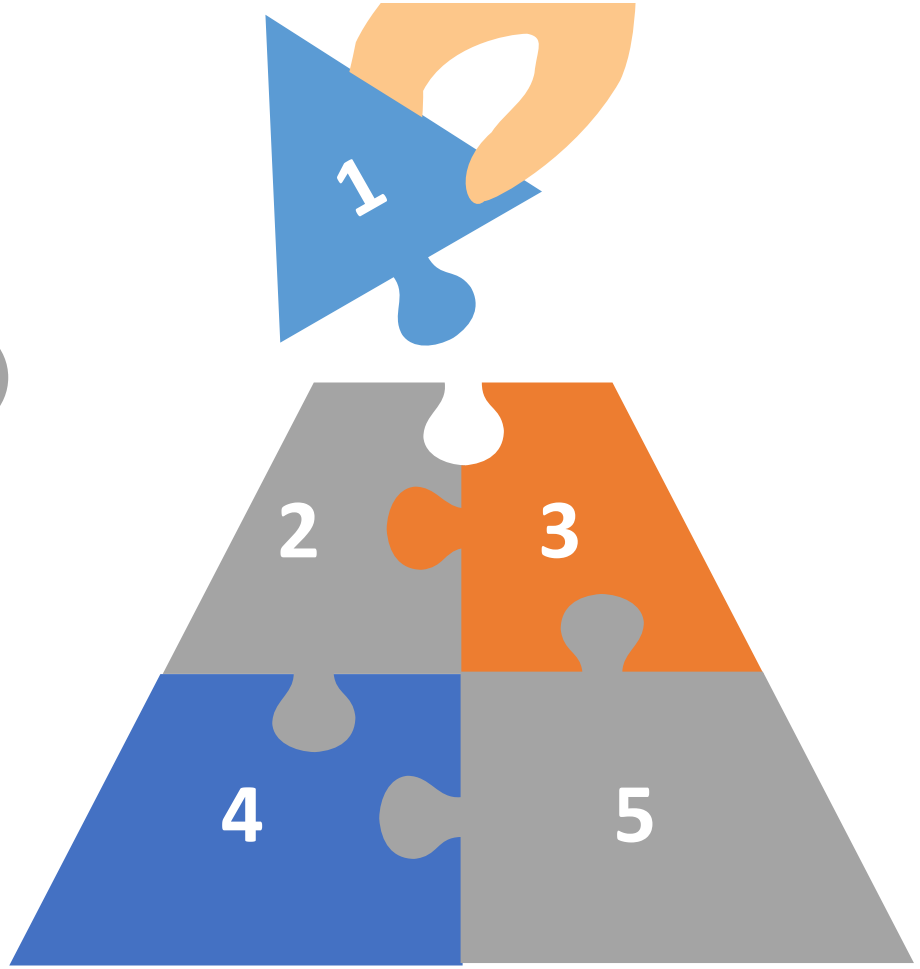
Increase sales 1

Increase market share 2

Increase gross profits 3

Reduce operating expenses 4

Reduce production costs 5



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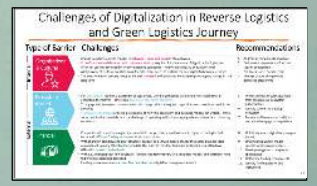
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Way forward enabling digitalization in Reverse Logistics and Green Logistics Initiatives in Malaysia

12 Emerging Opportunities for Digitalizing Reverse Logistics and Green Logistics

1. Alignment with Sustainable production and consumption development

2. Alignment with green economy

3. Concepts of circular economy and sustainable value chains

4. Indicators for digital technologies for decision making in RL and GL

5. Inefficiencies in technology diffusion for opportunities

6. Digital technologies should tackle customers' needs

7. Role of digital technologies

8. Establishment of digital tools and checklist

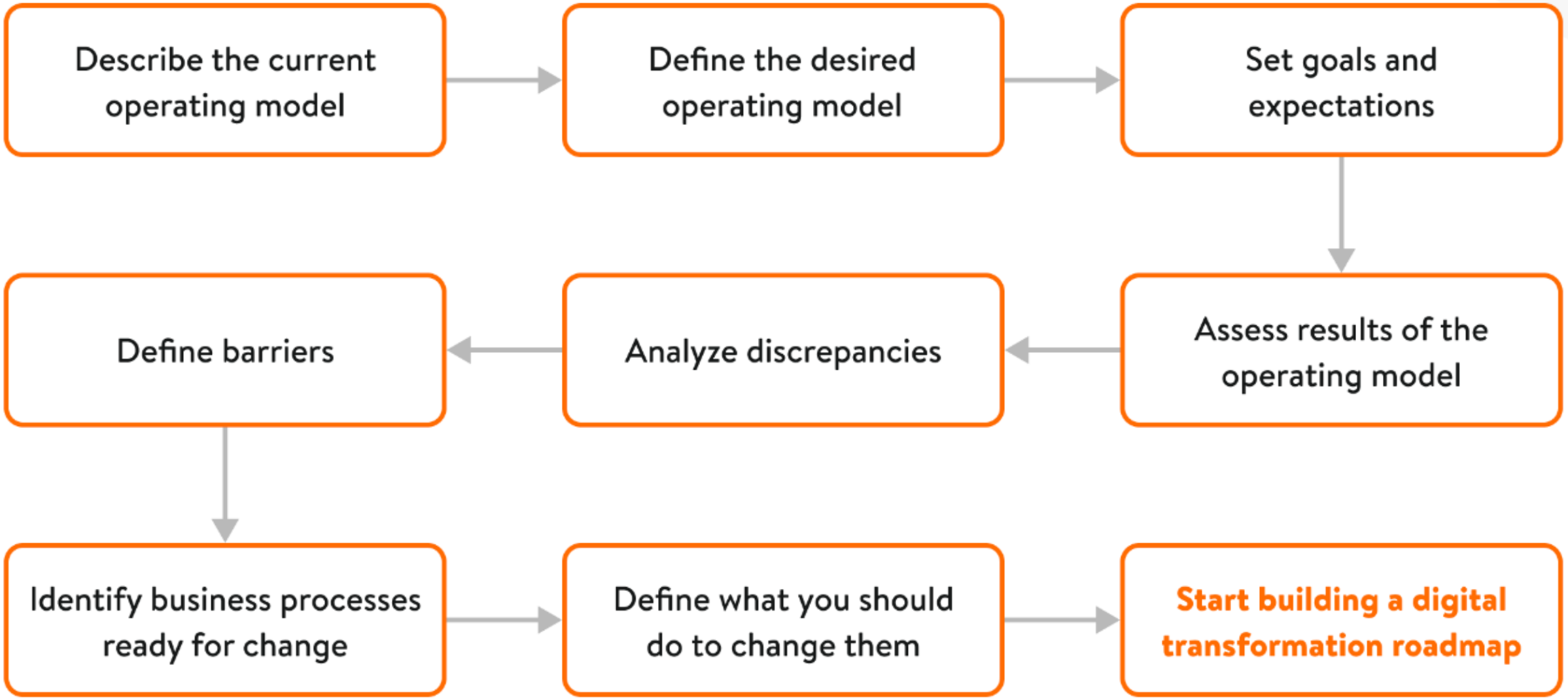
9. Importance of stakeholders culture and wisdom

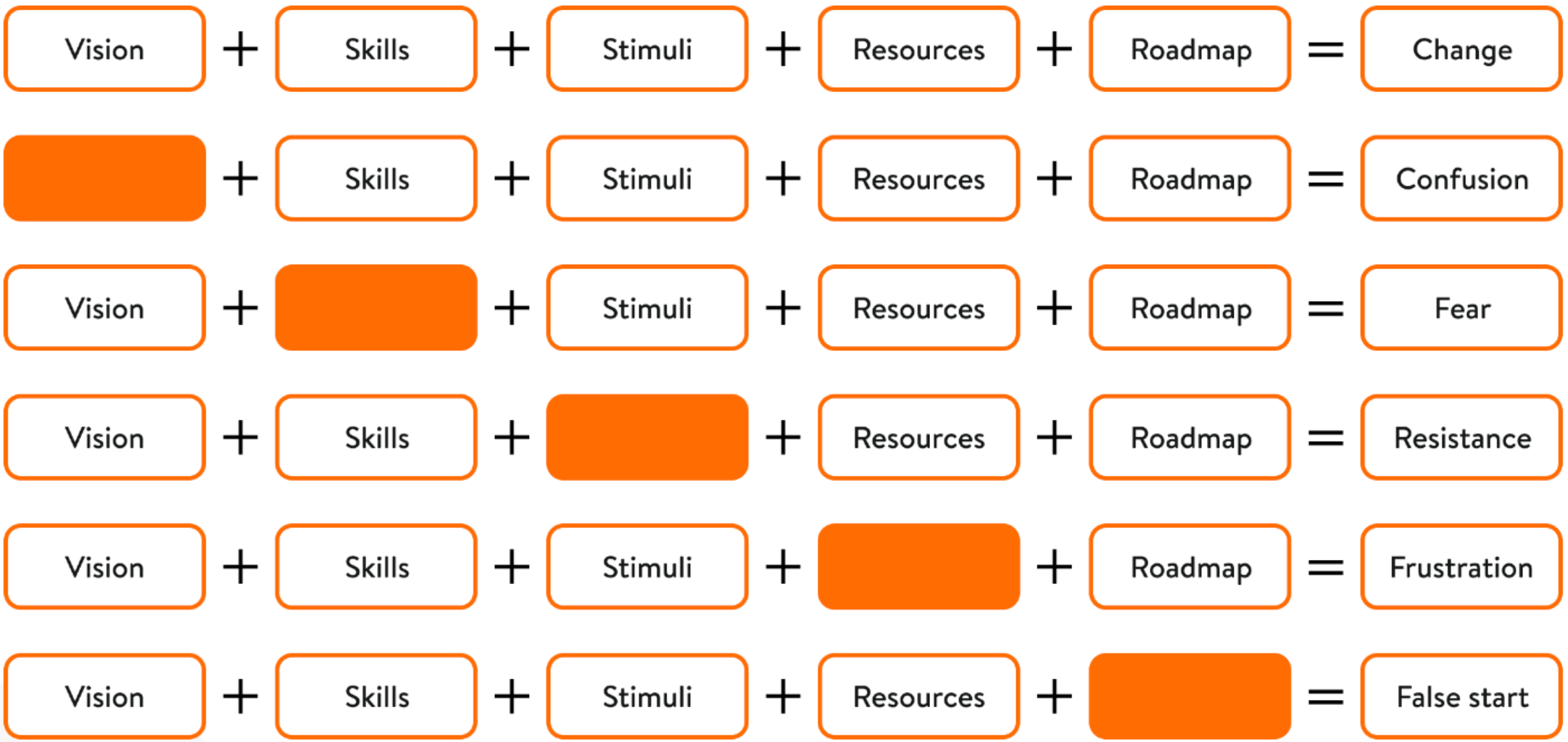
10. RL and GL financing is an important entry point

11. Recognition of implicit rules and regulations for digital applications

12. Collaboration and partnerships is a key to successful implementation

Process of Building a Digital Transformation Landscape




Vision + Skills + Stimuli + Resources + Roadmap = Change
+ Skills + Stimuli + Resources + Roadmap = Confusion
Vision + + Stimuli + Resources + Roadmap = Fear
Vision + Skills + + Resources + Roadmap = Resistance
Vision + Skills + Stimuli + + Roadmap = Frustration
Vision + Skills + Stimuli + Resources + = False start

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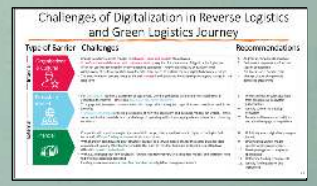
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Way forward enabling digitalization in Reverse Logistics and Green Logistics Initiatives in Malaysia

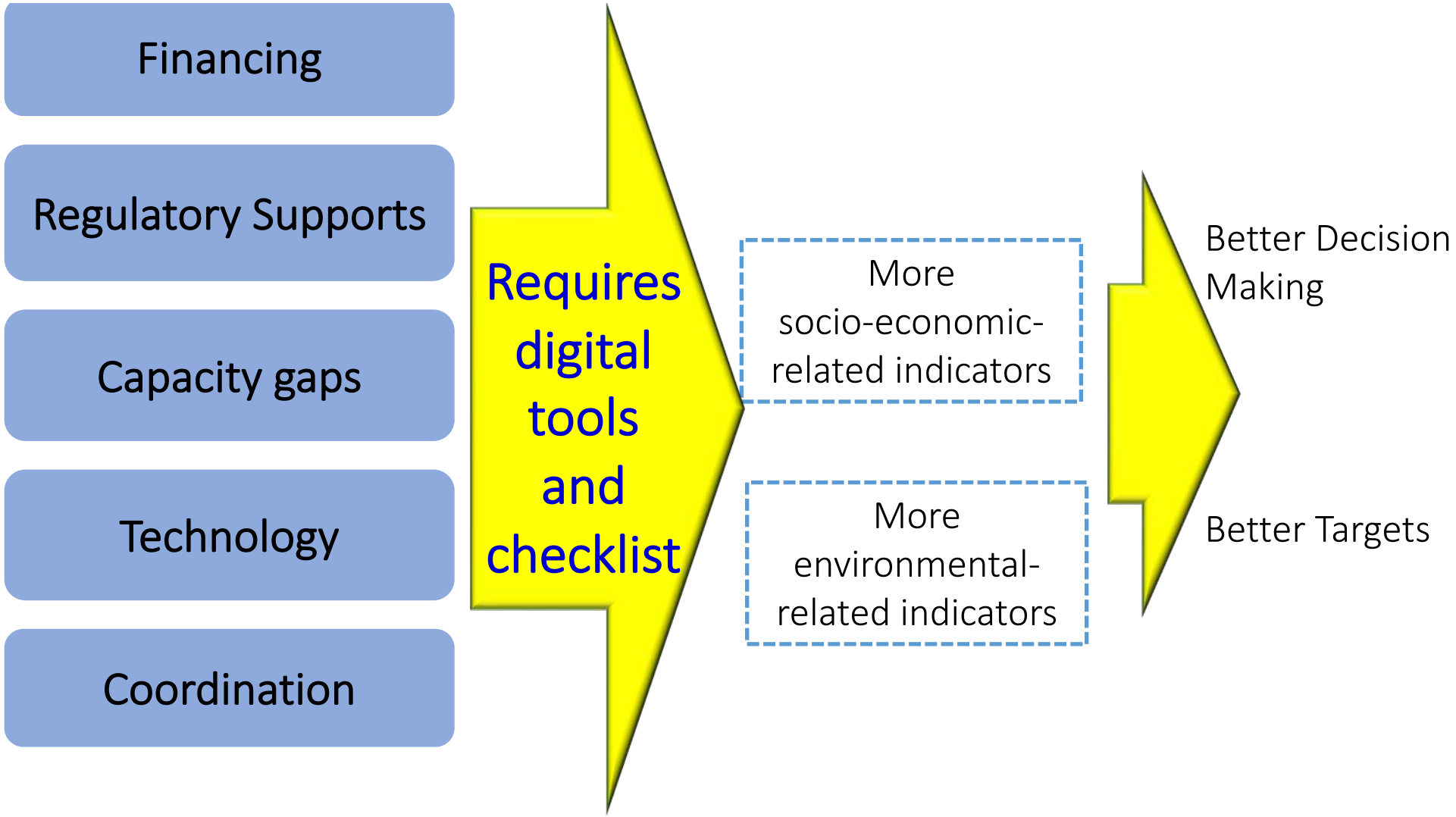
Challenges of Digitalization in Reverse Logistics and Green Logistics Journey

	Type of Barrier	Challenges	Recommendations
Internal	Organisational & Cultural 	• Change in culture requires changes in behaviour, value and mindset of employees • Cross-functional collaboration and customer-centricity required for the culture of digital technologies are often not yet well developed in linearly operating companies – neither on company or function-level • As the owner of customer relationships, the sales team needs to endorse the new digital technologies culture • The transformation process needs to be well managed and embraced by leadership to support change in the long-term	1. Address all components of culture 2. Define company-wide and function - specific components 3. Put special focus on sales team 4. Manage culture change with a dedicated programme
External	Ecosystem-related 	• Full digitalization requires a diverse set of capabilities. Only big companies will be able to establish such an ecosystem themselves – others can develop an ecosystem of partners • To engage with ecosystem partners, actors that can provide the required capabilities and know-how need to be identified • Framework conditions form the prerequisite of how the ecosystem and business models can unfold. While some new business models face the challenge of operating without any legal guidance, others face hindering conditions	5. Understand full circular advantage from collaborative ecosystem opportunities 6. Identify partners to develop ecosystem 7. Be aware of framework conditions and actively engage to shape them
External	Financial 	• Companies with a well running business model do not perceive a need to invest in digital technologies that come with different funding requirements, risks and returns • With change in cash flow and asset structure, product as a service models change the overall business logic as compared to many other business models. This leads to risks that financiers and businesses often have difficulties to assess and mitigate • With e.g., changing cash flow structures, funding requirements vary for all business models, and therefore need to be well assessed and described • Funding sources are scarce, as only few financiers have digital technologies experience	8. Holistically assess digital technologies benefit 9. Understand business model specific funding requirements 10. Develop mitigation strategies for specific risks 11. Determine funding requirements 12. Identify funding partner and instrument

Barriers in Digitalization

	2019	2020	2021
Data in silos	7%	5%	14%
Data in a centralized location	30%	38%	29%
Data shared with some external vendors	26%	15%	20%
Data shared upstream and downstream within organization	31%	36%	35%
Information transparency across entire business ecosystem	6%	6%	2%

Digital Tools and Checklist




THANK YOU

Collaboration of Design Thinking approach with Business Model Canvas for Expertise Product Innovation Design

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ABSTRACT

The creation of an innovative idea can lead to a business process to be developed into a product. For this reason, an innovator who has and develops innovation ideas, must understand the concept of innovation management according to the needs of the organization. It is hoped that the innovations developed into finished products will be able to solve the problems and needs of consumers. In this study, the development of innovative ideas and commercialization of the expertise products of PT Pembangkitan Jawa Bali (PT PJB) was carried out. In developing innovation ideas, the Design Thinking approach is used starting from the empathize, define, ideation, prototype, and test stages. By generating innovation ideas into the Minimum Viable Product (MVP) stage, it can be continued to develop the MVP product into the Minimum Marketable Product (MMP) stage.

The product development stage from MVP to MMP uses the Business Model Canvas (BMC) method so that it can produce a value proposition that is in line with consumer needs (Product-Market Fit). Of course, in creating and developing the value proposition, the BMC method is used which is an iterative process of 9 components starting from the Customer Segment, Value Proposition, Channel, Customer Relations, Revenue Streams, Key Activities, Key Resources, Key Partners and Cost Structure. The results of this MMP product are a complete step in the innovation model cycle which becomes a research process and continues to be developed at PT PJB. The quantitative method used is the Factor Analysis method of BMC components for the development and commercialization of expertise products so that the initial focus is known on the 9 integrated BMC components.

The result of this research is the development of expertise products that use collaborative innovation models starting from the development of innovation ideas, product development at the MVP stage, to the MMP stage. It is hoped that the full cycle of innovation development with product expertise at PT PJB can be a reference for other product lines so as to increase corporate revenue.

Keywords: Innovation Model, Business Model Canvas, Minimum Viable Product, Expertise

1. INTRODUCTION

The flow of the innovation process is not a linear process but an iterative process. This is because the innovation process must be carried out step by step in order to minimize the budget spent and minimize the possibility of loss to the initiator of an innovation. The solution created by an innovator must have the mindset to structure the process pattern from innovation ideas to providing economic benefits for the community. In developing the next innovation idea, the 5-stage approach to the Design Thinking model proposed by the Stanford Hasso-Plattner Design Institute is used, namely: emphatize, define, ideate, prototype, and test (Hasso, 2010). This model is used because it can be a reliable framework for designing something that suits the needs of consumers as users of products developed from these innovative ideas so as to produce MVP products.

According to (Zhu, 2019) in the innovation process flow that is more specific to the development of business ideas, a business development guideline is needed that is carried out in stages, where the goal is to produce business innovation ideas that are worthy of being called MVP. However, it should be noted that the MVP stage is a continuous improvement process, that to create the best MVP requires continuous feedback and research. In addition, there are incubator and accelerator stages that ensure product development from innovation ideas is more perfect.

Incubators and accelerators are an activity of a series of processes for the commercialization of innovative ideas. Incubation is the process of maturation and realization of innovation ideas into a product or service that is ready to be offered to the targeted consumer segment, while acceleration focuses more on the implementation of the commercialization business of the innovation idea with the target of commercialization of innovation ideas taking place effectively and efficiently to provide revenue to PT PJB .

Furthermore, in the incubator and accelerator process, according (Nur Yuniarto, 2022) an evaluation of the feasibility of the business, technology and market will be used in MVP innovation products towards products that have matured or are already at the MMP stage. According to (Levy Franca, 2016) MVP products focus on developing innovative ideas into minimum designs or prototypes that accommodate consumer complaints and desires. Then the product in the MMP stage focuses on the continued development of innovative ideas into products that aim to acquire consumers and the most effective investment costs in product development and return on investment. In developing the product from MVP to MMP, the researcher uses the Business Model Canvas (BMC) method so as to explore 9 components in the BMC to ensure that Product – Market Fit (PFM) occurs. According to (Guertler, 2020) the BMC method will test related to Product - Market Fit, so it is hoped that after the MMP stage, a business model will emerge that is ready to enter the Go To Market (GTM) stage so as to support business growth from these innovative products. According to (Long, 2021) furthermore, it is necessary to continue to pay attention to all inputs from potential consumers and determine the business development strategy to complement the BMC results with business proposals.

Further regarding the BMC method, according to (Hamwi, 2020) the process in the BMC method is an iterative process of 9 components starting from the Customer Segment, Value Proposition, Channel, Customer Relations, Revenue Streams, Key Activities, Key Resources, Key Partners and Cost Structure . In the iteration process, many have used existing perspectives and experience but have not guaranteed that the innovation product created is an actual embodiment of an idea that has benefits so that the execution of a business model can be developed.

In this study, the researcher uses the idea of innovation expertise at PT PJB to become a case study on designing an innovation model so that a full cycle of innovation models is obtained that is able to provide revenue for the company. In addition, it is hoped that the design of the

innovation model can be used to develop innovative ideas for business lines other than expertise at PT PJB. For further research, researchers will conduct analysis and research in designing an innovation model on BMC analysis for business innovation to the MMP product stage at PT PJB using quantitative methods with factor analysis of 9 BMC components that result in focus and integration. In addition to quantitative methods, researchers used a qualitative approach with the Design Thinking method.

2. LITERATURE REVIEW

The Design Thinking method is a creative problem solving method that involves the user in the thinking process and makes the user's perspective the main consideration of the problem solving process (Brown, 2008). Design Thinking is a method for creating value for potential users and the market opportunity as a whole, not just based on appearance and function. The whole system is based on the correspondence between desirability, technological feasibility and viability of business strategy.

This method is a combination of discussion processes, meetings and workshops to innovate new business ideas or previous business models, the aim of which is to produce comprehensive thoughts and strategies. Expected to be able to produce simple processes, fully related, easy to understand and able to answer the needs of complex business models.

According to (Nur Yuniarto, 2022) an innovation business will experience development from time to time in accordance with company goals. To achieve this goal, an innovator needs a roadmap or innovation model that is in accordance with (Torro-Jarin & Estefania Ponce, 2014), as a guide for the development of an innovative business idea that is carried out in stages. The existence of these gradual steps makes it easier for innovators to make strategic mappings that are carried out regularly. According to (Guertler, 2020) the innovation process begins with the discovery process which begins with a problem faced by PT PJB that requires an idea or solution to provide added value for PT PJB.

After the discovery process is completed and produces a design for the previous process iteration, the next step is to create a Minimum Viable Product (MVP) or prototype as the minimum goal. The purpose of making MVP is to help present problem solving ideas with more real illustrations. MVP is more intended to seek opinions from potential consumers who will use the product or service to solve the problems they face. Potential customers allow PT PJB internal parties (for solving internal problems faced by PT PJB) as well as external parties to solve common problems commonly faced by PT PJB, as well as having the potential for adoption by external parties of the company.

Next is the validation process for the MVP stage product so as to test all the assumptions written in the 9 components of the BMC. It is hoped that the result of this process is a business model that is ready to continue the product commercialization of the MVP stage where it must ensure that the front-end and back-end of the BMC are aligned.

According to (Guertler, 2020) the next step is the product development process or making products that are ready to be commercialized (Market Fit Products / PMF). In addition to PMF, products that are ready to be commercialized are called Minimum Marketable Products (MMP). The PMF or MMP generally have only one feature in the early stages that is in accordance with what is desired (pain-point) by consumers. When making an MMP, all factors of production are taken into account, including the supply chain of the product or service. So from this calculation the minimum price for product services can be determined. It can also be seen that the product development process is also a further validation of the BMC business model that has been

prepared previously. So it can be concluded that the BMC business model is the main method used in product development from the MVP stage to the MMP stage.

According to (Nur Yuniarto, 2022) if the innovation has passed the phase of getting consumers who are willing to pay or pass the PMF phase and use the product that has been developed, it can be concluded that the process and product innovation results have succeeded in answering the assumptions of the innovator. The assumption is "is there any consumers who want to use it?", as well as answering the assumption that product and process innovation can generate revenue. For that, the next is the efficiency process to increase organizational growth or start a start-up. From the previous explanation, it is part of a very important stage because this is where the foundation of the product innovation business can be started and is a sign that in this phase a business that generates revenue begins. According to (Ali Latifi & Nikou, 2021) in the early stages of entering the market, business assessment does not lead to how much revenue is earned, but rather focuses on how fast the business resulting from innovation ideas can grow and develop.

According to (Ali Latifi & Nikou, 2021) this phase the innovation business carried out has experienced an upward trend in revenue and has begun to move from the lowest point of the valley of death to the break even point of all the capital that has been spent while developing innovative products. This process is an exponential growth process so that according to (Sort, 2017) a business has succeeded in reaching the growth phase, the business has succeeded in answering the assumption that the innovation business will be profitable and the business processes carried out are correct.

3. METHODS

In this study, the implementation of this qualitative analysis, the researchers used a Design Thinking approach with 5 stages of the process, namely empathize, define, ideation, prototype, and test. With this approach, researchers mostly use technical interviews and discussions with consumer segments or called personas as users who will use product innovations or products at this MVP stage. Furthermore, for the implementation of quantitative analysis, researchers used the BMC method by mapping 9 components of BMC, namely Customer Segment, Value Proposition, Channels, Customer Relations, Revenue Streams, Key Activities, Key Resources, Key Partners and Cost Structure, where researchers conducted a survey on the impact of 9 components. This BMC with product development from the MVP stage to the MMP stage.

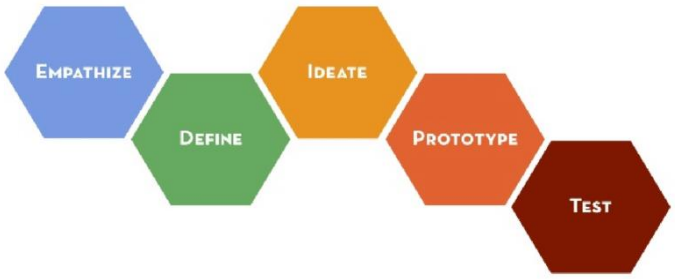


Figure 3.1 Design Thinking five stage model from Hasso-Plattner Institute of Design at Stanford

In this stage, the researcher conducts a further evaluation of the MVP stage Expertise product to validate the BMC business model that has been prepared. The validation technique is through In-Depth Interview or Focus Group Discussion to selected respondents where the opinion of these respondents has a significant impact on the linkage of the 9 components of BMC with the development of Expertise products from the MVP stage to MMP. Researchers have studied

references related to this research so that questions have been prepared that evaluate the relationship between the influence of the Business Model Canvas element on the development of company innovation and the company's business model so as to support research on product development from the MVP to MMP stage of Expertise.

In the stages and methods to be carried out in the research, starting with an overview of the research flow, research design, to the techniques used in processing and analyzing data. This research is a collaborative research between Design Thinking approach (qualitative analysis) with a survey on the BMC method (quantitative analysis) so as to produce an innovation model design. It is hoped that this collaboration will be able to produce research results that can match the needs of the company's innovation management implementation.

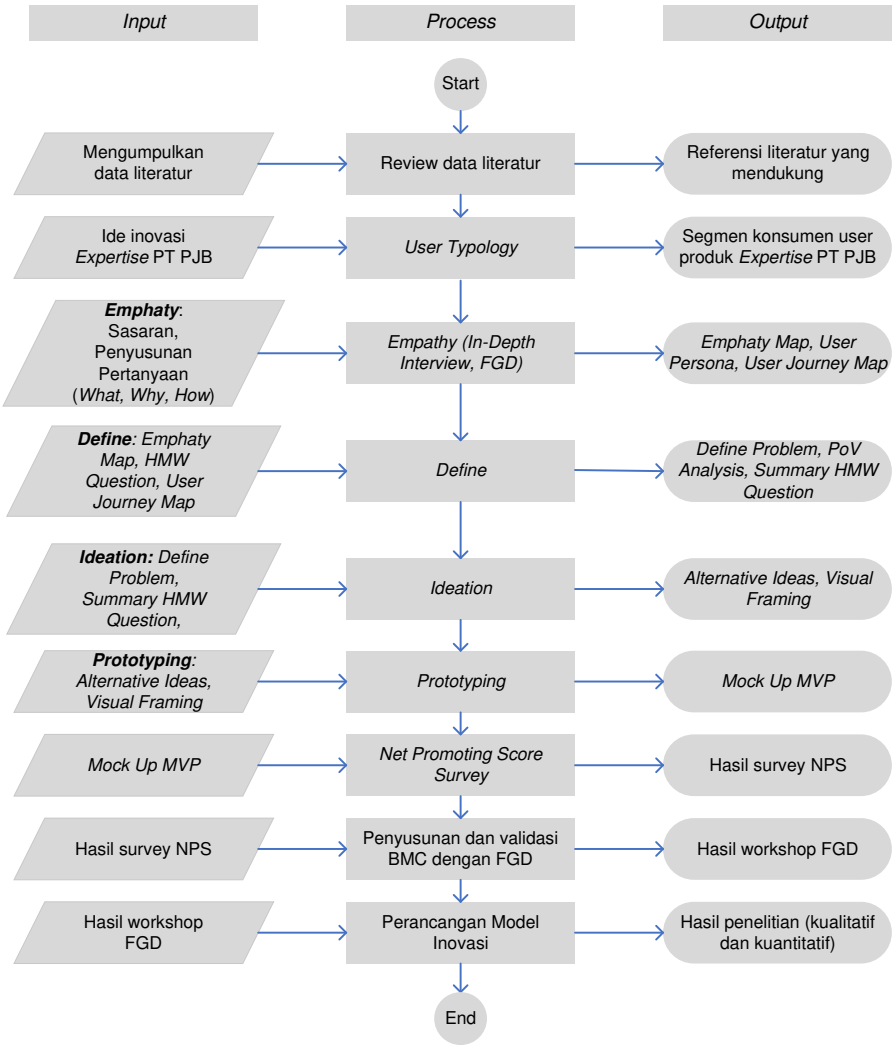


Figure 3.2 Research Methode

4. RESULTS

4.1 Qualitative Stage

Implementation of this qualitative analysis, the researchers used a Design Thinking approach with 5 stages of the process, namely empathize, define, ideation, prototype, and test. With this approach, researchers mostly use technical interviews and discussions with consumer

segments or called personas as users who will use product innovations or products at this MVP stage.

4.1.1 Problem Identification and Interview

Next is the process of developing innovative ideas using the Design Thinking method where the first stage begins with empathy. This stage begins with the identification of stakeholders who have the power and level of influence on the success of developing innovative ideas to become expertise products that sell well in the electricity market. In accordance with the stakeholder map image below, the Key Player quadrant has mapped B2B (Business to Business) consumer stakeholders such as IPP (Independent Power Plant) plant owners, other power generation companies, and PT PLN (Persero). From the focus on the Key Player quadrant stakeholders and the consumer segment of the STP strategy, then interviewed 4 representatives of the persona group with the following names:

1. RAP, is a District Representative of Water company
2. WK, is the Business Manager of the Transportation company
3. AI, is a Mechanical Engineer from the Manufacture company
4. SW, is the operating director of the IPP company

From this empathize process, where the researcher conducted interviews with 4 consumer groups representing the largest consumer segment for the commercialization of PT PJB's expertise products, then focused on the consumer groups for IPP generators as the focus for compiling the User Persona, Enphaty Map, and Customer Journey. Other facts that emerged in the process of this empathy stage include the experience of user persona SW as the operations director of IPP company, in hiring expertise from domestic supply companies. Based on the facts that emerged, it can be concluded as follows:

1. It is difficult to find the services of experts/experts easily and briefly.
2. There is no alternative provider of trusted and integrated expert services.
3. There is no transparent verification of the competence and capability of the available experts.

4.1.2 Define

Then, at the define stage, this research aims to better understand the broad information that has been collected from the empathize stage, then analyzed and synthesized to obtain the core problems faced by users to be identified and followed up. This define stage will be very helpful in solving the user persona problem, which in this study uses the user SW so that the basic pain and gain persona is used in determining the problem determination. The results of this define stage are Point of View and HMW (How Might We) analysis. Then for the list of How Might We (HMW) questions are:

1. How do users get access to complete expert availability data?
2. How do users get experts that match the company's needs?
3. How do users get trusted, flexible, and on-site/remote expert services?
4. How do users monitor the progress of the expert's work so that payments more reliable?

From the results of this define stage, it produces a Point of View (PoV) statement as follows:
"Users need the ease and completeness of access to expert data from the provider so that it can be used according to the company's needs (skills, competencies and experience) because they want the company's problems to be resolved immediately".
Next, the ideate stage will be carried out on the results of the define stage so as to produce a design concept which is the development of innovative ideas for PT PJB's expertise products.

3.1.3 Ideate

After the define stage, the next step is the ideate stage or the development of innovation ideas that are built based on the problems, needs, and desires of the user persona group. Expected to generate and explore ideas to produce solutions. With development to get as many innovation ideas as possible so that they are developed into problem solution ideas in the early stages of the idea phase.

The goal is to capture all or most of the identified innovation ideas into one large innovation idea design that is able to answer all or most of the problems, needs, and desires of the user persona group. This process has been stated in the table above which shows a summary of innovative ideas that deserve further development.

After the development of the innovation idea has been carried out, the next step is to start compiling a Value Proposition Canvas which aims to identify what customer pains, gains, and jobs were for the user persona SW above. By knowing this, it can then be aligned with the gains creator, pain relivers, and what products and services are able to achieve product and market fit (PMF). This PMF condition is to be achieved in the development of further innovation ideas to turn these ideas into products that are at the MVP stage. For this reason, the preparation of the Value Proposition Canvas is critical to work out how to design it to achieve this PMF condition.

In addition, according to the table above, it is a step for researchers to map out aspects of user needs, content requirements, and functional specifications as a further step in developing PT PJB's expertise innovation ideas. In the ideate stage process, it can be concluded that:

1. Development of innovation ideas for expertise products will be based on platforms or digital applications to make it easier for the consumer segment to access and place orders for PT PJB's expertise services.
2. The realization of an expertise product design will use the basis of the results of interviews, empathy maps, user personas, customer journeys, to the results of PoV and HMW analysis, so as to produce MVP stage products that are aligned with the Value Proposition Canvas and achieve Product Market Fit (PMF) conditions.

3.1.4 Prototype

Furthermore, after producing the initial expertise product design, it is necessary to analyze more deeply the realization of the PT PJB expertise product design prototype. So the first step is to explore the concept of PT PJB's expertise service for consumers which is according to the picture below, namely:

1. Customer needs
2. Expected value of expertise services
3. Feature requirement projects
4. Projection of the system to be built

After taking steps to explore the concept of PT PJB's expertise services for consumers, then further explore the aspects of PT PJB's expertise services with platform mechanisms or digital applications, namely:

1. The Ask Expert feature
2. Search Expert feature
3. The Expert Store feature

Once the user information flow has been compiled, the next step is to start designing and making digital prototyping of PT PJB's Expertise product so that the MVP stage product can be developed. With the consideration of using the Expertise product digital platform, it is hoped that it will simplify and accelerate the Expertise product commercialization process where the

willingness of PT PJB's experts is ready and available. According to the image below, there are 4 sets of Expertise product pages at the MVP stage that have been designed. Broadly speaking, the strength of Expertise product is the convenience of consumers to access expert data according to categories, skills, abilities, experiences, awards, and testimonials from previous consumers. With further development, namely making Expertise product a marketplace for experts who feel they have a portfolio of skills and abilities according to their respective categories, they can use this Expertise product media.

3.1.5 Testing

The final stage of the Design Thinking method is testing the MVP or Expertise product stage product to potential customers so that appropriate inputs and solutions are known. It is hoped that the testing and evaluation of Expertise product will provide feedback for further changes and improvements. The method used by the researcher in conducting the Expertise product test uses the Net Promoter Score (NPS) measurement method.

Net promoter score (NPS) is a score whose results reflect consumer loyalty or in research represented by respondents. The NPS score scale is from -100 to 100 or 0 to 5. To get the NPS number, the researcher gives questions to the respondents. The question asked was “on a scale of 0 to 5, how likely would you be to recommend this Expertise product to a friend or colleague?”. Then the results of this question data are processed and the results can be taken into consideration to improve or improve services so that the NPS score can increase. From the explanation of the NPS method above, the researchers then created a Google Form which contains:

1. Questionnaire on Expertise product digital prototype pages and content
2. NPS questions consisting of:
    a. Would you recommend this app to your coworkers, company or friends?
    b. What are the things that are not satisfactory or disappointing when you get information about this application?
    c. What things can we improve on this app?
    d. What features do you like about this app?

3.2 Quantitave Stage

For the quantitative analysis, the researcher used the BMC method by mapping 9 components of BMC, namely Customer Segment, Value Proposition, Channel, Customer Relations, Revenue Streams, Key Activities, Key Resources, Key Partners and Cost Structure, where researchers conducted a survey on the impact of 9 BMC components. This is with product development from the MVP stage to the MMP stage.

3.2.1 Level of implementation of Workshop and FGD

Furthermore, for the implementation of workshops and FGD on the results of the Expertise product product questionnaire at the MVP stage, by further developing it into an MMP stage product using the BMC method. During the implementation of the Expertise product development, the participants were also given a questionnaire related to the BMC method aimed at getting feedback regarding the development of the 9 elements of BMC (Customer Segment, Value Proposition, Channel, Customer Relations, Revenue Streams, Key Activities, Key Resources, Key Partners and Cost Structure). The input obtained will be carried out by factor analysis so that the most important and significant factors are known from each of the 9 BMC elements, which are then used as material for developing Expertise product from the MVP stage to the MMP stage.

The Expertise product MMP product is expected to be feasible for commercialization to the electricity market by PT PJB.

The results obtained from the implementation of the workshop and FGD with the BMC method can be concluded as follows:

1. Aligning the Value Proposition with the Customer Segment so as to achieve Product Market Fit (PMF) conditions. It is concluded that the Customer Segment element has a broad target consumer and is able and willing to pay for Expertise product services (according to the determination of the previous STP strategy). If the VP and CS elements are aligned, which is deeper analyzed with the Value Proposition Canvas so as to be able to achieve Product Market Fit conditions. With PMF conditions, it is expected that Expertise product commercialization will be more optimal.
2. Optimization of backend elements consisting of Key Activities, Key Resources, and Key Partners. The backend element is an internal performance element that fully supports the provision of Expertise product services to consumers so that it is expected to have optimum operational costs. Can be concluded that cooperation with partners is important for successful commercialization of Expertise product to target CS. If the collaboration of these 3 elements is carried out, it can be concluded that this backend element focuses on product design that fits between VP and CS, the rest optimizes partner support and external workforce.
3. Optimizing and upskilling Channel elements. This element focuses on how PT PJB provides Expertise product services to target consumers, where according to the ideation results above, it uses a digital platform for the delivery of this Expertise product service. By using this digital platform, it can be collaborated with Freemium, Subscriptions, and Add-On business patterns. It is intended that PT PJB can provide Expertise product services according to consumer needs.
4. Lean operations to maintain a competitive cost structure and boost product channeling to increase revenue streams. This element can be interpreted as having 2 sides, namely the Cost Structure element which is a measure of PT PJB's operational efficiency in providing Expertise product services, and the Revenue Streams element is the result of income obtained from consumer payments for Expertise product services. It is concluded that revenue projections need to be tested which must ensure the accuracy of Expertise product market intelligence.
5. Maintaining relationships through optimal Customer Relationship relationships. This element is an important complement to the Expertise product business model development cycle from the MVP to MMP stage. In addition, this element can also capture consumer feedback for further improvement of Expertise products. And also this CR element can collaborate with marketing strategies such as the 4Ps, namely Place, Price, Product and Promotion, so that real steps from this element have the ability to meet consumer satisfaction.

3.2.2 The planning stage of the innovation model

After getting the results of the workshop and BMC FGD above, a full cycle of Expertise product innovation idea development has been obtained to become a Expertise product at the MVP stage with the Design Thinking method, and then developed into a Expertise product at the MMP stage through the Business Model Canvas method. In accordance with the writing of the thesis above, the role of incubators and accelerators is needed to ensure that product development from innovation ideas is more perfect. The role of the incubator in the incubation process for innovation

ideas is a process to mature and realize innovation ideas using the Design Thinking method so that they become a product or service that is ready to be offered to the targeted consumer segment, or become a product at the MVP stage. Meanwhile, the role of the accelerator in the process of accelerating product development will focus more on the implementation of the commercialization business model of the innovation idea by using the Business Model Canvas method so as to achieve the target of commercialization of the product resulting from the innovation idea taking place effectively and efficiently to provide revenue to PT PJB.

6. CONCLUSIONS

Furthermore, in the table below is a resume of the conclusions generated by the researchers, namely:

1. MVP product design
   The collaboration of the Design Thinking method with the Business Model Canvas completes the way to design and produce products with the value proposition that customers need (Customer Driven).
1. Testing
   Testing is very important in realizing the Minimum Viable Product (MVP) stage, so getting customer feedback is a higher value.
2. Prototype
   MVP product design does not have to be a physical product but can be digital so that it is faster to be tested on customers and the best iteration of the MVP design is done.
1. Marketing Strategy
   Optimization of commercialization using a digital platform with an omnichannel marketing strategy.

Furthermore, in the table below is a resume of recommendations for further suggestions obtained by researchers for the future, namely:

1. Variables and test criteria
   Further research on product testing in the MVP stage with test measures so as to produce criteria and variable measures that ensure the testing meets customer needs.
2. BMC Variabel Variables and Criteria
   Further research on the Business Model Canvas method which processes product development from MVP to MMP so as to produce what criteria and variables are the measures of success.
3. Variables and criteria for Innovative Accounting
   Further research on the further stages of product commercialization at the MMP stage with variable size Innovative Accounting so that it becomes a guide in commercialization to reach the exponential growth stage.

REFERENCES

Brown, T. (2008). Design Thinking. In *Harvard Business Review.* Harvard Business School Publishing Corporation.

César Levy França, G. B.-H. (2016). An Approach to Business Model Innovation and Design for Strategic Sustainable Development. *Technovation*.

Hasso, P. (2010). *An Introduction to Design Thinking: Process Guide.* Hasso Plattner Institute of Design at Stanford University.

Jesper C. Sort, C. N. (2017). Using the business model canvas to improve investment processes. *Journal of Research in Marketing and Entrepreneurship*.

Matthias Rudolf Guertler, N. S. (2020). Exploring the enabling effects of project management for SMEs in adopting open innovation –A framework for partner search and selection in open innovation projects. *International Journal of Project Management*.

Michael Hamwi, I. L. (2020). Demand response business model canvas: A tool for flexibility creation in the electricity markets. *Journal of Cleaner Production*.

Miguel Angel Toro-Jarrín, I. E.-J.-C. (2014). Methodology for the of building process integration of Business Model Canvas and Technological Roadmap. *Technological Forecasting & Social Change*.

Mohammad-Ali Latifi, S. N. (2021). Business model innovation and firm performance: Exploring causal mechanisms in SMEs. *Technovation*.

Muhammad Nur Yuniarto, I. S. (2022). *Indonesian Electric Motorcycle Development.* IEEE.

Thomas B. Long, A. v. (2021). When bike sharing business models go bad: Incorporating responsibility into business model innovation. *Journal of Cleaner Production*.

Xiaoxuan Zhu, Z. X. (2019). The fit between firms' open innovation and business model for new product development speed: A contingent perspective. *Technovation*.

ANALYSIS ON THE INFLUENCE OF MUSLIM PRESIDENT DIRECTOR TOWARDS THE PROBABILITY OF LISTED COMPANIES USING ISLAMIC FINANCING IN INDONESIA

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ABSTRACT

Aside from the advantages and disadvantages of Islamic financing, the usage of Islamic financing may be related to the personal values of the company's president director and this is supported by upper echelons theory. Personal values may come from religions or beliefs. Study on the preferences of Muslim president directors towards Islamic financing in Indonesia is still relatively rare to be discussed so it is not widely understood by Indonesia's population. Therefore, this study examines the influence of Muslim president director on the probability of Islamic financing's presence in the capital structure based on data from 460 listed companies on the Indonesia Stock Exchange (IDX) in 2020. The relationship between Muslim president director towards the probability of Islamic financing's presence in the capital structure was analyzed through probit model. We find that Muslim president director has a positive and significant effect towards the probability of Islamic financing's presence in the capital structure. Islamic financing has a higher probability to be a part of the company's capital structure when the company is led by a Muslim president director, even higher for listed companies with bigger total assets. This implies that our findings support the upper echelons theory.

Keywords: Muslim president director; Islamic financing; Probit model

1. INTRODUCTION

Based on the World Population Review in 2021, Indonesia is a country with the largest percentage of Muslim population in the world. However, evidence shows that Islamic financing products are still underdeveloped in countries that dominated by Muslim such as Saudi Arabia, Pakistan, Malaysia, and Indonesia (Brahmana & You, 2021). This indicates that countries with large percentage of Muslim population such as Indonesia don't necessarily have a big contribution in supporting the development of Islamic financial or baking industry, including supporting the growth of Islamic financing. Islamic financing can be accessed by issuing loans to Islamic banks. Based on the Islamic banking statistics that published by Financial Services Authority of Indonesia, Otoritas Jasa Keuangan (OJK), the growth rate of Islamic banking in Indonesia is higher than the conventional and national banking industry. It shows that the development of the Islamic-based financial or banking industry has increased by the end of 2020.

Besides using Islamic banking products or services, companies in Indonesia also use Islamic way to gain capital by issuing sharia bonds named sukuk. According to the fatwa issued by Indonesia's National Sharia Council in 2002, sukuk are long-term securities with sharia principles

and consist of sukuk mudharabah and sukuk ijarah. Since the first ever issuance of sukuk in 2001, popularity of sukuk is increasing. Along with the increasing popularity of sukuk, many countries in the world, including non-Muslim countries, are currently competing to become Islamic financial hub in their respective regions. There are 274 outstanding corporate sukuk by the end of 2020 in Indonesia which is increasing from 232 outstanding corporate sukuk in 2019.

Islamic financing offers lower risk and better liquidity (Abdul Halim, How, Verhoeven, & Hassan, 2020). Islamic financing also guarantees halal principal on investing activities, while conventional financing either it's corporate bonds issuance or financing options from conventional financial institutions doesn't hold any religious values on investing activities. However, there are still criticisms regarding Islamic financing in Indonesia. One of them is the cost of Islamic financing that is quite high compared to conventional financing (Suretno & Yusuf, 2021). This indicates that Muslims will not necessarily prefer sharia financing compared to conventional financing due to the disadvantages of sharia financing and this may give sharia financing a tougher competition to beat conventional financing in Indonesia.

Aside from the advantages and disadvantages of Islamic financing, the usage of Islamic financing might be related to personal values owned by the president director of a company which is supported by upper echelons theory and related previous studies. Brahmana and You (2021) find that Muslim CEOs in Malaysia allocate more corporate financing to Islamic financing compared to non-Muslim CEOs, while Muslim stakeholders have no significant effect on Islamic financing. The main leader of the company (a president director or a CEO) has a crucial role in determining the company's activities on behalf of the shareholders. Therefore, if the main leader of the company has knowledge of Islamic values and deeper basic knowledge about Islam, this might influence the final decision of the president director to choose Islamic financing above conventional financing options.

Study on the preferences of Muslim president director towards Islamic financing in Indonesia is still relatively rare to be discussed so it is not widely understood by the Indonesia's population. Therefore, this study aimed to examine the influence of Muslim president director towards the probability of Islamic financing's presence in the capital structure of Indonesia's listed companies. The relationship between Muslim president director towards the probability of Islamic financing's presence in the capital structure of Indonesia's listed companies will be examined through probit model.

2. LITERATURE REVIEW

2.1. Culture and Corporate Behavior

Guiso, Sapienza, and Zingales (2006) define culture as values, beliefs, and social constraints that are owned by an individual that are inherited and relatively unchanged over time even under changing circumstances. Each individual may have a different culture from others, so each individual may have their own perception regarding their decisions in his or her life in accordance with the culture that the individual has. Culture is an important thing that related to corporate finance as decision makers in one company may have different perceptions with decision makers in another company regarding the risks and returns that they are willing to take (Baxamusa & Jalal, 2014). This is supported by the upper echelon theory. According to Hambrick (2018), upper echelon theory explains that leaders and stakeholders in a company may respond to a company's financial decision-making based on their experience, personal values, and personality.

President director in a company has a crucial role in determining the company's activities on behalf of the shareholders so that the religion of the president director may influence company's decisions and behavior. According to Baxamusa and Jalal (2014), religion is one of the most important constituents of culture. Consequently, treating religion separately from culture seems

impossible in practice. Religion consists of beliefs, values, and behavior of a person in accordance with the scriptures, rituals, and instructions of religious officials that make religious teachings are organized and their influences are easier to recognize. This is why Baxamusa and Jalal (2014) didn't identify every element of culture, but depend on differences that can be directly attributed to religious behavior, teachings, and traditions.

2.2. Religion and Corporate's Choice of Financing

According to Mansour and Jlassi (2014), religion may influence company's financial and investment decisions due to the cost of funds. Schoon and Nuri (2012) discussed the prohibition on interest as the cost of funds by three major monotheistic religions in the world consisting of Judaism, Christianity, and Islam. In addition, there is evidence that also shows that Hinduism and Buddhism prohibit taking interest activities (Visser & Macintosh, 1998). In Islam, interest counts as riba so that interest is forbidden in Islamic teachings because riba in interest burdens the borrower side. Moreover, in Christianity interest counts as a sin because it is considered as a desire or intention to get more returns from the lending/financing. The prohibition or restriction of interest rates to some extent in some religions eventually makes various financial instruments pay attention to religious elements. Mudharabah is an example of financial instrument that does not include interest system with those who have excess money lending the money in form of capital to other businesses with profit-sharing agreement (Iqbal & Mirakhor, 2012). Schoon and Nuri (2012) find that prohibition on interest in Judaism, Christianity, and Islam has a direct impact on a company's financial structure or in other words, religion influences a company's financial and investment decisions.

2.3. Hypothesis Development

Upper echelon theory explains that personal values owned by the president director influence how he/she perceives the company's financing situation and impact strategic decisions regarding the choice of financing. Personal values among president directors maybe different depend on his/her own religion or beliefs. Based on the upper echelon theory, then we develop our hypotheses and empirically test the influence of personal values owned by the president director based on his/her own religion on corporate choices towards Islamic financing.

Previous studies have addressed the religion of the president director as the main factor in decision making which it supports the upper echelon theory. Jiang, Jiang, Kim, and Zhang (2015) find that entrepreneurs tend to be risk-avoidance when they own such a high-level religiosity. Moreover, they also find that firm which is established by high-level religiosity entrepreneurs has lower leverage and less fixed assets investment compared to firm which is established by non-religious entrepreneurs. In studies with Islam as religion that being observed, Hooy and Ali (2017) find that Muslim CEO in Malaysia outperformed the non-Muslim in terms of profitability but underperformed for stock returns. This indicates that Muslim CEO has different effect on different firms' performances. Moreover, Alazzani, Wan-Hussin, and Jones (2019) also find that Muslim CEOs are significantly associated with greater disclosure of corporate social responsibility (CSR) information.

Islam, as a moral value, will profoundly focus on halal financing such as the sharia-compliant debts and loans (Oseni & Hassan, 2015). Ahmad (1991) argued that a Muslim CEO has a personal obligation to rely on their moral value based on divine orders and rules. Thus, if a Muslim president director accounts for an ethical and halal choice of financing, he/she will use Islamic financing as the source of financing. Accordingly, we have the main hypothesis that Muslim president director has a positive effect towards the probability of Islamic financing's presence in the capital structure of Indonesia's listed companies.

3. METHODS

3.1. Data Collection and Sample

For the analysis, we were using data from 460 listed companies on the Indonesia Stock Exchange (IDX) in 2020. Data for some variables such as size, revenue growth, non-debt tax shield, cost-effective, asset ratio, and profitability are retrieved from the annual report. Data for Islamic debt financing variable is also observed from the annual report, while religiosity that measured by president director's religion in this study is observed by several methods.

Following the method that being used by Brahmana and You (2021), religiosity in this study is measured by the Islamic religion as religion of the company's president director. Religion is not an information that publicly shared and can be found easily. In this study, we adopt the method that used by Ooi, Setiawan, and Hooy (2021) to identify the religion of president director. The method consists as follows. (1) Identifying the Islamic and also non-Islamic name in the president director's name such as "Muhammad" as the first name and "bin/binti" in the middle name that commonly used by Muslims, "Christian" as a part of the name that commonly used by Christians, Hajj title that commonly used for Muslim after fulfilling Hajj, etc.; (2) Using Google and social media consisting of Facebook, Instagram, and YouTube as sources of information to identify the religion adopted by the president director; (3) Contact the company's contact person or other company representatives on the phone number that stated on the annual report to confirm the president director's religion if methods (1) and (2) don't give any result.

For Islamic debt financing as the response variable, this study used different approaches from Brahmana and You (2021). We specify Islamic debt financing as the presence of Islamic financing as part of the capital structure in a company instead of the ratio of Islamic debt to the total debt of a company. We observed Islamic financing as part of the capital structure in a company from the annual report firm-by firm. As done previously by Brahmana and You (2021), we rely on the information that stated in the "Notes to the financial statement" and take conclusion regarding the presence of Islamic financing as part of the capital structure from it.

3.2. Research Variables

There are eight variables in total that being analyzed in this study. The variables consist of one dummy variable as response variable, one dummy variable as predictor variable, and other six control variables as predictor variables. The list of variables can be seen in Table 1.

Table 1. List of Variables and Definition

Variable	Type of Variable	Definition
IDF	Response Variable	Islamic Debt Financing (IDF) is dummy variable that equals one if the company use Islamic financing as part of the capital structure and equals zero if otherwise.
Muslim PD	Predictor Variable	Muslim PD is a dummy variable that equals one if the company's president director is a Muslim and equals zero if otherwise.
Size	Predictor Variable	Size is the natural logarithmic of the company's total assets which describes the size of the company.
Revenue Growth	Predictor Variable	Revenue Growth is the company's revenue growth rate in 2020 compared to 2019.

Table 1. List of Variables and Definition (Cont.)

Variable	Type of Variable	Definition
Tax Shield	Predictor Variable	Tax Shield is the ratio of dividends paid to the company's total equity.
Cost Effective	Predictor Variable	Cost Effective is the ratio of selling expenses to the company's total revenue.
Asset Ratio	Predictor Variable	Asset Ratio is the ratio of current assets to the total assets of the company.
Profitability	Predictor Variable	Profitability is Return on Assets (ROA) of the company that is calculated as the ratio of net income to total assets of the company.

3.3. Specification of The Baseline Model

We built the estimation model by adopting the baseline model of Brahmana and You (2021). These papers specify a linear regression model with several firm characteristics such as size, revenue growth, non-debt tax shields, cost-effective, asset ratio, and profitability as the significant factors for debt financing. As Brahmana and You (2021), we included religiosity that being measured by president director's religion into the baseline model to examine the relationship between religiosity to Islamic financing.

Two models that have been commonly used in econometric studies with categorical dependent variable are logit model and probit model. According to Long (1997), the use of logit model or probit model is actually a subjective personal choice of researchers. However, if the research uses response variables with three or more categories, then logit is recommended to be used because it is easier to calculate and interpret. In addition, the results of research by Ayunda (2018) which compares the probit model and the logit model with binary response variable has concluded that the probit model is better to use than the logit model when the response variable is binary. Thus, this study will use probit model since the response variable in this study is binary. So, the main hypothesis of this study that Muslim president director has a positive effect towards the probability of Islamic financing's presence in the capital structure of Indonesia's listed companies is examined by model as follows.

$$P_i = F\left(x_i\right) = F\begin{pmatrix} \beta_0 + \beta_1 Muslim_PD_i + \beta_2 Size_i + \beta_3 Revenue_Growth_i + \beta_4 Tax_Shield_i \\ + \beta_5 Cost_Effective_i + \beta_6 Asset_Ratio_i + \beta_7 Profitability_i \end{pmatrix} \quad (1)$$

where i = 1, 2, ..., 460 (total sample) and Pi or $F(x_i)$ is the function of cumulative normal probability that generates the probability of Islamic financing's presence in the capital structure. To make sure that the model is valid to interpret, we also run Likelihood Ratio test to test the significance of parameter coefficients simultaneously, Wald test to test the significance of parameter coefficients individually, calculating Variance Inflation Factor (VIF) to make sure there's no collinearity between predictor variables, calculating the goodness of fit by using Adjusted McFadden's R-Squared, and calculating the model classification accuracy by using Apparent Error Rate (APER).

4. RESULTS

Based on Figure 1, we can see that 25% of 460 listed companies on the Indonesia Stock Exchange (IDX) in 2020 are led by Muslim president directors, while 75% are led by non-Muslim

president directors. This shows that president director in Indonesia in 2020 is dominated by non-Muslims, even though Indonesia is actually a country that dominated by Muslim population. Moreover, Figure 2 shows that there are about 13% of listed companies in Indonesia that use Islamic financing, while around 87% of listed companies in Indonesia still only use conventional financing or bonds to gain capital from outside the company in 2020. This shows that Islamic financing or the issuance of Islamic bonds (sukuk) as an option to get capital from outside the company has not been able to beat conventional financing or bonds in 2020.

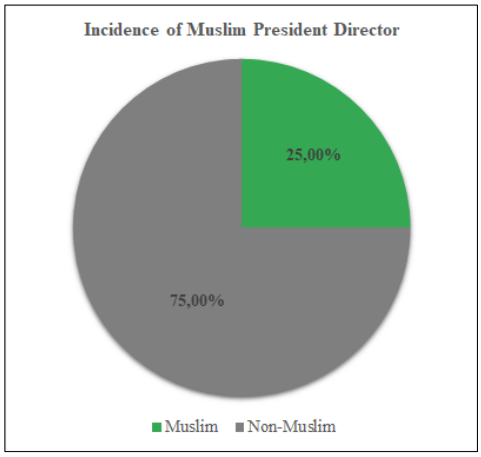


Figure 1. Incidence of Muslim President Director in 2020

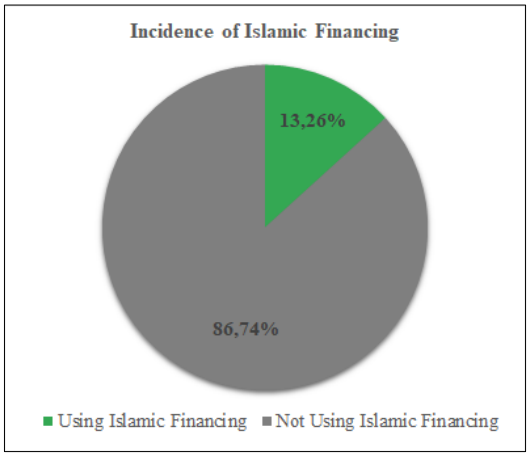


Figure 2. Incidence of Islamic Financing in 2020

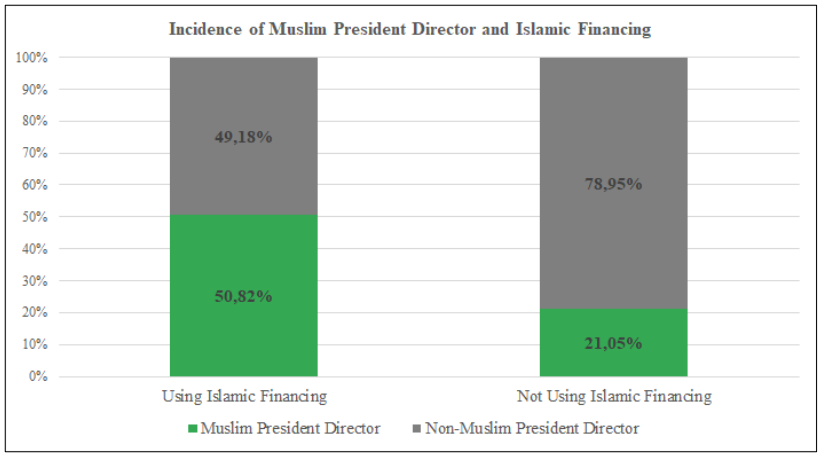


Figure 3. Incidence of Islamic Financing by President Director's Religion in 2020

Next, Figure 3 shows the relatively equal proportion of Muslim president directors and non-Muslim president directors in listed companies that use Islamic financing as a way to get capital from outside the company in 2020. Moreover, we can see listed companies that do not use sharia financing as a way to get capital from outside the company in 2020 is dominated by listed companies that led by non-Muslim president directors. Thus, based on the results of descriptive analysis, we indicate that listed companies tend not to use Islamic financing in Indonesia when led by non-Muslim president directors. This information has strengthened our hypothesis that religiosity may have influence towards the presence of Islamic financing's presence in the capital structure of listed companies in Indonesia. This indication then will be examined through probit model.

The modelling of probit model consists of estimating the parameter coefficients, testing the significance of the parameters simultaneously, and testing the significance of the parameters partially. The parameter coefficients of the probit model were estimated using Maximum Likelihood Estimation (MLE). The estimated parameter coefficients of probit model can be seen in Table 2.

Table 2. The Results of Maximum Likelihood Estimation and Wald Test

Variable		Coefficient	Standard Error	Statistics Wald (W)	p-value
Response	IDF	-4,785	0,804	-5,952	0,000***
Predictor	Muslim CEO	0,711	0,171	4,165	0,000***
	Size	0,246	0,050	4,942	0,000***
	Revenue Growth	0,003	0,108	0,027	0,979
	Tax Shield	-7,126	3,330	-2,140	0,032**
	Cost Effective	-1,392	0,741	-1,878	0,060*
	Asset Ratio	-0,095	0,354	-0,268	0,789
	Profitability	0,027	0,216	0,126	0,900

(Notes: ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively)

After the parameters have been estimated, the significance of the parameters simultaneously was tested with the Likelihood Ratio Test. Testing the significance of the parameters simultaneously is done before we test the significance of the parameters partially because if the parameters are not significance simultaneously, it means that there is no parameter in the model that statistically significant and testing the significance of the parameters partially is not necessary. The results of the Likelihood Ratio Test can be seen in Table 3.

Table 3. The Results of Likelihood Ratio Test

G (Chi-square) Statistics	p-value
64,068	0,000***

Based on Table 3, we can see that the G test statistics has probability value that close to zero which is less than 1%, 5%, and 10% level. Thus, it can be concluded that the parameters of the probit model are significant simultaneously and testing the significance of the parameters partially is necessary. Based on Table 2, it can be seen that by using the significance level of 10%, the parameter coefficients that are significant partially consist of the constant, Muslim president director, natural logarithmic of total assets (size), the ratio of dividends paid to shareholders to total equity (tax shield), and the ratio of selling expenses to company's total revenue (cost effective). Thus, we know that Muslim president director, size, tax shield, and cost effective are predictor variables that significantly influence the probability of Islamic financing's presence in the capital structure of Indonesia's listed companies in 2020. Probit model that has been formed to examine the influence of Muslim president director and other six control variables toward the probability of Islamic financing's presence in the capital structure of Indonesia's listed companies based on estimated parameter coefficients in Table 2 inscribed as follows.

$$P_i = F(x_i) = F\begin{pmatrix} -4,785 + 0,711(Muslim_PD_i) + 0,246(Size_i) + 0,003(Revenue_Growth_i) \\ -7,126(Tax_Shield_i) - 1,392(Cost_Effective_i) - 0,095(Asset_Ratio_i) \\ +0,027(Profitability_i) \end{pmatrix} \quad (2)$$

From the model above, we can see that Muslim president director and the natural logarithm of total assets (size) has a positive influence towards the probability of Islamic financing's presence in the capital structure of Indonesia's listed companies in 2020, while the ratio of dividends paid to shareholders to total equity (tax shield) and the ratio of selling expenses to the company's total revenue (cost effective) has a negative effect. Meanwhile, revenue growth and the ratio of net income to total assets (profitability) also have a positive effect towards the probability of Islamic financing's presence in the capital structure of Indonesia's listed companies in 2020, but the effects are not statistically significant as well as the negative effect of the ratio of current assets to total assets (asset ratio).

Next, we use the probit model and the median value of each predictor variables in the model to calculate the difference in the probability of the presence of Islamic financing as part of the capital structure when the company is led by a Muslim president director compared to when the company is led by a non-Muslim president director.

Table 4. Median of Predictor Variables and Difference in The Probability

Median						President Director	x_i	$F[x_i]$ or P_i
Size	**Revenue Growth**	**Tax Shield**	**Cost Effective**	**Asset Ratio**	**Profitability**			
14,59	-15,19%	0,00%	5,13%	40,52%	0,67%	Muslim	-0,60	27,59%
						Non-Muslim	-1,31	9,58%
Difference in Probability								18,01%

Based on the results that can be seen in Table 4, there is a 18% difference in the probability of the presence of Islamic financing as part of the capital structure when the company is led by a Muslim president director compared to when the company is led by a non-Muslim president director. In other words, if the president director is a Muslim, then Islamic financing has 18% higher probability to be present as part of the capital structure compared to when the company is led by a non-Muslim president director.

We also calculated the Variance Inflation Factor (VIF) to make sure that the there's no multicollinearity in the probit model. All the VIF values are estimated around one which are less than ten as the threshold. Thus, it can be concluded that there is no multicollinearity or any relationship between the predictor variables in the probit model, so that the model is valid. In addition, based on the Adjusted McFadden's R-Squared, the probit model can explain around 13% of the variance regarding the probability of Islamic financing's presence in the capital structure of Indonesia's listed companies in 2020, while around 87% of the variance is explained by other factors that are not being examined in this study. By calculating the Apparent Error Rate (APER), we also find that the probit model can predict the probability of Islamic financing's presence in the capital structure of Indonesia's listed companies with 88% accuracy rate.

6. CONCLUSIONS

Muslim president director has a positive and significant influence on the probability of Islamic financing's presence in the capital structure of Indonesia's listed companies in 2020. Cumulative normal probability function of Islamic financing's presence is higher when the company is led by a Muslim president director compared to when the company was led by a non-Muslim president director. The higher cumulative normal probability function results in a higher probability of Islamic financing's presence in the capital structure of Indonesia's listed companies. Therefore, as one of the personal values owned by an individual, religiosity is one of the factors that can influence the financial decisions taken by the president director of a company. This is consistent with the upper echelon theory that leaders in a company may respond to a company's financial decision-making based on their experience, personal values, and personality and they are related to the religiosity which is measured by the religion that being adopted by each president director who leads the company.

Aside being influenced by the Muslim president director, the probability of Islamic financing's presence in the capital structure of Indonesia's listed companies is also significantly influenced by several other factors. The natural logarithm of total assets (size) has a positive influence on the probability of Islamic financing's presence in the capital structure of Indonesia's listed companies in 2020, while the ratio of dividends paid to shareholders to total equity (tax shield) and the ratio of selling expenses to the company's total revenue (cost effective) has a negative effect. Meanwhile, revenue growth, the ratio of current assets to total assets (asset ratio), and the ratio of net income to total assets (profitability) do not significantly affect the probability of Islamic financing's presence in the capital structure of Indonesia's listed companies in 2020. Thus, it can be concluded that the probability of Islamic financing's presence in the capital structure of Indonesia's listed companies in 2020 will be higher when the company is led by a Muslim president director and even higher for listed companies with bigger total assets.

By using median value of each predictor variables in the model, we find that Islamic financing has about 18% higher probability to be part of the capital structure when the company is led by a Muslim president director. Thus, the influence of Muslim president director towards the usage of Islamic financing by listed companies in Indonesia is not that substantial although the effect is statistically significant. Therefore, Islamic banking institutions, Bank Indonesia, Otoritas Jasa Keuangan (OJK), and other parties that related to the development of Islamic financing in Indonesia are suggested to not only focus to the religion of the company's president director, but also focus to other factors that influence the presence of Islamic financing as part of the company's capital structure in determining the right strategies or the right policies to increase the growth of Islamic financing in Indonesia.

However, the methods that being used in this study to identify the religion of the president director has been done with the best efforts, but they are still likely to give such an inaccurate result or even didn't give any result at all for some listed companies. This limitation made us lost several companies as research sample. Therefore, we hope that future researchers can have a more accurate method for identifying the religion of the president director such as collaborating with Indonesia's Director General of Population and Civil Registration, but maybe this will require a longer time regarding the process and the permits. Future researchers are also expected to be able to conduct this research after the COVID-19 pandemic ends using panel data that includes data for several years because it may provide different results regarding the effect of religiosity towards the probability of Islamic financing's presence in the capital structure of listed companies in Indonesia.

REFERENCES

Abdul Halim, Zairihan, How, Janice, Verhoeven, Peter, & Hassan, M. Kabir. (2020). Asymmetric information and securitization design in Islamic capital markets. Pacific-Basin Finance Journal, 62, 101189.

Ahmad, Sayyid Fayyaz. (1991). The ethical responsibility of business: Islamic principles and implications. Journal of objective studies, 3(1), 23-43.

Alazzani, Absdulsamad, Wan-Hussin, Wan Nordin, & Jones, Michael. (2019). Muslim CEO, women on boards and corporate responsibility reporting: some evidence from Malaysia. Journal of Islamic Accounting and Business Research, 10(2), 274-296.

Ayunda, Pramitya Lisnawaty. (2018). Analisis Perbandingan Regresi Logistik Model Logit dan Probit untuk Menentukan Variabel yang Mempengaruhi Fluktuasi Harga Beras pada Daerah Surplus dan Defisit.

Baxamusa, Mufaddal, & Jalal, Abu. (2014). Does religion affect capital structure? Research in International Business and Finance, 31, 112-131.

Brahmana, Rayenda Khresna, & You, Hui Wei. (2021). Do Muslim CEOs and Muslim stakeholders prefer Islamic debt financing? Global Finance Journal, 100625.

Guiso, Luigi, Sapienza, Paola, & Zingales, Luigi. (2006). Does culture affect economic outcomes? Journal of Economic perspectives, 20(2), 23-48.

Hambrick, Donald C. (2018). Upper Echelons Theory. In Mie Augier & David J. Teece (Eds.), The Palgrave Encyclopedia of Strategic Management (pp. 1782-1785). London: Palgrave Macmillan UK.

Hooy, Chee-Wooi, & Ali, Ruhani. (2017). Does a Muslim CEO matter in Shariah-compliant companies? Evidence from Malaysia. Pacific-Basin Finance Journal, 42, 126-141.

Iqbal, Zamir, & Mirakhor, Abbas. (2012). The Islamic Financial System. In (pp. 113-136).

Jiang, Fuxiu, Jiang, Zhan, Kim, Kenneth A., & Zhang, Min. (2015). Family-firm risk-taking: Does religion matter? Journal of Corporate Finance, 33, 260-278.

Long, J.S. (1997). Regression Models for Categorical and Limited Dependent Variables: Sage Publications.

Mansour, Walid, & Jlassi, Mouna. (2014). The Effect of Religion on Financial and Investing Decisions. In Investor Behavior (pp. 135-151).

Ooi, Chai-Aun, Setiawan, Doddy, & Hooy, Chee-Wooi. (2021). Muslim CEOs and bank risk-taking: Evidence from Indonesia. Global Finance Journal, 50, 100507.

Oseni, Umar A., & Hassan, M. Kabir. (2015). Regulating the governing law clauses in Sukuk transactions. Journal of Banking Regulation, 16(3), 220-249.

Schoon, Natalie, & Nuri, Julinda. (2012). Comparative Financial Systems in Judaism, Christianity and Islam: The Case of Interest. SSRN Electronic Journal.

Suretno, Sujian, & Yusuf, Rivai. (2021). Mahalnya Pembiayaan di Bank Syariah. Ad-Deenar Jurnal Ekonomi dan Bisnis Islam, 5 (02), 179-192.

Visser, Wayne, & Macintosh, Alastair. (1998). A Short Review of the Historical Critique of Usury. Accounting, Business and Financial History, 8, 175-189.

Analysis of Investing Behaviors of Investors with Compulsive Gambling Symptoms

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ABSTRACT

The growing popularity of stock market trading in recent years has attracted numerous investors to try their luck in the financial markets. Some investors use the stock market as a substitute for gambling, which is considered an illegal activity in Indonesia. This study investigates the prevalency of compulsive gamblers in the Indonesian financial markets. We then test how much it affects more frequent and speculative investing behaviours, such as higher stock transaction frequency, and investing in leveraged and other derivative products using logistic regression. Data is gathered in a questionnaire distributed to Indonesian investors, based on a standard diagnostic checklist from the American Psychiatric Association to screen for compulsive gambling behaviour. Investors who classify as compulsive gamblers have a more speculative investing style and transact more frequently, supported by their frequency of trades and investing in leveraged products and derivatives.

Keywords: compulsive gambling, investors, investor behavior

1. INTRODUCTION

In recent times, many investors trade actively in a variety of financial products such as cryptocurrencies, options and stocks even though frequent or overtrading has been shown to result in poor returns overall (Mills, 2019). This can be attributed to investors overestimating their investment skills. Another reason is that investors derive enjoyment from trading actively (Black, 1986). It has also been researched that some investors trade as a substitution for gambling and as a form of entertainment (Gao & Lin, 2015).

This substitution for gambling can be detrimental to the financial well-being of such investors. Specualtion in the financial markets may yield huge returns but also huge losses. A concern of investing as a form of gambling is that it may be problematic or even compulsive for a small subgroup of investors.

It is currently not known if Indonesian investors classified as compulsive gamblers trade more frequently and speculatively compared to other investors, hence why this study is being conducted. This study will employ the American Psychiatric Association (APA) diagnostic checklist and the DOSPERT gambling propensity scale (Markiewicz, 2013) to assess the number of investors showing symptoms of gambling disorders in the market and their propensity to gamble. The researcher will spread a questionnaire to investors in the Indonesian stock market to collect data on their investing behaviour and whether they have compulsive gambling symptoms.

The data will then be used in a logistic regression model to test if investors with compulsive gambling symptoms have more speculative and active investment style.

2. LITERATURE REVIEW

A study by Cox et. al. (2020) showed that a certain group of investors in the stock market exhibit symptoms of compulsive gambling, or trading addiction, based on the American Psychiatric Association's diagnostic checklist. The study found that in a sample of Dutch stock market investors, 4.4% of investors met the criteria to be classified as a compulsive gambler. 3.6% met the criteria for problem gambling, which is a less severe form of gambling disorder.

Gao and Lin (2015) studied lottery jackpots and individual investor trading in Taiwan. Their study found that when a lottery jackpot exceeded 500 million Taiwan dollars, trading volume decreased around 5.2% and 9.1% among stocks favored by individual investors. The study found that big lottery jackpots are associated with fewer options trades by Taiwanese investors.

Kumar (2009) conducted a study which showed that the propensity to gamble and investment decisions are correlated. At the aggregate level, individual investors prefer stocks with lottery features, and like lottery demand, demand for lottery-type stocks increases during economic downturns. These results suggest that lotteries and lottery-type stocks attract individuals with very similar socioeconomic backgrounds.

Dorn and Sengmueller (2009) found that the propensity to gamble and investment decisions among German investors were quite correlated. Investors that reported their motives for investing for the enjoyment of it showed a portfolio turnover rate twice as much as other investors..

3. METHODS

This study uses a causal conclusive research type using quantitative data. All data and information for this study was collected from primary sources through a questionnaire. The population in this study are Indonesian investor that invest in the stock market. The study uses purposive sampling with a sample of students in 299 investors using screening criteria of if they have conducted any investment transactions in the stock market within the last 12 months. This research uses logistic regression model to to determine the effect of several or more than one independent variables (compulsive gambler, gambling propensity, investment motives and various control variables). Results are then interpreted accordingly from the regression.

4. RESULTS

In total, there were 319 people who filled out the questionnaire distributed by the researchers. However, there were 20 respondents who could not continue the research because they did not pass the screening question stage. The screening questions are in the form of questions about whether the respondent is an investor in the Indonesian stock market. So in total there are 299 respondents who took the main test. The respondent's profile can be seen from

various aspects according to the relevance of the research such as gender, age, last education, income, investment experience, stock trading frequency, and investment in derivatives/leveraged products.

Table 1. Respondent's Profile

Category	Group	Amount	%
Age	17 - 19	4	1.3%
	20 - 25	117	39.1%
	26 – 35	**129**	**43.1%**
	36 – 40	21	7.0%
	> 40	28	9.4%
Gender	Male	**157**	**52.5%**
	Female	144	47.5%
Highest education recieved	Highschool	58	19.4%
	Diploma	3	1.0%
	Bachelor's	**193**	**64.6%**
	Masters	44	14.7%
Income	< Rp 5.000.000 per month	101	33.8%
	Rp 5.000.000 - Rp 10.000.000 per month	**135**	**45.2%**
	> Rp 10.000.000 per month	63	21.1%
Investment experience	< 1 year	91	30.4%
	1 – 5 year	**168**	**56.2%**
	> 5 years	40	13.4%
Freuqency of stock transactions	I rarely buy/sell stocks	64	21.4%
	1-10 times/ year	**118**	**39.5%**
	1-10 times / month	80	26.8%

	3-4 times/ week	29	9.7%
	Almost everyday	9	3.0%
Day trading in the last twelve months	**No**	**194**	**64.9%**
	Yes	105	35.1%
Invests in derivatives	**No**	**285**	**95.3%**
	Yes	14	4.7%
Compulsive Gambler (4 or more compulsive gambling symptoms)	**No**	**241**	**80.6%**
	Yes	58	19.4%

Based on Table 1, there are quite similar percentages for female and male respondents in this study. Meanwhile, based on age category, the age group of 26-35 years is the largest group in this study with 43.1% followed by the 36-40 year group with 7.0%, and finally the 17-19 group with 1.3%. The majority of respondents have an income in the range of IDR 5,000,000 - IDR 10,000,000 per month (45.2%), followed by a range of < IDR 5,000,000 per month (33.8%) and followed by a range of > IDR 10,000,000 per month (21.1%). The majority of respondents trade stocks 1-10 times/year (39.5%), followed by 1-10 times/month (26.8%), then rarely sell/buy stocks (21.4%), 3-4 times/week (9.7%) and lastly almost every day (3%). The majority of respondents have investment experience for 1-5 years (56.2%), followed by experience < 1 year (30.4%) and experience > 5 years (13.4%). The majority of respondents (64.9%) did not day trade stocks in the last 12 months and the majority of respondents did not invest in derivatives/leveraged products (95.3%). Then the majority of respondents did not meet the classification criteria for compulsive gamblers (80.6%).

Table 2. Regression Results

Variable		**Coefficient**	***Standard error***	**p-value**
Dependent	**High stock transaction frequency**	-1.92552	0.884934	0.0296 **
Independent	C.gambl	1.05187	0.297055	0.0004 ***

	G.prop	0.970589	0.298699	0.0012 ***
	Inv1	0.231686	0.227240	0.3079
	Inv2	0.381586	0.292677	0.1923
	R.Tol	0.132941	0.0776565	0.0869 *
	Fin.Lit	–0.00880000	0.205680	0.9659
	Inv.Skill	0.0237160	0.230606	0.9181
	Overconf.	0.219270	0.356740	0.5388
	H.Invexp	–0.0143173	0.383014	0.9702
	Age	–0.0367358	0.0175284	0.0361 **
	Male	0.192877	0.237805	0.4173
	Masters	0.917094	0.358455	0.0105 **
	L.Income	0.0349103	0.290405	0.9043
	H.Income	0.692776	0.326945	0.0341 **
Variable		**Coefficient**	***Standard error***	**p-value**
Dependent	**Invests in derivatives**	–4.39633	1.28698	0.0006 ***

Independent	C.gambl	1.92252	0.558305	0.0006 ***
	G.prop	0.465225	0.523221	0.3739
	Inv1	1.33654	0.504523	0.0081 ***
	Inv2	0.338326	0.541833	0.5324
	R.Tol	–0.0158199	0.147382	0.9145
	Fin.Lit	–0.261473	0.330541	0.4289
	Inv.Skill	–0.197594	0.406596	0.6270
	Overconf.	–0.384455	0.588877	0.5138
	H.Invexp	0.761948	0.692450	0.2712
	Age	0.0736574	0.0266153	0.0056 ***
	Male	–0.136572	0.447368	0.7602
	Masters	0.616682	0.693954	0.3742
	L.Income	0.0685857	0.513380	0.8937
	H.Income	–0.695157	0.746459	0.3517

4.1 Effect of Compulsive Gambler Classification on High Stock Transaction Frequency and Investing in Derivatives

The compulsive gambler classification has a positive and significant influence on high stock transaction frequency. When investors are classified as compulsive gamblers, there is a difference in the cumulative normal probability function for investors having a high stock transaction frequency of around 1.05 compared to when investors are not classified as compulsive gamblers. A larger cumulative normal probability function will lead to the possibility of investors having a high frequency of stock transactions. Thus, it can be concluded that the results of this study support the literature from the American Psychiatric Association which states that compulsive gamblers have an irresistible urge to place bets, regardless of the losses and other negative consequences that gambling activities cause in their lives.

The compulsive gambler classification has a positive and significant impact on the activity of investing in derivatives/leveraged products. When investors are classified as compulsive gamblers, there is a difference in the cumulative normal opportunity function for derivative investments/leveraged products of about 1.92 compared to when investors are not classified as compulsive gamblers. A larger cumulative normal chance function will lead to the possibility of investors investing in leveraged derivatives/products.

4.2 Effect of Gambling Propensity on High Stock Transaction Frequency and Investing in Derivatives

Gambling propensity has a positive and significant influence on the high frequency of stock transactions. Each increase of one unit of gambling propensity will increase the cumulative normal probability function for the possibility of investor having a high frequency of stock transactions by 0.97. A larger cumulative normal chance function will lead to the possibility of investors having a high frequency of stock transactions.

Gambling propensity has a positive and insignificant effect on derivative investment activities/leveraged products. Each increase of one unit of G.prop will increase the cumulative normal probability function of the possibility of derivative investment activity by 0.46 units. A larger cumulative normal probability function will lead to the possibility of investors investing in leveraged derivatives/products

4.3 Effect of Investor Motives on High Stock Transaction Frequency and Investing in Derivatives

The investment motive for challenge has a a positive and insignificant effect on the high frequency of stock transactions. Each increase of one unit of Inv1 will increase the cumulative normal opportunity function for investors having a high stock transaction frequency by 0.23. A larger cumulative normal chance function will lead to the possibility of investors having a high frequency of stock transactions. These results are in accordance with research from Grinblatt and Keloharju (2009) which found that thrill/challenge-seeking investors tend to trade stocks more frequently.

The investment motive to become rich has an insignificant effect on the high frequency of stock transactions. Each increase of one unit of Inv2 will increase the cumulative normal opportunity function for the possibility investors haing a high frequency of stock transactions by 0.38. A larger cumulative normal chance function will lead to the possibility of investors doing day trading and having a high frequency of stock transactions. These results are consistent with

research from Dorn and Sengmuller (2009) which found that investors may also actively trade stocks to pursue small opportunities to get rich, similar to lottery players.

The investment motive for challenge has a positive and significant impact on the activity of investing in derivatives/leveraged products. Each increase of one unit of Inv1 will increase the cumulative normal probability function of the possibility of derivative investment activity by 1.33 units.

The investment motive to become rich has a positive and insignificant effect on the activity of investing in derivatives/leveraged products. Each increase of one unit of Inv2 will increase the cumulative normal probability function of the possibility of derivative investment activity by 0.33 units. A larger cumulative normal chance function will lead to the possibility of investors investing in leveraged derivatives/products.

4.4 Effect of Control Variables on High Stock Transaction Frequency and Investing in Derivatives

Risk tolerance has a positive and significant effect on investors having a high frequency of stock transactions. Age has a negative and significant effect on investors having a high frequency of stock transactions. Each increase of one unit of R.Tol will increase the cumulative normal probability function for the possibility of having a high stock transaction frequency by 0.13 . Each increase of one unit of age will decrease the cumulative normal probability function for the possibility of having a high stock transaction frequency by 0.04. A larger cumulative normal opportunity function will lead to the possibility of investors having a high frequency of stock transactions.

Age has a positive and significant effect on investing in derivatives/leveraged products. Each increase of one unit of age will increase the cumulative normal probability function of the probability of investing in derivatives by 0.03. A larger cumulative normal opportunity function will lead to the possibility of investors investing in leveraged derivatives/products.

5. CONCLUSIONS

Our results reveal that 19.4% of a representative sample of Indonesian investors classify as compulsive gamblers based on APA criteria. Our data also reveals that most investors trade stocks less than 10 times a year, and do not invest in derivatives or leveraged products. The results of the regression show that the classification of compulsive gamblers has a positive and significant effect on the activities of active and speculative investors. Gambling propensity has a positive but not significant effect. The challenge investment motive has a positive and insignificant effect on the high frequency of stock transactions, but has a positive and significant effect on the activity of investing in derivatives/leveraged products. The investment motive to become rich has a positive and insignificant effect on the high frequency of stock transactions and investments in derivatives/leveraged products. Logistic regression modeling shows that there is a strong relationship between investors with classified as compulsive gamblers with active and speculative investing activities. Among the control variables, the possibility of investors having a high frequency of stock transactions and investing in derivatives is significantly influenced by several other factors. Risk tolerance, education and high income have a positive influence on the possibility of high stock transaction frequency and age has a negative effect. The age of the

investor has a significant and positive effect on the possibility of investors investing in derivatives/leveraged products.

REFERENCES

American Psychiatric Association, 2013. Diagnostic and Statistical Manual of Mental Disorders (DSM-5). American Psychiatric Publishing, Washington, DC.

Black, F. (1986). Noise. Journal of Finance, 41(3), 528-543.

Cox, R., Kamolsareeratana, A., & Kouwenberg, R. (2020). Compulsive gambling in the financial markets: Evidence from two investor surveys. Journal of Banking and Finance, 111.

Dorn, D., & Sengmueller, P. (2009). Trading as Entertainment?, 55(4), 591–603.

Gao, X., & Lin, T. C. (2015). Do Individual Investors Treat Trading as a Fun and Exciting Gambling Activity? Evidence from Repeated Natural Experiments. The Review of Financial Studies, 28(7), 2128–2166.

Kumar, A. (2009). Who Gambles in the Stock Market? The Journal of Finance, 64(4), 1889–1933.

Markiewicz, Ł., & Weber, E. U. (2013). DOSPERT's Gambling Risk-Taking Propensity Scale Predicts Excessive Stock Trading.

Mills, D. J., & Nower, L. (2019). Preliminary findings on cryptocurrency trading among regular gamblers: A new risk for problem gambling? Addictive Behaviours, 92, 136–140.

ALTERNATIVE DESIGN SELECTION 150 KV TRANSMISSION LINE *HOLTEKAM – ANGKASA* PAPUA WITH MCDM TOPSIS METHOD APPROACH

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ABSTRACT

Mostly, the evacuation of 150 kV (High Voltage) electricity in Indonesia is carried out by transmission with the type of High Voltage Overhead Line (SUTT) considering the type of simple construction and technology in common. The government's target in accordance with the Electricity Supply Business Plan (RUPTL) 2021-2030 is the *Holtekam – Angkasa* Papua transmission line which is targeted for completion in 2022 with three types of transmission design options, namely High Voltage Overhead Line (SUTT), High Voltage Underground Cable Line (SKTT) and High Voltage Marine Cable (SKLTT). The cheapest cost is not always be the final solution because PLN has many of experience when constructing SUTT in the Papua area, many problems arise resulting in design changes during the construction and other social problems as inhibiting factors and delays of time. Based on these things, empirical research using the TOPSIS method is needed to analyze the most appropriate alternative design decisions. The result of the research is SUTT as the recommended decision. But considering the sensitivity analysis, the weight of preference factor has a significant role to affect the decision. So if it's deemed necessary, this can be developed in the next comprehensive research.

Keywords: TOPSIS, OHL, UGC, Submarine, MCDM.

1. INTRODUCTION

PT PLN (Persero) is one of the state-owned companies that holds a Business License for the Provision of Electricity for the public interest or the benefit of the wider community (Haraguchi, Miyano, & Nakamura, 2021), (Ibraheem, 2020), which is obliged to provide electricity continuously in sufficient quantities with good quality and reliability (Jayapriya, Monica, Nathiya, A., & Sowmiya, 2017), (Zohuri & P. McDaniel, 2019). The availability of electricity is one of the important needs in creating economic growth to achieve community welfare (Nkalo & Agwu, 2019). The Government of the Republic of Indonesia has launched the 35-thousand-Megawatt (MW) program, which is stipulated through Presidential Regulation No. 4 of 2016 concerning the Acceleration of Electricity Infrastructure Development (Aigboviosa, Idiake, Nkordeh, Ehimen, & Victory, 2018), in which PT Perusahaan Listrik Negara (Persero) (PLN) was appointed as the executor of electricity infrastructure development in the program. To support government programs, especially in the Papua region, the targeted projects are handled by UIP Papua by the RUPTL 2021-2030 program (Kementerian Energi dan Sumber Daya Mineral

Republik Indonesia, 2021), namely a total generating capacity of 431.4 MW, Substations of 781,8 MW and a transmission length of 1,132 KMS. From this target, a transmission project plan for power evacuation (Garg & Ghatak, 2020), (Nirwan, Shah, Shah, & Velani, 2018) from the Holtekam power plant site to the Angkasa area targeted for 2022

2. LITERATURE REVIEW

According to the historical experience of the high-voltage overhead line transmission (SUTT) project contract carried out in Papua, the SUTT transmission line with a distance of 10-15 km route has a planned completion time of 365 calendar days (1 year). However, there are many non-technical factors during the execution of the work, from the detailed design process to the construction process in the field, which causes this project to be late for completion. Therefore, the Holtekam-Angkasa Papua Transmission Line needs further research related to a more effective design (Fahad & Chillab, 2020), especially concerning maintenance issues when it is successfully established and used (Piana, Bignucolo, Donini, & Spezie, 2018). Considering that in the RUPTL, three alternative designs can be used so that the power evacuation plan that has been planned to operate in 2022 can be in line with expectations.

The location of a power center is in a special area so as not to disturb the environment and reduce the social aspect of the local population (BICEN, 2019) (Nawaz & Khan, 2016). The flow of electrical power that tends to be around the power center is carried out using special distribution lines at the medium voltage and then transformed to low voltage to be further distributed to the electricity user community through existing substations. However, load centers (power users) who are far from the power plant location with long distances with large power evacuations tend to use high-voltage power transmission lines (Unni & Soumya, 2016) to evacuate power from the power center to the load center through the system of the substations so that the evacuated power does not experience a voltage drop or loses so that the electric current in the load center is in a reliable state. According to Budiyanto (2018) the types of voltage in Indonesia are divided based on the voltage criteria into Very Low Voltage / LV (50 volts - 1000 volts / 1 KV volts), Medium Voltage / MV (1 kV-36KV), High Voltage / HV (36 kV -150 kV), Extra High Voltage / HEV (150 kV-750 kV), and Ultra High Voltage / HUV (range above 750 kV).

To reduce the decrease in voltage quality and power loss along the transmission line, high voltage is used in the distribution of electrical energy (Arismunandar, 2001, Jurnal Surya Energy Vol 3 2019). Based on this, in terms of evacuating high-voltage electric power from the generator to the location of the substation or load center, several types of transmission can be carried out, such as 1. High Voltage Overhead Line (SUTT), 2. High Voltage Underground Line (SKTT), 3. High Voltage Marine Cable Channels (SKLTT). All three have their own advantages and disadvantages, both in terms of usage, operational costs, and others such as :

a. High Voltage Overhead Line (SUTT/OHL)
   This type of transmission by using a conductor cable that is stretched between the poles to the poles (tower) through insulators with high-voltage systems (30 kV, 70 kV, 150 kV) (National Symposium RAPI XII-2013 FT UMS) (Setayeshgar, 2016). High Voltage Over Head Lines Transmission are currently the most commonly used and most widely used type of transmission in Indonesia for the evacuation of electrical power from generators or from one substation to another substation to the load center. All materials for this type of transmission can generally be easily found in Indonesia, so the main materials used, such as tower materials and conductor materials, are not the main problem in carrying out their work

b. High Voltage Underground Line (SKTT/UGC)
   This type of transmission by using cables that are stretched in the ground with certain methods, either by drilling in the ground (HDD) or by digging the soil like drainage (open trench) (Public Service Commission of Wisconsin, 2016). In today's era SKTT with XLPE (Cross-Linked Polyethylene) cable is an attractive choice for transmission lines located in densely populated areas or urban areas in terms of aesthetics. Unlike the Air Duct, this SKTT is covered with insulation that can withstand temperatures up to 90 degrees Celsius. When placed at temperatures above 90 degrees this cable will experience accelerated damage (B Kukharchuck IOP material Science & Engineering 2018). So that in its application a detailed survey must be carried out for the existing media or soil conditions [20]. The planning and implementation of this SKTT must comply with Ministerial Regulation Number 10 of 2021 concerning Electricity Safety and SPLN.
c. High Voltage Marine Cable Channels (SKLTT/Marine Cable)
   This type of transmission used to transmit electrical power with low voltage or high voltage from a generator to the load center by laying submarine cables on the seabed (Umeda et al., 2007). The use of High Voltage Marine Cable Channels (SKLTT) is also widely used to transmit electricity from Offshore Wind Power Plants to the mainland or the nearest load center or also used in an interconnection system. The selection of the type of cable in accordance with the characteristics of the local seawater will affect the quality of the evacuation of electric power and affect the power losses that occur so the parameters of this cable must be evaluated properly in order to function properly.

Based on the Feasibility Study by consultant (PLN E) The route of each alternative which are use for analysis can be seen from figure 1 as follows :

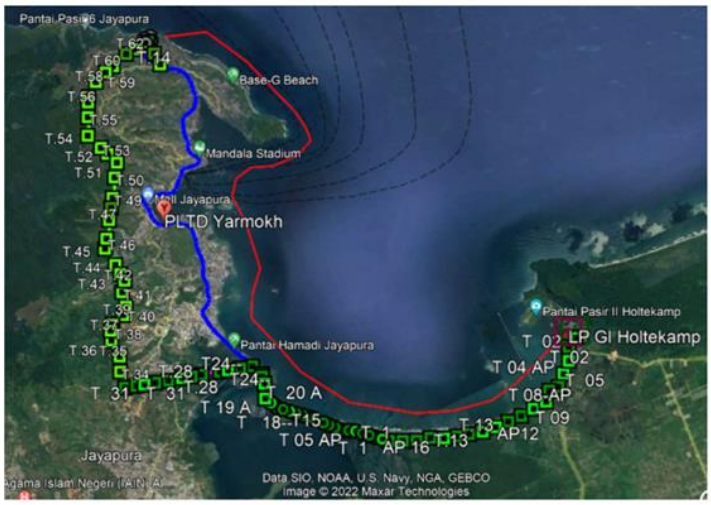


Figure 1 Alternative Route Based on Design Plan

3. METHODS

This study uses the concept of quantitative analysis using feasibility study data (Masanja, 2020)(PLN E 2020) published by the expert consultant of PLN Engineering. At the beginning of the study, the author will collect a list of core parameters and attributes obtained from each design option (Ciptomulyono, U 2010) starting from the High Voltage Overhead Line (SUTT), High Voltage Underground Channel (SKTT), and High Voltage Marine Cable Channel (SKLTT) then modelled in the form measurements for each of the design parameters. The measurement results obtained from the results of each alternative will become a measurable criterion and have a value that will be used for further modelling as a composing decision matrix criterion (Ciptomulyono, U

2010). To determine the preference scale for the criteria, a questionnaire survey will be conducted to determine the data for the appropriate preference weight for each criterion in each alternative design.

In primary data collection, it was carried out by conducting focused group discussions (O.Nyumba, Wilson, Derrick, & Mukherjee, 2018) with consultants or practitioners who are considered experts as outlined in the form of Minutes of Technical Discussion Meetings relating to the discussion of alternative choices in this design. Questionnaire survey data was also carried out regarding analysis based on practitioners who are considered experts (Ponto, 2015) to find a comparison scale and preference weights. For secondary data collection, this study uses data such as data transmission route plans for the three design alternatives (SUTT/SKTT/SKLTT) which consist of technical analysis & specification data, construction cost estimate data, work schedule data for the duration of the implementation plan, risk analysis data for the three design alternatives according to PLN E Feasibility Study Document. Next, an empirical approach will be carried out on the results of the criteria as they are which can be used as a decision matrix. So that the decisions obtained can be more precise, the author will use the TOPSIS method (Zulqarnain, Saeed, Ahmad, Dayan, & Ahmad, 2020).

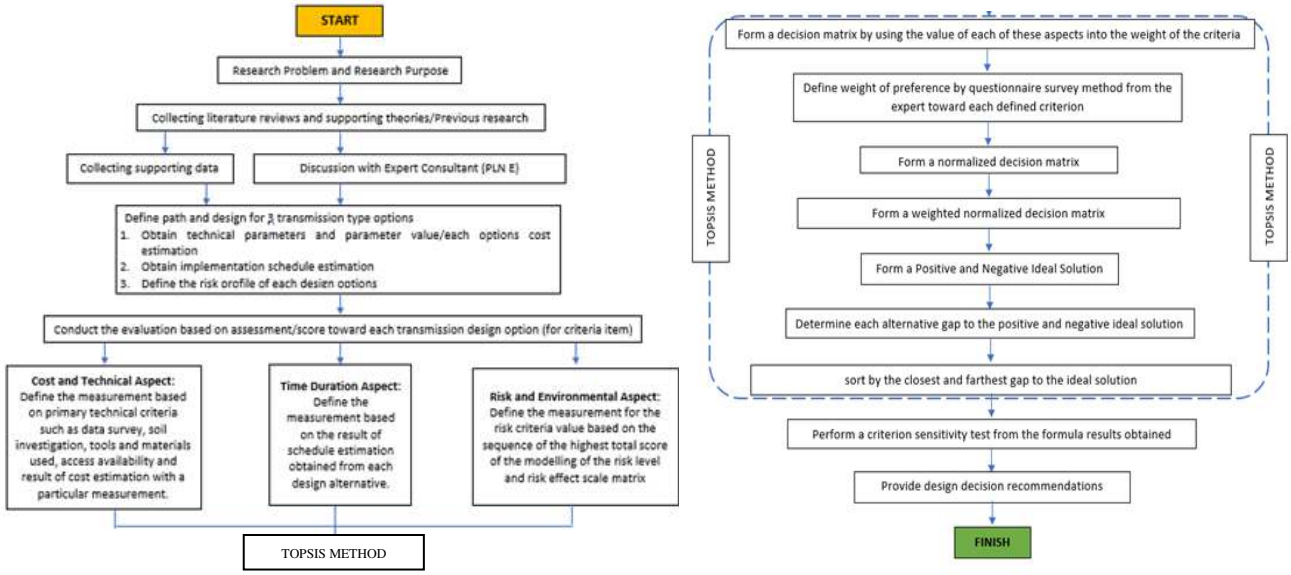


Figure 2 Solution Framework Flowchart

4. RESULTS

From the description above (figure 2) the main points of criteria for each design can be seen in the following Table 1 as criteria data that will be used in the next stage (Decision Design Stage).

Table 1. Recap of Criteria Results for each Alternative

Criteria Description	Criteria		Category	Result						
				SUTT	X_n	SKTT	X_n	SKLTT	X_n	Unit
Line Length (km)	Criteria 1	(c1)	Cost	29,8	X_{11}	25,7	X_{21}	21	X_{31}	Km
Soil Investigation (qc)	Criteria 2	(c2)	Benefit	30	X_{12}	60	X_{22}	10	X_{32}	Kg/cm^2
Domestic Material Portion (%) – (rupiah currency)	Criteria 3	(c3)	Benefit	100	X_{13}	47,3	X_{23}	8,88	X_{33}	%
Land Acquisition requirement (m2)	Criteria 4	(c4)	Cost	24.080	X_{14}	9.180	X_{24}	500	X_{34}	m^2
Estimated Work Cost (Rp)	Criteria 5	(c5)	Cost	183.600.392.324	X_{15}	351.249.274.496	X_{25}	705.549.192.081	X_{35}	Rupiah
Estimated Duration (month)	Criteria 6	(c6)	Cost	32	X_{16}	34	X_{26}	28	X_{36}	Month
Risk Analysis	Criteria 7	(c7)	Benefit	44	X_{17}	34	X_{27}	51	X_{37}	unit

From the Table 1 above, The TOPSIS decision matrix can be seen as follows :

Table 2. Decision Matrix

No	Alternative	Cost/Technical Criteria					Time Duration Criteria	Risk Criteria
		c1	c2	c3	c4	c5	c6	c7
1	SUTT (OHL)	29,80	30	100	24.80	183.600.392.324	32	44
2	SKTT (UGC)	25,70	60	47,30	9.180	351.249.274.496	34	34
3	SKLTT (MARINE)	21	10	8,88	500	705.549.192.081	28	51

c1 = Line Length
c2 = Soil Investigation Data
c3 = Domestic Material Portion
c4 = Land Requirement
c5 = Estimated Cost of Work
c6 = Estimated Duration of work
c7 = Risk & environmental analysis

After the decision matrix (as Table 2 above) being founded, to continue the calculation of TOPSIS, we need to find the preference weight. For the requirement of the Preference Weight Factor in TOPSIS, the author use an online google form by requires an opinion related to attributes that will be assessed based on a significant scale of importance and need from 1 to 5. The results of the survey data obtained can be seen in Figure 2 below:

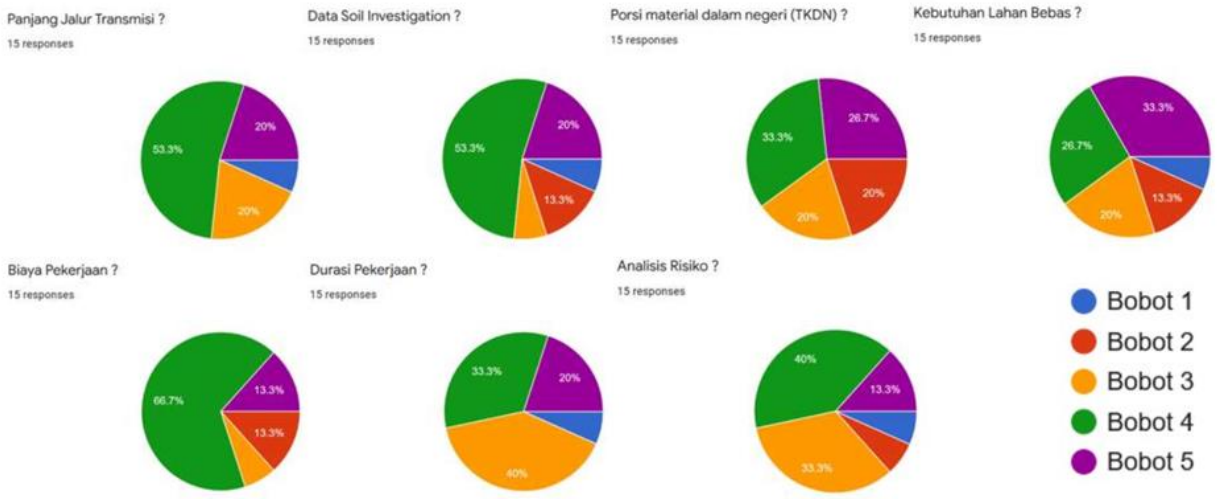


Figure 3. Results of the Preference Weight Questionnaire Survey

From the decision matrix that has been obtained in Table 1 above, by following the TOPSIS steps that have been determined in accordance with Figure 2 and using the results of the preference weight survey in accordance with Figure 3 above, we get an ideal solution that is close to what is seen in the Table 3 below:

Table 3. Solution Value of Each Alternative

No	Value	Alternatives
v1	0,612304	SUTT (OHL)
v2	0,399136	SKTT (UGC)
v3	0,601292	SKLTT (Marine)

From these results, the value of the ideal solution with the greatest preference is v1 which is the SUTT alternative. So, with this calculation, the SUTT results can be recommended in principle as an alternative to the chosen decision.

After obtaining alternative results from Table 3 above, author make the analysis of sensitivity by doing iteration from the equation in the TOPSIS calculation against the value obtained from each criterion to test the sensitivity level of the alternative solution along with the calculated criteria that can be seen at figure 4 and figure 5 below:

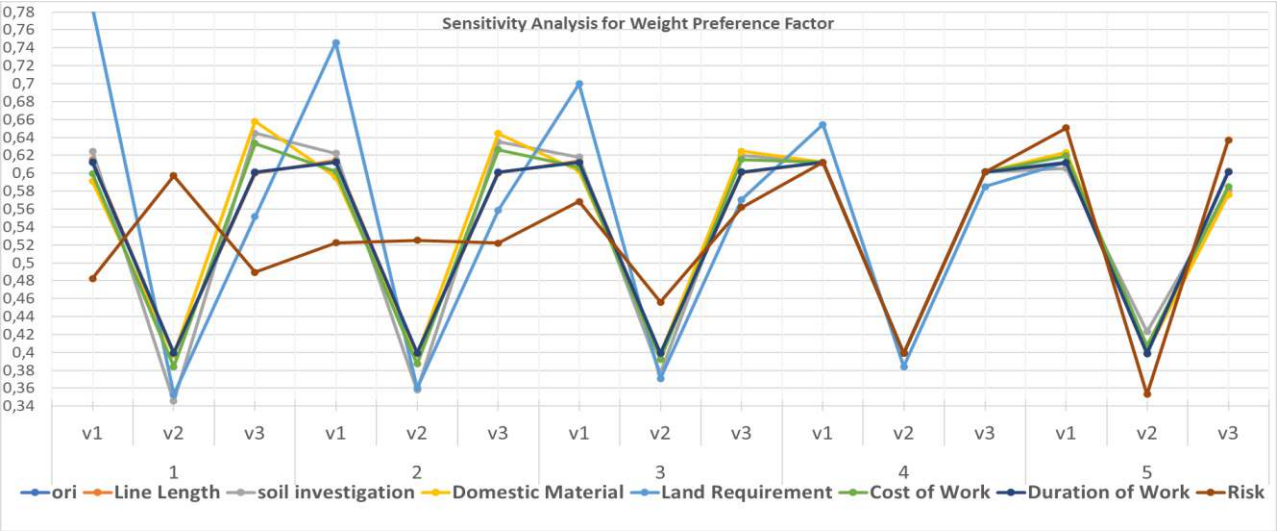


Figure 4. Sensitivity Analysis of Weight Preference

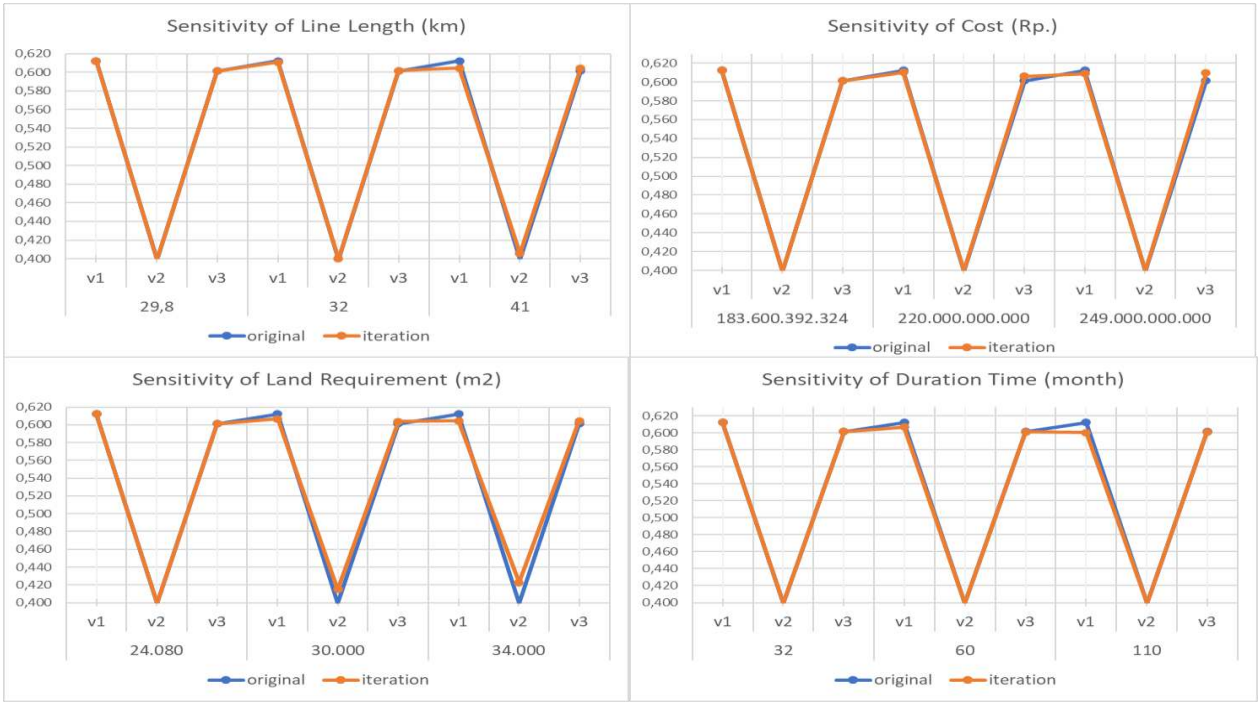


Figure 5. Sensitivity Value Analysis of Criteria

6. CONCLUSIONS

From the results of research conducted with the TOPSIS method above, it can be concluded as follows:

1. Decision making with the TOPSIS method approach can be used as a tool in finding solution recommendations and empirical decisions so that the basis for decision making can be achieved by valid calculations and tested mathematically.
2. From the results of research and calculations that have been carried out, it was found that the alternative SUTT 150 kV ACSR/AS, 1 x Hawk, 2 Circuit along 29.8 km is the closest solution to optimum recommendation as an alternative solution chosen for the Holtekam - Angkasa transmission plan.
3. From the sensitivity analysis, it was found that the preference weight value greatly affects the results of the TOPSIS that has been carried out, where the dominant change that is most likely to occur in the iteration is the change in the decision solution to an alternative to SKLTT rather than SKTT.
4. From the calculations and iterations carried out under these conditions, the chosen alternative solution is SUTT (OHL) transmission, will still be a recommended decision solution if still within the sensitivity limits at the following values:
    1. Line Length of SUTT < 41 km
    2. Cost of Work < 249 M
    3. Land Acquisition Requirement < 34,000 m2
    4. Duration of Work < 110 Months
5. Considering the sensitivity analysis from point no 3, the weight of preference factor has a significant role to change the decision so if it's deemed necessary, this can be developed in the next comprehensive research.

REFERENCES

Aigboviosa, A. P., Idiake, U. S., Nkordeh, N., Ehimen, A. A., & Victory, K. (2018). Development of Electrical Power Generation System Through the Use of Speed Breaker. *Proceedings of the International Conference on Industrial Engineering and Operations Management*, (pp. 347-351). Washington DC,.

Bhole, G. P., & Deshmukh, T. (2018). Multi-Criteria Decision Making (MCDM) Methods and its applications. *International Journal for Research in Applied Science & Engineering Technology (IJRASET), 6*(V), 899-915.

BICEN, Y. (2019). The Future Perspectives of Overhead and Underground Transmission Lines in Turkey. *3rd International Engineering Research Symposium INERS'19.*

Chetty, L., & Ijumba, N. (2012). Rural electrification using overhead HVDC transmission lines. *Journal of Energy in Southern Africa, 23*(2), 56-64.

Ciptomulyono. U, ITS (2010), *Paradigma Pengambilan Keputusan Multikriteria Dalam Perspektif Pengembangan Projek dan Industri yang Berwawasan Lingkungan*, Surabaya

Fahad, J. Q., & Chillab, R. K. (2020). Design aspects of high voltage transmission line. *Bulletin of Electrical Engineering and Informatics, 9*(3), 853~861.

Garg, A., & Ghatak, A. (2020). An Empirical Study on Power Evacuation Projects' Performance: A Strategic Layout in the Indian Context. *Asia-Pacific Journal of Management Research and Innovation, 16*(1), 31–42.

Haraguchi, M., Miyano, H., & Nakamura, T. (2021). Power generation and society. *Fundamentals of Thermal and Nuclear Power Generation* (JSME Series in Thermal and Nuclear Power Generation), 227-274.

Ibraheem, S. M. (2020). Power Supply. *Journal of Electrical Engineering*.

Jayapriya, T., Monica, E. M., Nathiya, N., A. P., & Sowmiya, T. (2017). Uninterrupted Power Supply to The Society in Variable Resources with High Efficiency. *International Journal of Engineering Research & Technology (IJERT), 5*(13).

Kementerian Energi dan Sumber Daya Mineral Republik Indonesia. (2021). *Rencana Usaha Penyediaan Tenaga Listrik (RUPTL) 2021-2030 PT PLN.* Jakarta: Kementerian Energi dan Sumber Daya Mineral Republik Indonesia.

Masanja, N. M. (2020). *Practical Guide to Writing a Feasibility Study.* Mwanza, Tanzania: NMM Printers.

Nawaz, M. S., & Khan, I. (2016). Design and Construction of 33/11 KV Line & Substation. *International Research Journal of Engineering and Technology (IRJET), 3*(7), 722-727.

Nirwan, S., Shah, V., Shah, P., & Velani, K. (2018). Design and Analysis of Power Evacuation System for Solar Power-Plant. *Journal of Emerging Technologies and Innovative Research (JETIR) 445, 5*(11), 445-450.

Nkalo, U. K., & Agwu, E. O. (2019). Review of the Impact of Electricity Supply on Economic Growth: A Nigerian Case Study. *IOSR Journal of Electrical and Electronics Engineering (IOSR-JEEE), 14*(1), 28-34.

O.Nyumba, T., Wilson, K., Derrick, C. J., & Mukherjee, N. (2018). The focus group discussion methodology: Insights from two decades of application in conservation. *Methods in Ecology and Evolution, 9*, 20-32.

Parida, P. K. (2019). A General View of TOPSIS Method Involving Multi-Attribute Decision Making Problems. *International Journal of Innovative Technology and Exploring Engineering (IJITEE), 9*(2), 3205-3214.

Piana, E. A., Bignucolo, F., Donini, A., & Spezie, R. (2018). Maintenance of a High-Voltage Overhead Transmission Line: Sustainability and Noise Impact Assessment. *Sustainability, 10*(491).

Ponto, J. (2015). Understanding and Evaluating Survey Research. *J Adv Pract Oncol, 6*, 168-171.

Public Service Commission of Wisconsin. (2016). *Underground Electric Transmission Lines.* Wisconsin.

Puget Sound Energy. (2014). *Underground transmission lines fact sheet.* Puget Sound Energy.

Setayeshgar, A. (2016). *Principles of Mechanical Design in Overhead Transmission Lines.* Aalto University.

Sontakke, S., & Sakhale, C. N. (2021). A Short Review on Various Types of Transmission Tower Structure and Its Design. *International Journal of Innovations in Engineering and Science, 6*(9), 9-13.

Umeda, S., Ishii, N., Horiguchi, N., Maeda, M., Yamaguchi, T., Tanaka, H., et al. (2007). *Underground Power Cable, Distribution Cable, Overhead Transmission Line, Industrial Cable and Their Accessories.* Furukawa Electric Industrial Cable.

Unni, N. S., & Soumya, A. (2016). Transmission Line Characteristics. *IOSR Journal of Electronics and Communication Engineering (IOSR-JECE)*, 67-77.

Zohuri, B., & P. McDaniel. (2019). The Electricity: An Essential Necessity in Our Life. *Advanced Smaller Modular Reactors*, pp. 1-21.

Zulqarnain, R. M., Saeed, M., Ahmad, N., Dayan, F., & Ahmad, B. (2020). Application of TOPSIS Method for Decision Making. *International Journal of Scientific Research in Mathematical and Statistical Sciences, 7*(2), 76-81.

THE EFFECT OF MEANINGFUL WORK AND SENSE OF COMMUNITY ON INTENTION TO STAY: THE MEDIATING ROLE OF WORKPLACE WELL-BEING

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ABSTRACT

The aim of the study was to see how meaningful work and a sense of community affect intention to stay through workplace well-being. Insurance company employees were selected as participants in the study, with a sample size of 180 people. Structural equation model was used to analyze the data. Research shows that having a sense of community and doing meaningful work increases well-being at work and intention to stay. Differences were observed in the effect of different dimensions of employee well-being on intention to stay. The research is groundbreaking in conceptualizing and testing theoretical models linking meaningful work, feelings of community, workplace well-being, and intention to stay particularly in the context of insurance company employees.

Keywords: Meaningful Work, Sense of Community, Intention to Stay, Workplace Well-being

1. INTRODUCTION

The concept of meaningful employment has piqued the interest of academics and practitioners alike as an important field of research (MacInnis et al, 2020). Employees who are able to set work goals have the capacity to influence personal turnover intentions or behavior, as well as the conduct of their coworkers (Zeglat and Janbeik, 2019). Employees who have work goals have meaningful interactions with coworkers and combine core work principles (such as honesty and integrity) with company goals (Milliman et al., 2018). Employee work attitudes including job satisfaction, organizational commitment, OCB, and organizational performance have been proven to be positively correlated with meaningful work experiences and a sense of community at work (Utami et al, 2021).

The turnover rate in insurance firms is relatively high (Kontan.co.id, 2020), thus this survey, which is being undertaken among insurance company personnel, gains more relevance. Furthermore, employee well-being has emerged as one of the most crucial concerns for managers and employees searching for ways to improve their well-being (Brunzell et al., 2018). Individual outcomes as well as organizational performance and productivity are influenced by more favorable emotional experiences at work (Caringal-Go and Hechanova, 2018). Employees can only identify with profession and the company as a whole if have a sense of closeness to work and workplace (Oksa et al, 2021).

2. LITERATURE REVIEW

2.1 Meaningful Work

Meaningful work, is work that is significant, positive, and important for individuals in reaching life objectives, delivering psychological experiences on effective work results, and job involvement that has a broader impact on others (Sharabi et al, 2019). The factors that become the benchmark for meaningful work have several dimensions, including the economic orientation, intrinsic orientation, interpersonal relations, obligation norms, entitlement norms, work centrality, and job satisfaction. The authors does not employ all of the relevant work dimensions. Dimensions of work meaning used in research include entitlement norms, job satisfaction, and interpersonal relation.

2.2 Sense of Community

A sense of community is the sensation that community members are connected to one another, as well as the broad idea that members' needs can be met with a commitment to being together (Halamova et al, 2018). Dimensions that contribute to a sense of community include mission, responsibility, harmony, influence, membership, needs fulfillment and shared emotional connection. The authors does not use all the dimensions of sense of community, the dimensions used in this research are mission, responsibility, and harmony.

2.3 Workplace Well-being

Workplace well-being is a positive sensation and a growth feature that enables individuals and organizations to improve and thrive (Bartels et al, 2019). Furthermore, several dimensions of workplace well-being are negative aspects, positive aspects, and social responsibility. Negative aspects of work are factors that contribute to bad feelings related to work. Trust, cooperation, security, risk-taking support, accountability, and equality are characteristics of a positive aspects of work. The tendency of individuals to show themselves in a generally acceptable way is known as social desirability.

2.4 Intention to Stay

Intention to stay shows an employee's dedication to the organization and the desire to continue working (Dechawatanapaisal, 2018). The research typology is based on the work of Bell & Sheridan (2020) and is elaborated on the research of Kuo et al (2018). Intention to stay has three dimensions: intention to stay in the organization indefinitely, thoughts about leaving, and intention to search for a new job.

2.5 Theoretical Framework and Hypothesis Development

Meaningful work has a beneficial effect on well-being in the workplace (Wallace's, 2019). Furthermore, employees engage in meaningful work as a result of job design that increases job satisfaction and purpose (Aboobaker et al., 2019). Managers assist employees in experiencing goals by offering the challenge, clarity, and authenticity associated with each task. Furthermore, managers ensure that employees like their work and see it as a contribution to the greater benefit of society (Abarantyne et al, 2019).

***H1a**: Meaningful work has a positive effect on negative aspects*

***H1b**: Meaningful work has a positive effect on positive aspects*

***H1c**: Meaningful work has a positive effect on social desirability*

A sense of community has a positive impact on well-being in the workplace (Boyd and Nowell, 2020). A sense of community is a feeling of belonging that is shared by colleagues, and managers play an important role in fostering a work environment that fosters team spirit and positive personal relationships (Coun et al, 2019). Managerial techniques aimed at improving the social and organizational environment have been shown to increase employee satisfaction in the

workplace (Islami et al, 2018). As a result, a sense of community is seen as a job resource and job attribute driven by the organization.

***H2a**: Sense of community has a positive effect on negative aspects*
***H2b**: Sense of community has a positive effect on positive aspects*
***H2c**: Sense of community has a positive effect on social desirability*

Workplace well-being and the drive to leave has a negative association (Shi et al, 2021). Compared to wanting to leave, wanting to stay is a positive thing (Perryman and Calvert, 2020). Employees who want to stay in a company want to stay until they quit or for some other reason (Pueyo, 2020). Thus, workplace well-being has an impact on the decision to stay.

***H3a**: Negative aspects has a negative effect on intention to stay*
***H3b**: Positive aspects has a positive effect on intention to stay*
***H3c**: Social desirability has a positive effect on intention to stay*

The study wanted to investigate the underlying mechanisms by which meaningful work and a sense of community influence intention to stay through workplace well-being, based on research by Wallace (2019); Boyd and Nowell (2020); Shi et al. (2021).

***H4a**: Negative aspects mediates the effect of meaningful work on intention to stay*
***H4b**: Positive aspects mediates the effect of meaningful work on intention to stay*
***H4c**: Social desirability mediates the effect of meaningful work on intention to stay*
***H5a**: Negative aspects mediates the effect of sense of community on intention to stay*
***H5b**: Positive aspects mediates the effect of sense of community on intention to stay*
***H5c**: Social desirability mediates the effect of sense of community on intention to stay*

Referring to the model of previous studies, the followings are the research model as shown in Figure 1:

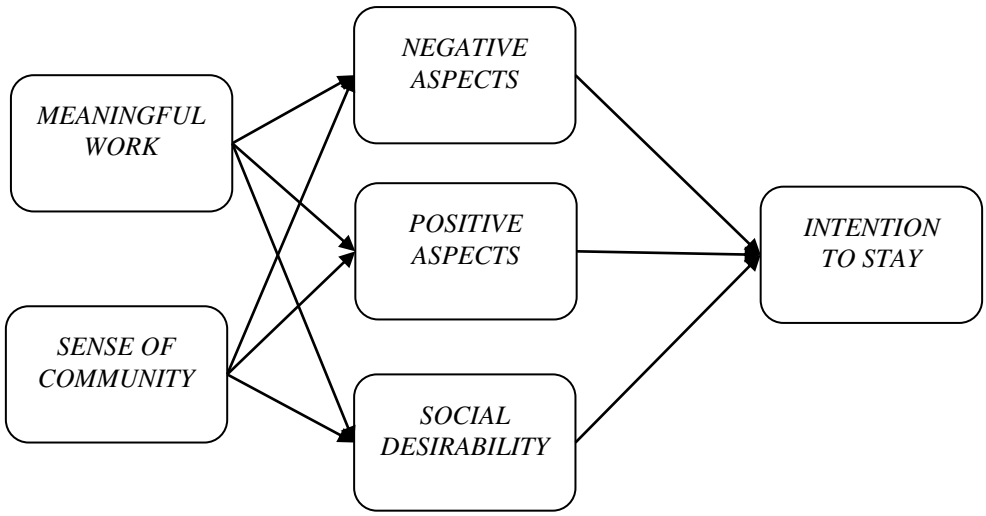


Figure 1. Proposed Conceptual Framework of the Study

3. METHODS

A total of 180 employees in five provinces in Indonesia were surveyed for the study. Only employees with at least one month of experience with the company were selected, as many parts of the study required a significant period of work experience to ensure accurate construction measurements. Information was collected by distributing self-reporting questionnaires by Google form to respondents who were selected using a non-probabilistic purposive sampling method.

There were 72.8 percent of men and 27.2 percent of women in the sample. The majority of the sample is between the ages of 20 to 30 (82.2%), with an average monthly expenditure of more than IDR 3,000,000 (49.4%), and 71.1 percent of them have a bachelor's degree. Of the total respondents, 44.4 percent are recent graduates or have less than one year of experience, most of the respondents work in DKI Jakarta (58.89%) and are permanent employees with a percentage of 61.7 percent.

Meaningful work was adapted from Sharabi et al (2019), and it comprised nine items and measured three dimensions: economic orientation, intrinsic orientation, and interpersonal relations (α=.827). The sense of community was assessed using a nine-item scale developed from Halamova (2018), which had three dimensions: membership, influence, and emotional shared connection (α=.836). The Bartels et al. (2019) scale, which has nine items and three dimensions—negative aspects (α=.864), positive aspects (α=.828), and social desirability (α=.829)—was used to measure workplace well-being. Intention to stay consisted of nine items and was developed and measured using three dimensions (α=.867) modified from Bell & Sheridan (2020): intention to stay in the organization indefinitely, thoughts about leaving, and intention to search for a new job. On a five-point Likert scale, responses for constructs were assessed (1=strongly disagree, 5=strongly agree). According to Table 1, all scales met the internal reliability of minimum 0.7 criteria (Hair et al., 2010).

The hypothesized hypotheses for the underlying linkages were validated using SmartPLS 3 with structural equation modeling. The data is valid if the value of probability less than 0.05. The data is reliable if the value of construct reliability is greater than 0.7.

Table 1. Reliability and Validity Measures of Constructs

	MEAN	**CR**	**KMO**	**SIG**
IS	3.20	0.867	0.688	0.000
MW	4.31	0.827	0.656	0.000
NA	3.65	0.864	0.674	0.000
PA	4.29	0.828	0.650	0.000
SOC	4.14	0.836	0.694	0.000
SD	4.05	0.829	0.607	0.000

4. RESULTS

The mean, construct reliability, KMO and significance are shown in Table 1. The mean values were 4.31 (meaningful work), 4.14 (sense of community), 3.65 (negative aspects), 4.29 (positive aspects) 4.05 (social desirability), and 3.20 (intention to stay).

4.1 Measurement model testing

The provided hypotheses for the underlying links were validated using a factor analysis technique with IBM SPSS 25.0. The loadings on each measuring item were all higher than .50. Each construct's Cronbach's Alpha was higher than 0.70, indicating reliability. Validity is supported by Table 1's KMO and significance values for each construct. Overall, the model is

adequately supported, allowing us to move forward with an estimation of the structural model and careful hypothesis testing.

4.2 Structural model hypothesis testing

The facts observed and the proposed model matched together well ($\chi 2/df=2.999$; SRMR= 0.004, GFI=0.910; RMSEA= 0.799; NFI=0.910). Table 2 provides an overview of the regression coefficients for each path and their statistical significance. Meaningful work has influence on negative aspects (H1a-supported), while sense of community did not significantly predict negative aspects (H2a-not supported). Positive aspects are influenced by meaningful work (H1b-supported), however positive aspects were not significantly predicted by sense of community (H2b-not supported). Social desirability and sense of community have a strong positive association (H2c-supported) but meaningful work didn't show up as a significant predictor of social desirability (H1c-not supported). The largest impact on intention to stay is negative aspects (H3a-not supported), followed by positive aspects (H3b-supported), and social desirability (H3c-supported) (see table 2).

Table 2. Hypotheses Testing

HYPOTHESIS	PATH	ESTIMATE	S.E	C.R	P
H1a	Meaningful Work → Negative Aspects	-.356	.094	3.770	***
H1b	Meaningful Work → Positive Aspects	.632	.057	11.024	***
H1c	Meaningful Work → Social Desirability	.042	.093	.448	0.654
H2a	Sense of Community → Negative Aspects	.033	.102	.324	.746
H2b	Sense of Community → Positive Aspects	.120	.081	1.480	.139
H2c	Sense of Community → Social Desirability	.457	.094	4.852	***
H3a	Negative Aspects → Intention to Stay	-.273	.084	3.272	***
H3b	Positive Aspects → Intention to Stay	.260	.079	3.280	***
H3c	Social Desirability → Intention to Stay	-.294	.098	3.018	.003

Notes: n=180; ***p<0.001

The mediation analysis was carried out in SEM (using SmartPLS 3), with a 95 percent confidence interval and 180 bootstrap samples (Walters, 2019); see Table 3. We use a sequence of regression equations in the Bartram (2021) approach to find the mediating effect with regard to one independent variable and one dependent variable at a time. However, in the context of our research, we used a bootstrapping method to determine how workplace wellbeing mediates the relationship between meaningful work, sense of community, and intention to stay, taking into account both direct and indirect effects of each of the dimensions of meaningful work and sense of community.

The standardized direct and indirect effects between hypothesized paths were examined, and it was discovered that negative aspects mediated the relationship between meaningful work and intention to stay ($t=2.677$, $p<0.05$) (H4a-supported), but had no effect on the relationship

between sense of community and intention to stay (t=.282, p=.754) (H5a-not supported). Positive aspects mediated the link between meaningful work and intention to stay (t=2.925, p<0.05) (H4b-supported) but had no impact on the link between sense of community and intention to stay (t=.193, p=.473) (H5b-not supported). The association between meaningful work and desire to remain was unaffected by social desirability (t=.480, p=.705) (H4c-not supported), yet meaningful work has a positive, significant impact on intention to stay as a direct result. Furthermore, social desirability served as a mediator between sense of community and intention to stay (t=2.128, p<0.05) (H5c-supported).

Table 3. Mediating effects of Workplace Well-Being

HYPOTHESIS	PATH	DIRECT EFFECT T-VALUE (P-VALUE)	INDIRECT EFFECT T-VALUE (P-VALUE)
H4a	Meaningful Work → Negative Aspects → Intention to Stay	2.360 (***)	2.677 (***)
H4b	Meaningful Work → Positive Aspects → Intention to Stay	2.360 (***)	2.925 (***)
H4c	Meaningful Work → Social Desirability → Intention to Stay	2.360 (***)	.480 (.705)
H5a	Sense of Community → Negative Aspects → Intention to Stay	1.693 (.931)	.282 (.754)
H5b	Sense of Community → Positive Aspects → Intention to Stay	1.693 (.931)	.193 (.473)
H5c	Sense of Community → Social Desirability → Intention to Stay	1.693 (.931)	2.128 (***)

Notes: n=180; ***p<0.05

6. CONCLUSIONS

The employee's sense of belonging to the organization has an impact on the ability to learn new skills. Consistent with Chanana's (2021) research, in general, companies that implement employee engagement programs will advance professionally. Because employees are part of the business, reflection on the business will influence them to concentrate on work because they really like work. Identification is a psychological notion that represents the extent to which employees feel that their sense of self is in line with their feelings towards the company (Chaudhary, 2019). The company reflection will have no impact on the business partnership. Contrary to Wallace's

(2019) research, effective inclusive business initiatives recognize the ability of strategic cooperation to influence outcomes and provide long-lasting effects.

Contrary to Masenya (2022) research, increasing competition among businesses has forced more and more businesses to design the best retention strategies for top talent or skilled individuals who can ensure the competitiveness and viability of the company. Employees' attention to producing work they truly enjoy is not influenced by skills learned on the job. In contrast to Yates (2022), unmotivated workers put in minimal effort, stay away from the office, leave the company if given the opportunity, and perform substandard work. The ability of employees to improve capabilities within the organization has an impact on the ability to build and maintain business partnerships. Employees are inspired to work enthusiastically in a work environment when they are treated fairly (Jose et al, 2021).

Employee skills have an impact on actively seeking new positions. Skills mismatches, deficiencies, and gaps can have an impact on labor productivity and employability (Brunello and Wruuck, 2019). Workers who prioritize getting work done because they really enjoy it are less likely to actively seek other positions. Companies with high employee engagement have low employee turnover (Milliman et al, 2018). Strong inner connections have an impact on employees who are not actively looking for new positions. Elements that affect employee community integration can affect the intention to remain in the community (Prasetyo et al, 2020).

Employees, who are an integral part of the business, will reflect the business effect by preventing them from actively seeking new jobs. Employees expect work to be a substantial source of meaning (Dhingra et al, 2021). When an employee is recognized as part of a company, the reflection of the company will have an impact on the employee's decision to focus on work rather than actively looking for a new job. Managers can assist staff members in developing a vision in career path (Zakkariya & Aboobaker, 2020). When recognized as a member of a company, the employee's reflection will be a reflection of the organization and will not affect the aggressiveness of looking for a new job through strong internal connections. Motivated employees stay with the company because they have a strong desire to be part of the company (Paais & Pattiruhu, 2020).

Increasing the ability of employees in the organization will not have an impact on how aggressively employees seek new positions through undeveloped employee skills. Employees that receive sufficient training can perform at a higher level and complete jobs well (Niati et al, 2021), but will not affect how actively people look for new jobs. Increasing the level of employee ability in the company will not affect how actively people look for other jobs through employees concentrating on work because they really enjoy. Contrary to Milliman et al (2018), employees who feel part of a unique culture, team, and environment will stay in business. Employees need strong internal connections because an increase in the ability level of employees in the organization will affect how actively people look for other jobs through business partnerships. Through networking, job openings are made known, and hearing about what others are doing at their companies motivates employees to use new methods or abilities (Eriksson & Ferreira, 2021).

REFERENCES

Abarantyne, I., Naidoo, V., & Rugimbana, R. (2019). The impact of psychological contracts on employee engagement at a university of technology. *SA Journal of Human Resource Management*, *17*(1), 1-11.

Aboobaker, N., Edward, M., & Zakkariya, K. A. (2019). Workplace Spirituality, Employee Wellbeing and Intention to Stay: A multi-group analysis of teachers' Career Choice. *International Journal of Educational Management*.

Bartels, A. L., Peterson, S. J., & Reina, C. S. (2019). Understanding well-being at work: Development and validation of the eudaimonic workplace well-being scale. *PloS one*, *14*(4), e0215957.

Bartram, D. (2021). Cross-sectional model-building for research on subjective well-being: Gaining clarity on control variables. *Social Indicators Research*, *155*(2), 725-743.

Bell, M., & Sheridan, A. (2020). How organisational commitment influences nurses' intention to stay in nursing throughout their career. *International journal of nursing studies advances*, *2*, 100007.

Boyd, N. M., & Nowell, B. (2020). Sense of community, sense of community responsibility, organizational commitment and identification, and public service motivation: A simultaneous test of affective states on employee well-being and engagement in a public service work context. *Public Management Review*, *22*(7), 1024-1050.

Brunello, G., & Wruuck, P. (2019). Skill shortages and skill mismatch in Europe: A review of the literature.

Brunzell, T., Stokes, H., & Waters, L. (2018). Why do you work with struggling students? Teacher perceptions of meaningful work in trauma-impacted classrooms. *Australian Journal of Teacher Education*, *43*(2), 116-142.

Caringal-Go, J. F., & Hechanova, M. R. M. (2018). Motivational needs and intent to stay of social enterprise workers. *Journal of Social Entrepreneurship*, *9*(3), 200-214.

Chanana, N. (2021). Employee engagement practices during COVID-19 lockdown. *Journal of public affairs*, *21*(4), e2508.

Chaudhary, R. (2019). Corporate social responsibility perceptions and employee engagement: role of psychological meaningfulness, safety and availability. *Corporate Governance: The International Journal of Business in Society*.

Coun, M. J., Peters, P., & Blomme, R. J. (2019). 'Let's share!'The mediating role of employees' self-determination in the relationship between transformational and shared leadership and perceived knowledge sharing among peers. *European Management Journal*, *37*(4), 481-491.

Dechawatanapaisal, D. (2018). Employee retention: the effects of internal branding and brand attitudes in sales organizations. *Personnel Review*.

Eriksson, T., & Ferreira, C. (2021). Who pays it forward the most? Examining organizational citizenship behavior in the workplace. *Journal of Theoretical Social Psychology*, *5*(3), 215-228.

Hair, J. F., Ortinau, D. J., & Harrison, D. E. (2010). *Essentials of marketing research* (Vol. 2). New York, NY: McGraw-Hill/Irwin.

Halamová, J., Kanovský, M., & Naništová, E. (2018). Development and psychometric analysis of the sense of community descriptors scale. *Psychosocial Intervention*, *27*(1), 44-55.

Islami, X., Mulolli, E., & Mustafa, N. (2018). Using Management by Objectives as a performance appraisal tool for employee satisfaction. *Future Business Journal*, *4*(1), 94-108.

Jose, R. J. S., Minh, H. T. T., Ullah, S. E., & Sadiq, M. (2021). Enhancing Staff's Work Motivation in Vietnamese Companies. *Turkish Journal of Computer and Mathematics Education (TURCOMAT)*, *12*(14), 4402-4410.

Kontan.co.id. (2020, August 11). *AAJI: Turnover tinggi bikin asuransi jiwa terus rekrut agen walau ada pandemi*. Retrieved July 22, 2021, from

https://keuangan.kontan.co.id/news/aaji-turnover-tinggi-bikin-asuransi-jiwa-terus-rekrut-agen-walau-ada-pandemi

Kuo[1], L. C., Lim, L. C., & Naghavi, N. (2018). Preliminary study of intention to stay among the IT employees in Klang valley, Malaysia.

MacInnis, D. J., Morwitz, V. G., Botti, S., Hoffman, D. L., Kozinets, R. V., Lehmann, D. R., & Pechmann, C. (2020). Creating boundary-breaking, marketing-relevant consumer research. *Journal of Marketing*, *84*(2), 1-23.

Masenya, T. M. (2022). Integrating Talent and Knowledge Management Practices in the New Normal Business Environment: Developing Future Leaders in Public Sector Organizations. In *Navigating the New Normal of Business With Enhanced Human Resource Management Strategies* (pp. 113-144). IGI Global.

Milliman, J., Gatling, A., & Kim, J. S. (2018). The effect of workplace spirituality on hospitality employee engagement, intention to stay, and service delivery. *Journal of Hospitality and Tourism Management*, *35*, 56-65.

Niati, D. R., Siregar, Z. M. E., & Prayoga, Y. (2021). The effect of training on work performance and career development: the role of motivation as intervening variable. *Budapest International Research and Critics Institute (BIRCI-Journal): Humanities and Social Sciences*, *4*(2), 2385-2393.

Oksa, R., Kaakinen, M., Savela, N., Ellonen, N., & Oksanen, A. (2021). Professional social media usage: Work engagement perspective. *New Media & Society*, *23*(8), 2303-2326.

Paais, M., & Pattiruhu, J. R. (2020). Effect of motivation, leadership, and organizational culture on satisfaction and employee performance. *The Journal of Asian Finance, Economics and Business*, *7*(8), 577-588.

Perryman, J., & Calvert, G. (2020). What motivates people to teach, and why do they leave? Accountability, performativity and teacher retention. *British Journal of Educational Studies*, *68*(1), 3-23.

Prasetyo, Y. T., Castillo, A. M., Salonga, L. J., Sia, J. A., & Seneta, J. A. (2020). Factors affecting perceived effectiveness of COVID-19 prevention measures among Filipinos during enhanced community quarantine in Luzon, Philippines: Integrating Protection Motivation Theory and extended Theory of Planned Behavior. *International journal of infectious diseases*, *99*, 312-323.

Pueyo, T. (2020). Coronavirus: Why you must act now. *Politicians, community leaders and business leaders: what should you do and when*.

Sharabi, M., Polin, B., & Yanay-Ventura, G. (2019) "The effect of social and economic transitions on the meaning of work: A cross-sectional study among Israeli employees", *Employee Relations: The International Journal*, https://doi.org/10.1108/ER-04-2018-0111

Shi, X., Gordon, S., & Tang, C. H. (2021). Momentary well-being matters: Daily fluctuations in hotel employees' turnover intention. *Tourism Management*, *83*, 104212.

Utami, N. M. S., Sapta, I., Verawati, Y., & Astakoni, I. (2021). Relationship between workplace spirituality, organizational commitment and organizational citizenship behavior. *The Journal of Asian Finance, Economics and Business*, *8*(1), 507-517.

Wallace, J. E. (2019). Meaningful work and well-being: a study of the positive side of veterinary work. *Veterinary Record*, *185*(18), 571-571.

Walters, G. D. (2019). Why are mediation effects so small?. *International Journal of Social Research Methodology*, *22*(2), 219-232.

Yates, E. (2022). Developing or Degrading Young Workers? How Business Strategy and the Labour Process Shape Job Quality Across Different Industrial Sectors in England. *Work, Employment and Society*, 09500170211070447.

Zeglat, D., & Janbeik, S. (2019). Meaningful work and organizational outcomes: The mediating role of individual work performance. *Management Research Review*.

FAMILY OWNERSHIP AND THE PROPORTION OF PROFESSIONAL DIRECTORS, THEIR EFFECT ON SUSTAINABILITY REPORT DISCLOSURE (study in banking listed on IDX 2015-2021)

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ABSTRACT

This study will analyze the effect of company ownership and family ownership and profile on the use of sustainability reports in the banking industry listed on the stock exchange from 2015 to 2021. The variables used in this study are family ownership of the company, professional selection seen from not being affiliated with the owner or major shareholders, family ownership as moderating a professional table and directors using the sustainability report and Busy size and company size as control variables. The research sample is banks listed on the stock exchange as many as 18 samples of banks. The data is obtained from the annual reports and results of each company. The research method uses panel data regression analysis using eviews. The results of the study indicate that family ownership has a negative effect on sustainability reports, professional storage has a positive effect on sustainability reports, family ownership has a moderating factor that weakens the relationship between professional libraries and sustainability reports. Then for the control variable, Director busy has a positive effect and company size has a positive effect on negative sustainability reports. This research is expected to contribute to the banking sector so that they can make better sustainability reports and can meet the interests of the company's stakeholders.

Keywords: Sustainability Report, Family Own, Profesional Direksi, Banking Industry

1. INTRODUCTION

Banking in carrying out its functions and business always refers to the concept of prudence, because the main function of the bank is as a collector and distributor of public funds and aims to support national development, one of which is to increase equitable development, economic growth and national stability. Banking regulation and supervision has been supervised by the Financial Services Authority, because banks have an important role in economic activity.

Banking is a business that is quite unique compared to other businesses called trust institutions because the source of bank operational funds is mostly from the people who entrust their funds to be deposited, loss of trust can lead to the collapse of a bank. Banks also have an important role in monetary policy, by looking at the structure of the national financial system which is dominated by the banking sector. an institution that can move the real sector and the wheels of the economy, a channel that will facilitate the circulation of funds for the sustainability of economic development activities.

Seeing the important role of banking above, banking is an industry that needs to be highly regulated and operates in a prudential concept, because failure for banks can also have a systemic impact, which means that banks that are declared can no longer be rehabilitated by banking

supervisory institutions. whose impact endangers the continuity of its business and affects the global financial system (Aditya, 2017). Banks can cause systemic problems, for example in the investment bank Lehman Brothers in the subprime mortgage case, due to poor management that led to defaults and early bankruptcy and triggered the crisis that occurred in 2008. It can be seen that the failure of the bank did not only affect the company. but can have a global impact. as in Indonesia there was the case of Century bank experiencing liquidity difficulties which led to a clearing failure in 2008, the guarantor institution decided to help the bank with a bailout of 6.7 trillion, although the closure of this bank did not play a significant role in the economy but the century failure occurred when the economy was in crisis. and it is feared that it could affect other financial institutions.

This is due to inappropriate management and an ineffective supervisory role, and off-site supervision in which Bank Supervisors examine and analyze routine and non-routine bank reports to BI as well as information from other sources. Second, direct supervision (on-site supervision) where the bank supervisor conducts field inspections directly at the supervised bank. Under normal circumstances, inspections are carried out at least once a year. Indirect supervision can be carried out by Stakeholders through report disclosure.

Various studies also show that crises are often preceded by poor corporate governance, especially in banks (Erkens et al., 2012) making supervision crucial. The unique characteristics of banks, including high opacity, tight regulations, potential moral hazard, too-big-to-fail (TBTF) and government intervention (Levine, 2004) make banks vulnerable to these risks, therefore, studies in the banking sector should not only attention to external factors (eg macroeconomic variables) only but also aspects of corporate governance that affect risk and performance (Adams and Mehran, 2012; Macey and Maureen, 2003). This study will look at several internal factors that might be an indirect supervisory factor for banks.

OJK as a supervisor tries to pay attention to controlling issues in banks. In 2016 OJK tried to regulate share ownership in commercial banks in order to limit the influence of control and dominance owned by controlling shareholders. For example, 20% for individual ownership, 30% for non-financial legal entity shareholders and 40% for bank and non-bank financial institutions.

In an effort to also supervise, OJK issued regulations in POJK No. 51 / POJK.03/2017 regarding the implementation of sustainable finance for financial service institutions, issuers and public companies. This regulation implements a sustainability report for each company that is reported to the OJK every year. This is an effort so that Stakeholders can indirectly supervise and provide a sense of security, as well as consideration for decision making for Stakeholders

Several studies have examined the Sustainability Report, on family companies such as research from (Alfredo and Ivan, 2022) which examines the influence of companies with Family Ownership on sustainability practices, comparing the level of Stakeholder trust in the Sustainability Report issued by companies with family ownership and others. conducted by (Naciti, 2019) as well as research conducted by (Kumar et al. 2022) which examines the independent structure of the board of directors on sustainability disclosure. Past research only looked at the influence between the role of family ownership and the role of the board of directors on the Sustainability Report, but none saw the effect of family ownership between the Board of Directors and the disclosure of the Sustainability Report.

This study contributes to seeing whether family ownership as a moderator strengthens or weakens the relationship between the Professional Directors and the Sustainability Report in which banks are highly regulated companies that generally adhere to a Two Tier system that separates the owners (owners) and directors (managers). Do the previously mentioned internal factors have an impact on the company's willingness to disclose sustainability reports. Does a company with

family ownership make sustainability reporting better or vice versa and or these internal factors do not affect the reporting.

2. LITERATURE REVIEW

This study refers to several theories as follows: Stakeholder theory states that the company is not an entity that only operates for its own interests, but must provide benefits to its stakeholders (shareholders, creditors, consumers, suppliers, government, society, analysts and other parties) (Ghozali and Chariri, 2007). Legitimacy theory is a company management system that is oriented towards taking sides with the community, government, individuals and community groups (Gray at el, 1996), expressed in (Marsono and Yustia 2013), which means that this is a condition in which acceptance of the leader's decisions and the control holder has complied with procedures applicable to the general public and in accordance with appropriate political or moral values. And agency theory The interests between principals and agents in the company have differences where the principal tends to maximize the utility of his company and the agent tends to satisfy himself because he has more information than the principal which causes a conflict of interest (Charbel, Elie, and Georges, 2013 and 2013). Jensen and Meckling, 1976). This difference in interests between the principal and the agent is called the agency problem

This study also looks at the agency theory aspect of the relationship between principal and agent in developing and advancing the company, in this study the principal can be described from the ownership of the company, namely Family Ownership and agents who are presented as professionalism from the directors who run the company's operations. From these two factors, this study wants to see its relationship to social responsibility that is disclosed voluntarily by companies, namely sustainability reports.

A sustainability report is a performance report carried out by a company to measure, disclose, and manage change in order to open up sustainable activities. Sustainability Report is also a report that not only contains information on financial performance but also non-financial consisting of environmental and social performance activities, so that the company is able to grow sustainably (Elkington, 1997). This report provides an overview of how the company demonstrates its commitment to managing the company's risk for the business processes it carries out. SR reporting is a form of company transparency on its business activities.

Sustainability reports are also useful for companies to understand, measure and communicate the resulting economic, social and environmental impacts to stakeholders. The preparation of a sustainability report is an important thing, because it can be used by the government, the community, environmental organizations, the mass media to investors to assess the company's performance.

Kepemilikan Keluarga adalah Perusahaan yang dimiliki oleh keluarga sebagai suatu companies whose largest ownership is family or 20% individual ownership, Chi et al. (2014). Adiarti (2015:36) states that family ownership of a company is owned by a family if a family has 10% final ownership and or the family has a position on the board of directors or board of commissioners. Companies with family ownership have strengths and weaknesses. Thomas Zellweger (2017) mentions that there are at least 6 weaknesses that may occur in a family business, including: Dependence on the family, the emergence of agency costs due to altruism and agency problems with management, challenges in preparing successors, resource limitations, declining business orientation, and role ambiguous.

A board of directors is an executive committee that jointly oversees the activities of an organization, which can be a for-profit or non-profit organization such as a business, a non-profit organization, or a government agency. The board of directors who heads an organization consists

of: President Director, Finance Director, Operations Director, Technical Director, Marketing Director, GA & HRD Director, and so on. BOD is the highest position in the organizational structure, its personnel are appointed from potential employees or recruited from other companies. BOD is elected and dismissed by the commissioner as the owner of the company, through the General Meeting of Shareholders (GMS).

POJK No. 33/Pojk.04/2014 concerning the Board of Directors and Board of Commissioners of Issuers or Public Companies, has clearly regulated the provisions regarding the board of directors in detail starting from general provisions, appointments and dismissals as well as qualifications that must be possessed by the board of directors.

3. METHODS

Hypothesis Development

The dominance of share ownership by families, especially in Asia with the level of economic development of various countries makes it unique in terms of ownership and control by families (Claessens and Fan, 2002. Several cases of bank burglary are also commonly experienced by banks with family ownership, this is not regardless of the SOP of the troubled bank, or from the supervision of the bank itself. Research from (Setiyono 2015) on the effect of family ownership on performance and risk, the results of the analysis show that family ownership has a negative effect on performance and positive on risk. The argument is that banks with ownership families tend to have poor performance because they tend to want to gain profit for themselves, and are prone to risk (Fraud).In line with research (Alfredo and Ivan, 2022) which examines the influence of companies with family ownership on sustainability practices, research reveals that firms with family ownership are on average less involved in sustainability activities.

(Stutz and Schell, 2022) Examining stakeholder trust in the credibility of the disclosure of Sustainability Reports conducted by family and non-family companies, the results of the study reveal that the disclosure of Sustainability Reports to families does not affect the credibility of the report. This is different from research from Hsueh (2018), his research says that sustainability reports disclosed by family companies tend not to be credible from the view of stakeholders and vice versa.

For this reason, this study will look at empirically the disclosure of the Sustainability Report by banks with family ownership and others. The results will describe whether the disclosure of the Sustainability Report issued by banks in Indonesia tends to be carried out well by family ownership or not.

H1 Sustainability Report disclosures are lower in banks with family ownership than others

Independence is becoming increasingly crucial in banking because of the characteristics which are financial contracts, intangible assets and involve third party funds (the public). for example, modifying the risk and return profile, reaching a certain threshold associated with the bonus/compensation, as a signal of success, or reducing the risk of being taken over. Therefore, banks are also indicated to be susceptible to earnings management practices compared to other sectors (DeBoskey and Jiang, 2012).)

Independent of the board of directors can mean that the directors are appointed based on their professionalism or the ability of a person to the position. The professional qualifications of directors indicate the profession of expertise in certain fields can be from educational background, experience and training according to (Suhardjanto et al 2017), (Anjani 2019) and (Daghsson 2011), which means that directors are appointed from their expertise for the position not because of an affiliated relationship. both to the owner and the majority of shareholders or to other

directors, because these circumstances can reflect the work of the directors for the benefit of the company and not for another person or company and also companies in seeking independent directors will look for professional and high quality ones (Fairchild & Li, 2005).

The board of directors is also a factor in the sustainability of the company because of its vital position and power that can determine the direction and strategy of the company (Savitri, 2022). When viewed from the size, referring to research (Rahardja and Sukandar, 2014) stated the results of the study found that the size of the board of directors had a significant influence on the company's financial performance. This shows that a larger number of members of the board of directors will allow an increase in company performance.

Kumar et al., (2022) examined the independent directors on sustainability disclosure, the results of the study that a high number of independent directors did not increase sustainability disclosure

Kouaib, Mhiri (2020) examined the effectiveness of the Board of Directors on sustainability performance, the results of the study revealed that the effectiveness of the board of directors had an effect on economic and environmental performance but did not affect social performance.

Naciti (2019) researching the effect of the composition of the Board of Directors on sustainability performance found that companies with more diversity on the board and the separation between the roles of chairman and CEO (Professional Directors) showed higher sustainability performance and a higher number of independent directors led to higher sustainability performance. low.

Some of the studies above show negative results, meaning that between Professional Directors and Sustainability Performance have a negative influence. The argument is, the research was conducted on companies abroad which generally adhere to a one tier system where usually the owner of the company will act as management (director) of the company. Usually this system can be an advantage and a weakness for the company, the advantage is in determining the company's strategy that will prioritize the company because it is concerned with the owner's profits and quick decision making because the owner and CEO are the same person. In line with the research above, the high number of independent directors (CEOs and owners of different companies) will be a barrier to the company's sustainability performance.

In contrast to companies in Indonesia, especially in banking, which generally adheres to a two-tier system and directors are required to be independent, which means that directors are appointed from their professionalism, which appointments and dismissals are based on the performance of the Directors. This means that the owners or shareholders through the GMS will try to find the best Directors to be able to maximize the performance of the company, from the differences in the company system used from various countries, this study will empirically examine the positive influence of the professionalism of the directors on the disclosure of the Sustainability Report in banks listed in BEI.

H2 Professional Directors have a positive effect on the disclosure of the Sustainability Report

Substantively assessed family ownership is related to the professionalism of the board of directors, indirectly family ownership can affect the professionalism of the managerial, the argument is that the interests of the board of directors and the owner are different. Owners by all means will try to maximize their profits, directors will also try to maximize their performance (Zulkarnaen, 2020). This is in line with agency theory, where each (owner and manager) has a relationship with each other, but with different goals, because it is related to Ownership (Capital) and Managerial (Performance).

The issue of corporate governance and separation of ownership was first highlighted by (Berle and Means, 1932). Since then, various studies on the role of majority shareholders, independent directors have tried to examine and find solutions to these agency problems. The

majority of research uses agency theory as a theoretical basis (Mustakallio, 2002). Therefore, the Board of Directors becomes vulnerable in a company that is dominated, because the greater control causes the scope of the board of directors to be increasingly limited.
This study will empirically examine Family Ownership which can weaken the relationship between the professionalism of directors and the disclosure of the Sustainability Report. Research related to the role of family ownership as moderating was conducted by (Zulkarnaen, 2020), Researching Family Ownership Moderating the relationship between Corporate Governance Practices and Earnings Management, the result is that family ownership weakens the relationship between the two variables. The research shows that family ownership will affect governance practices within the company which allows for sustainability practices as well.

H3 Family Ownership Weakens the Relationship between the Professionalism of the Board of Directors and Disclosure of Sustainability Reports

OJK Regulation No. 55/ POJK.03/2016, chapter 2 Article 7 explains the rules for concurrent positions of directors. Whereas the board of directors is prohibited from holding concurrent positions as directors, members of the board of commissioners and executive officers at banks, companies and or other institutions and does not include concurrent positions for the supervisory function of bank participation in subsidiary companies, carrying out functional duties as members of the board of commissioners in non-bank subsidiary companies that controlled by the bank, because the board of directors can still hold concurrent positions in certain corridors which can affect the performance of the board of directors on their main duties. This situation can cause directors to have more than 1 job and can cause conflicts of interest between jobs which are feared to be detrimental to the company.

H4 Busy Director has a negative effect on the disclosure of the Sustainability Report

Research from (Rosmiyanti 2020) examines the Effect of Profitability, Leverage, and Company Size on Sustainability Report Disclosure. The results show that profitability has a negative effect on the Sustainability Report, leverage has a negative effect on the Sustainability Report, and company size has no significant effect on the disclosure of the Sustainability Report

H5 Firm Size has a positive effect on the disclosure of the Sustainability Report

Variable Operational Definition

1. Dependent Variable

The dependent variable in this study is the disclosure of the Sustainability Report in Banking which refers to the Regulation of the Financial Services Authority (POJK) No. 51/POJK.03/2017 concerning Sustainable Finance, in which the regulations attach a minimum of items that must be disclosed by the company. This study will measure the index score using the GRI standard. Because it can reveal the minimum standard according to OJK regulations, its general nature makes it possible to be understood globally and also refers to previous research studies using specific GRI standards on sustainability reports.

By using content analysis, each of which will give a value of 1 or 0 for each item, where a value of 1 will be given if the item on the index is disclosed by the company and will be assigned a value of 0 on the contrary. If scoring has been completed on each item, it will produce a level disclosure.
The calculation to determine the disclosure level carried out by (Lestari, 2013), (Husna, 2016) and (Latifah and Luhur 2017) is as follows:

$$Disclosure\ Level = \frac{Number\ of\ complied\ level}{Total\ score}$$

2. Variable Independent

The independent variables used in this study are
1.Family Ownership (Family Ownership),
The definition of family used in this study is as follows
Family (1) : Family is all individuals and companies whose ownership is registered (ownership of 5% and above must be recorded, except for public companies, State) and public, this definition of family is used by La Porta et al., (1999) Claessens et al. , (2000) and (Arifin, 2015)
Family (2) : Benefical owner In domestic and international commercial law, beneficial owners are natural persons or persons who ultimately own or control an interest in a legal entity or arrangement, such as a corporation, trust, or foundation.
Family (3): A company can be said to be a family, if there are individuals who have at least 20% and the highest shareholder, this definition is used by research (Chakrabarty, 2009) and (Kamalsan et al., 2013).

Based on observations, it is categorized into categorical variables (dummy variables) which are ownership structures by certain families, namely:
1 = Bank with share ownership in certain individuals, families and companies
0 = other.

2. Proportion of professional directors (Independent)
Professionals in this study are defined as individuals who have no affiliation with the owner of the company, the Board of Directors, the Commissioner and or the majority of the shareholders.
The results are obtained from the number of Directors who are not affiliated with company owners, directors, commissioners and the majority of shareholders

3. Variable Control

1. Busy Director is obtained from the percentage of directors who hold concurrent positions
2. Firm Size is obtained from loan total assets

Research Model
MODEL 1 $SR\ n,t = \propto + \beta 1FO + \beta 2PD + \beta 3BD + \beta 4Size + \varepsilon$
MODEL 2 $SR\ n,t = \propto + \beta 1FO + \beta 2PD + \beta 3FO * PD + \beta 3BD + \beta 4Size + \varepsilon$

SR = *Sustainability Report*

FO = *Family Ownership*

PD = Profesional Direksi

BD = *Busy director*

Size = *Firm Size*

FO * PD = Interaksi

4. RESULTS

Sampel Selection Result

No	Bank	Jumlah
1	Jumlah Bank Umum	109
2	Bank Umum yang terdaftar di BEI	46
3	Bank yang mengeluarkan laporan tahunan dan laporan keberlanjutan tahun 2015-2021	18

Based on the results of sample selection with several criteria previously mentioned in chapter 3, where the sample was taken from purpouse sampling with 3 criteria including, banks listed on the IDX, banks issuing financial reports from 2015 to 2021 and banks issuing sustainability reports. from 2015 to 2021.

Based on the data obtained and that meet the research requirements are 18 commercial banks. Banks with ownership of 10 samples are Bank BCA, Jtrust, Danamon, Maybank, Permata, Sinarmas, OKE, Artha, CCBI, OCBC and other banks are Bank BNI, BRI, Mandiri, BTN, BPD Jatim, QNB, CIMB. The total time used is 7 years, so the total sample in this study is 126 samples. The sample in this study belongs to the panel balance data where the cross-sectional unit has the same number of time series observations.

Descriptive Statistics Test

The conclusion is that when viewed as a whole from the table above, the disclosure of the Sustainability Report by each bank is still relatively low, judging from the lowest value the company only discloses 30% of the items available in the report, the average of all banking samples only reaches about 50% of the items disclosed. . Then when compared between banks with family and government ownership, state-owned banks show a higher level of disclosure in the Sustainability Report reaching 90%, which means that there are several banks that disclose 90% of items in the Sustainability Report, the bank is Bank BRI in 2020 and 2021 and Bank Mandiri in 2021 the two banks are the 2 largest banks in Indonesia based on total assets, this makes it important for banks to maintain good relations with stakeholders by sharing detailed information about the company.

Professional directors in banks with government ownership are more than banks with family ownership, this shows the qualifications and determination of the selection of a professional director is more stringent than banks with family ownership, the argument is that banks with family ownership can be controlled indirectly by only a few people and strong control This makes the selection of directors based on the benefits of only a few parties. This is in line with the disclosure of the Sustainability Report above, as disclosure by banks with other ownership is better, the argument is that reports under the performance of directors directly do not have dominant control and pressure on not disclosing sustainability reports.

Tabel 4. 1 Result Determining the Best Model

Model 1			**Model 2**		
Uji chow	0.000	**FEM**	Uji chow	0,000	**FEM**
Uji hausman	0.005	**FEM**	Uji hausman	0,001	**FEM**
Uji LM	0.000	**REM**	Uji LM	0,000	**REM**

Sumber : olahan penulis (2022)

Furthermore, the results of the lagrange multiplier test model 1 and model 2 show a chi-square cross section value of 0.000, which means that the selected test is REM, seen from the table above. (Fixed Effect Models)

Hypothesis testing

Tabel 4. 2 Result

Variable	Model 1		Model 2	
	Coefficient	Prob	Coefficient	Prob
FO	-0,16***	0,000		
PD	0,025***	0,01	0,049***	0,002
BD	-0,312**	0,051	-0,26**	0,054
Size	0,90***	0,005	0,10***	0,004
MI (FO*PD)	-	-	-0,50**	0,02

Sumber : olahan penulis (2022)

Based on the results from the table above, the probability of PD in the first regression is 0.01 which is smaller than 0.05 which indicates it has a significant effect, then in the second regression the probability value of MI which is moderation (FO*PD) is 0.002 which results is smaller than 0.05 which indicates it is significant. So it can be said that M1 is a Quasi Moderator

The professional influence of the board of directors on the disclosure of the Sustainability Report

The first hypothesis, the first hypothesis in this study is to examine the effect of family ownership on the negative effect of Sustainability Report disclosure. It is known that the Coefficient value is -0.16 and the significance value (Prob) is 0.000 which is <0.05 significant value. Then H1 is accepted, which means that family ownership has a negative and significant effect on the disclosure of the Sustainability Report. It can be translated that family ownership is lower on the disclosure of the Sustainability Report than others.

Judging from the Sustainability Report issued by banks with family ownership, they tend to be incomplete and less disclosed and although in 2017 the obligation for sustainability reports as of

2019 has been established, the Bank will then receive administrative sanctions in the form of written warnings and warnings, but in fact several There are banks that have not issued sustainability reports. This may be due to the fact that the cost of making this report is not small and banks with family ownership tend to present something that is profitable for the company because it is related to their large ownership in the company, but this does not mean that the quality of the Sustainability Report disclosed by banks with family ownership is not good.

The professional influence of the board of directors on the disclosure of the Sustainability Report

The professional influence of the board of directors on the disclosure of the Sustainability Report

The second hypothesis in this study is to examine the effect of the professionalism of the directors having a positive effect on the disclosure of the Sustainability Report. It is known that the Coefficient value is 0.025 and the significance value of Prob is 0.01, which is smaller than 0.05, the significant value is **H2 Accepted**, which means that professional directors have a positive effect on the disclosure of the Sustainability Report.

These results are consistent as previously stated that companies in Indonesia use a two-tier concept where management is usually not from the owner but is chosen from professionalism, so that management or directors will maximize their work because there is a supervisory system by stakeholders and even though the duties and authority of this sustainability report are are directly under the supervision of the board of directors, the statistical results of this study show that it is not an abuse to not report aspects of the sustainability report. However, the report that is disclosed does not necessarily indicate the quality of the report.

Family Ownership Weakens Relationships Between Professional Directors and Sustainability Report

The third hypothesis of this research is to test whether family ownership can weaken the relationship between professional directors and the disclosure of sustainability reports. It is known that the Coefficient value is -0.050 and the significance value of Prob is 0.02 which is smaller than 0.05 significant value, then **H3 is accepted**. These results can be interpreted as Family Ownership has a moderating effect in weakening the relationship between the Professionalism of the Board of Directors and the Disclosure of the Sustainability Report.

The argument is that family ownership can affect the professionalism of the board of directors in disclosing the Sustainability Report, this indicates a strong control owned by family ownership and the actions taken by the board of directors will greatly consider the ownership of the company.

Influence of Busy Director on Sustainability Report disclosure

The fourth hypothesis, the fourth hypothesis in this study is to test the effect of Busy Director having a negative effect on the disclosure of the Sustainability Report and it is known that the Coefficient value is -0.321 and the significance value of Prob is 0.051 which is smaller than 0.05, the significant value is then **H4 is accepted**. These results can be interpreted as Busy Director has a negative effect on the Disclosure of the Sustainability Report.

The argument is, Busy Director as measured by concurrent positions of directors in the company can indicate negligence of duty or conflict of interest from one position to another position or authority.

Effect of Firm Risk on Sustainability Report disclosure

The fifth hypothesis is to test the effect of firm size on the disclosure of the Sustainability Report and it is known that the coefficient value is 0.90 and the significance value of Prob is 0.005, which

is smaller than 0.05, the significant value is then **H5 is accepted**. These results can be interpreted as Firm Size has a positive effect on the Disclosure of the Sustainability Report.

6. CONCLUSIONS

Based on the results of the study, Family Ownership has a negative effect on the disclosure of the sustainability report. The results of the study are in line with previous studies by (Setiyono, 2015), (Stutz and Schell, 2022) and (Hsueh, 2018) which state that the factor of family ownership has a negative effect on sustainability performance. His argument is that family ownership tends to present something beneficial for companies because it is related to their large ownership of the company and is in accordance with research (Alfredo and Ivan, 2022) which says companies with family ownership are on average involved less in sustainability activities whose results are used for disclosure. on the sustainability report.

Professional Directors have an effect on the disclosure of the sustainability report. The results of this study show a positive value which means that the more professional directors the better the disclosure of the sustainability report. This study finds differences with previous studies by (Kumar ea al 2022), (Kouaib, Mhiri 2020) and (Naciti 2019) which shows that the independence or professionalism of the board of directors has no effect and has a negative effect on sustainability, in line with what is stated that the research was carried out abroad where generally the directors and owners are people who are or affiliated (one tier), which in determining policy will refer to personal gain and indirectly to the company, then the presence of independent directors will tend to weaken the company's performance, because independent directors will be very performance-oriented.

The research contributes to seeing the role of family ownership as a moderator that can weaken the relationship between professional directors on sustainability report disclosure, the results of the hypothesis show that family ownership can weaken the relationship between directors and sustainability report disclosure. These results are in line with estimates from research on agency problems, and family ownership can affect the professionalism of the directors in the disclosure of the Sustainability Report, this indicates the strong control owned by family ownership and the actions taken by the directors will greatly consider the ownership of the company.

Briefly write the conclusions of your study. Preferably it is in the form of paragraphs. At the end of your conclusion, it is customary to briefly describe the managerial implications of your work.

EFFECT OF DIGITAL TRANSFORMATION ON PERFORMANCE THROUGH DIGITAL INNOVATION AS A MEDIATION VARIABLE, CASE STUDY: APPLICATION OF CONTRACT PROCUREMENT MANAGEMENT SYSTEM PROGRAM IN CIPUTRA GROUP

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ABSTRACT

World companies including Indonesia's companies also need a good performance to run. One way or another companies need to join digital transformation as an invitation to Revolution Industry 4.0 for better performance. Digital transformation in companies is no longer an option considered in this industrial revolution, but a necessity because it will create new opportunities for companies with more informative, efficient, fast, and organizational services to become more agile. Although, there are 62% companies fail to implement digital transformation due to employee unpreparedness to make changes. Accordingly, this study aims to determine relationship and result of digital transformation on performance variable with addition of digital innovation on Case Study: Application Of Contract Procurement Management System Program (CPMS) in Ciputra Group which analyzed with Structural Equation Model Partial Least Square on SmartPLS. This study obtained that digital transformation effects good on performance worth to 0.647, but with additional of digital innovation effects better performance worth to 1.105. So, application of Contract Procurement Management System Program (CPMS) in Ciputra Grup is succeed and there are positive relationships for the three variables.

Keywords: Digital Transformation, PLS-SEM, digitalization, performance, digital innovation

1. INTRODUCTION

Worlds including Indonesia are getting ready to join Revolution Industry 4.0 with breakthrough for all industries through digitalization, such as banking, health sector, property, and household assistant all using artificial intelligent. Klaus Schwab as Chairman of World Economic Forum mentioned about Revolution Industry in his book titled The Fourth Industrial Revolution, that Revolution Industry basicly can change work style, life style, and also communications. For Indonesia, as mentioned by *Kementrian Komunikasi dan Informatika Republik Indoesia* at Making Indonesia 4.0 in 2018 there are most five sectors to join digital industry that accelerate Indonesia

vision as top ten world's largest economic. Digitalization in Indonesia is a nesecity also gives chances to accelerate sustainable development goals to services, connectivity, and efficiency in developing smart city, green city, and sustainability city. It will develop by government and also property developers in Indonesia. Digital transformation needs colaboration of digital savvy leadership, culture, and information technology. Digital transformation in companies is no longer an option considered in this industrial revolution, but a necessity because it will create new opportunities for companies with more informative, efficient, fast, and organizational services to become more agile. Although, there are 62% companies fail to implement digital transformation due to employee unpreparedness to make changes.

These constraints may happen in Ciputra Grup especially in Construction and Development team, as pre-selling team commited to follow digitalization on every jobdesc such as planning, tender, constructing, and payment which is before using manual program Lotus and Ms. Office. Ciputra Group as a company wants performance run good so join digital transformation with Contract Procurement Management System (CPMS) as support of digital innovation in this company. This program aims to help Construction and Development team to make workorder by project manager, continue to quantity surveyor to calculate owner estimate and contract for contractor, then send to supervisor to do field progress. This program also aims to make paperless works so works can be finished anywhere and everywhere as long as connected to internet.

Accordingly, this study aims to determine relationship and result of digital transformation on performance variable with addition of digital innovation on Case Study: Application of Contract Procurement Management System Program (CPMS) in Ciputra Group which analyzed with Structural Equation Model Partial Least Square on SmartPLS. SEM-PLS aims to test the relationship between variables directly or indirectly. And SEM is defined as a multivariate analysis technique where this analysis technique is a combination of regression analysis and factor analysis. SEM analysis can also measure latent variables and can analyze three variables simultaneously, namely validity checks and realibility instruments.

Some similar studies have been done with SEM-PLS, three variables also used in this study: relation of digital transformation to performance through digital innovation, relation of transformation digital to performance, relation of transformation digital to digital innovation, relation of digital innovation to performance. In pursuit to know the relation of digital transformation to performance through digital innovation has been studied by Kurniawan, Rahayu, dan Wibowo (2021), Yeni dan Arie (2021), Youssef dan Lebdaoui (2020). Relation of digital transformation to digital innovation has been studied by Satyani dan Sundiman (2021), Fransesco et al (2019). Relation of digital transformation to performance has been studied by Guzman-Ortiz (2020) and relation of digital innovation to performance has been studied by Khin dan Ho (2018).

Those studies have not fully provided information on the positive relationship between digital transformation and performance in the property sector, so in this study is expected to know the relationship and how effect of digital transformation of the company through digital innovation the Contract Procurement Management System program improves the performance of Ciputra Group employees, especially the Construction and Development department. In this study takes surveys for ten projects of Ciputra Group around Central Java and East Java, with total 102 end users of CPMS including quantity surveyor, head of divisions, manager, general manager, associate director and director.

2. LITERATURE REVIEW

Mentioned by Szosda (Pasaribu, 2021), that industry revolution appeared in every aspect of life with digitalization including companies' activity and increasing productivity, efficiency,

and lifestyle quality. Gartner says that companies need to apply digital transformation to increase business growth because 87% companies agree to it and 13% feels digital transformation is a threat. Accordingly, this alteration needs management to commit to apply digital transformation. Alteration Management as Nauheimer (2009) says that this aim to approach teams, individuals, even organization to change. By the time applying this alteration, there must lead by digital savvy leader even though will occur some constraints and challenges ahead such as culture, savvy leader, resources, teamwork, and information security system. By applying digital transformation, the company is able to save the budget in all aspects of both aspects of processes, labor, marketing, and even processes in management and helps accelerate the development of the company by increasing the margins obtained by the company.

2.1. Digital Transformation

This digital transformation is one of the changes in today's companies in facing the era of globalization in order to become dynamic. Digitalization is also a business where digital convection functions communication, interaction and business. Digitalization complements the transformation by migrating business processes, functions, and business models to digital technologies (Qlausa, 2018). As reported by Republika.com in an interview with Mevira Munindra, Senior Research Manager for Consulting and Head of Operations at International Data Corporation (IDC) Indonesia mentioned success indicator of digital transformation are digitally-savvy leadership style, active online, product innovation, customer advocacy, colaborative workplace, simplified work operation, and employee development.

2.2. Digital Innovation

Digital innovation as strategic alteration is a need to show good performance to survive for future challenges, it needs innovative action and critical thoughts (Siagian, 2007). As mentioned by Lussier (1997), alteration of companies consists of strategic, technology, and human alteration. Technology alteration consists of software, networking, auto process, and etc. As mentioned by Palandino in Khin (2018), success indicator of digital innovation are a better quality and feature of digital solution/innovation, and how easy the application works and upgrades from existing competitors.

2.3. Performance

Bates, RA and Holton F (2011) explain that performance is a concept and a management process with outcome result given from planning process, development, evaluation, and rewarding to best labor. Performance also connects to productivity which is growing colaboration between people and department. Hery tells about performance on *Manajemen Kinerja* (2020) that performance leads to productivity, so indicators of perfomance are productivity, timelines, work quantity, understanding of work, coordination between individuals or departments.

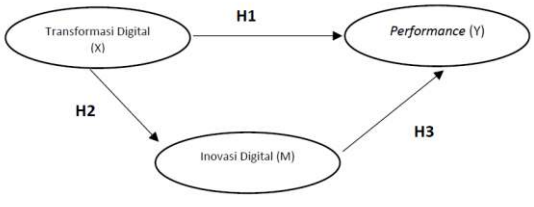


Figure 1. Conceptual Framework

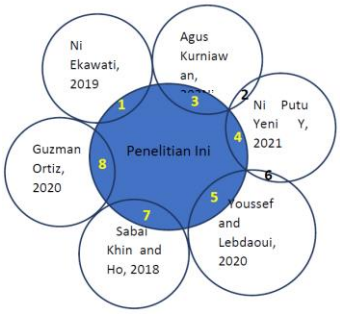


Figure 2. Research Position

In this study refers to some research that has been done before as seen on Figure 2, 1.7 Adoption of digital innovation variables as mediation variables, 2,6,8 Adoption of SEM-PLS, 3 Adoption of digital transformation variables to performance, and 4.5 Adoption of digital transformation

variables to performance. Concept of this study as shown to Figure 1, with H1: Digital transformation have positive relationship and significant to performance, H2: Digital transformation have positive relationship and significant to digital innovation, H3: Digital innovation have positie relationship and significant to performance.

Structural Equation Modeling was chosen as a better alternative compared to using path analysis, multiple regression, factor analysis, time series analysis, and covariance analysis on the grounds that allows flexible assumptions, can be used in confirmatory study, and less variable can be run.

3. METHODS

In this study determined as confirmatory study, based on previous studies to confirm an existing result or theory with hyothesis mentioned. As seen on conceptual framework, variables are being identify as exogent variable (X1) is digital transformation that effects performance, endogent variable (Y) is performance that effected by digital transformation, and intervening variable (X2) is digital innovation that strengthen/weakened the relationship between digital transformation and performance (Santoso, 2014). These variables are made of indicators (reflective model), reflective indicators do not effects variables as seen on Figure 3 below.

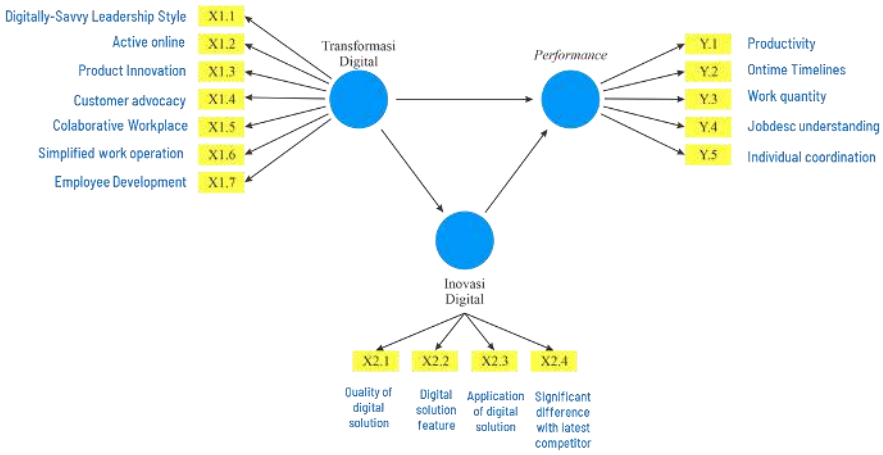


Figure 3. Path Diagram

These indicators are the numbers to be questionned in questionnaire that disseminated to 10 projects of Ciputra Group that spread all over Central Java and East Java, with total of 102 end users of web program CPMS consist of quantity surveyor, quantity surveyor division head, construction division head, infrastructure division head, supervisor, manager, general manager, associate director, and director. Questionnaire will be analyzed with descriptive statistic and inferensial statistic.

3.1. Descriptive Statistic

According to Salvatore and Reagle (2002), descriptive statistics is defined as a data processing technique to obtain the mean value of the variance, standard deviation of variables, total values, minimum and maximum values, and skewness of data to help the picture of the data to be analyzed. Descriptive statistics simply describe the data without presenting the relationships between the existing variables.

3.2. Inferensial Statistic

Inferential statistics is a type of statistic used to test numerical data that will be used by analyzing, estimating, and drawing conclusions from existing data by giving random distribution assumptions with parameter variables as the basis, (Salvatore and Reagle, 2002). Inferential statistics used in this study using the Partial Least Squares – Structural Equation Modelling (PLS-SEM) method which consist of outer model and inner model.

a. Outer Model

Outer model used to explain relationship of indicator and latent variable. To analyze this measurement model, two tests are needed: convergent validity testing and discriminant validity testing, and the indicator block will be tested using composite reliability.

Convergent validity testing is used to measure the correlation relationship between the construct and component score. According to J.F. Hair et al (2013), convergent validity testing can be declared high if it correlates with values of more than 0.7 and is considered sufficiently valid with a value of 0.5 – 0.6 at the research stage. The discriminant validity test will be measured using cross correlation with the construct with the expectation that the output of the indicator being tested has a higher loading value than other constructs. If the test results are obtained invalid indicators, the distribution of questionnaires and / or retesting is carried out.

The reliability test according to Hartono (2011), it is stated that this test can be measured through the Croanbach Alpha value which is said to be reliable when the value exceeds 0.6 and the composite reliability value must exceed 0.7 and this reliability test has the aim of producing the same results in many tests and guaranteeing the stability and consistency of the instruments used, (Silaen & Widiyono, 2013: 107)

b. Inner Model

The tests in this study used SEM-PLS using the SMARTPLS application. Inner Model is used to predict the relationship of latent variables that have been tested using R-square test, Q-square test, and path coefficient. Testing inner models can use Bootstrapping help on SmartPLS applications. R^2 uses in every latent endogen variable to predicted structural model, (Chin, 2011). R^2 expressed by range 0-1 with strong (0.67-1), medium (0.33-0.66), and weak (0.19-0.32). Q^2 is explained how well the observation value generated by the model, Q^2 is a combination of R^2 shown in :

$$Q^2 = 1 - ((1 - R_1^2)(1 - R_2^2) \ldots .. (1 - Rj^2))$$

With:

R_1^2 R_2^2 ….. $Rj2$ is R-square variabel endogen in model

Q^2 is determinate coefficient of total path analysis

Path coefficient is able to explain the size of the magnitude of the relationship ability between latent variables. The significance of this path coefficient can be seen from the t value obtained through SEM-PLS bootstrapping. If the value obtained by the t-test > t-statistics, the results are said to be significant. The result of the path coefficient can also be seen through the p-value. If the p-value < Alpha then it is concluded that the hypothesis that has been made is supported.

4. RESULTS

Descriptive statistic only used for present data according respondents' answers. In this section present gender, position, length of work, and projects as shown in tables below.

Table 1. Respondent' Gender

Gender	Respondent	%
Female	24	23.53
Male	78	76.47
TOTAL	**102**	**100**

Table 2. Length of Work

Time	Respondent	%
<1year	8	7.84
1-5years	30	29.41
6-10years	24	23.53
>10years	40	39.22
TOTAL	**102**	**100**

Table 3. Position in Projects

Position	Resp	%
QS	13	12.75
Div. Head QS	6	5.88
Div. Head Construction	4	3.92
Div. Head Infrastr	7	6.86

Table 3. Position in Projects (contd)

Position	Resp	%
Supervisor	50	49.02
Others	22	21.57
TOTAL	**102**	**100**

Table 4. Projects

Gender	Resp	%
CitraSun Garden Semarang	7	6.86
CitraGrand Semarang	13	12.75
CitraLand Surabaya	17	16.67
Citraland The GreenLake Surabaya	7	6.86
CitraLand Utara Surabaya	15	14.71
CitraLand CBD Driyorejo	6	5.88
CitraGarden Sidoarjo	9	8.82
Citra Harmoni Sidoarjo	8	7.84
CitraLand Puncak Tidar Malang	10	9.80
The Taman Dayu Pandaan	10	9.80
TOTAL	**102**	**100**

As shown in the tables, 10 projects dominated male respondents, with the most respondents have been working in Ciputra Grup for >10years, and position dominated by supervisor and others (managers, GM, director). And the result of variables with likert scale on every indicator shown in Figure 4, 5, 6.

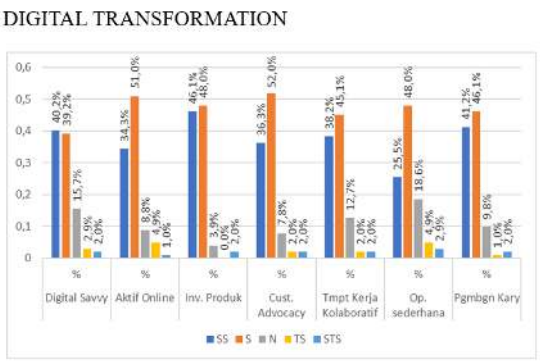


Figure 4. Descriptive Analysis Digital Transformation

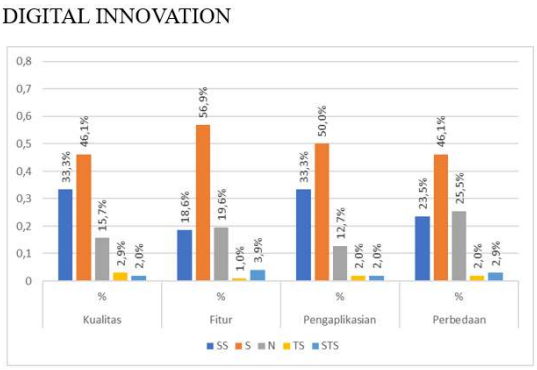


Figure 5. Descriptive Analysis Digital Innovation

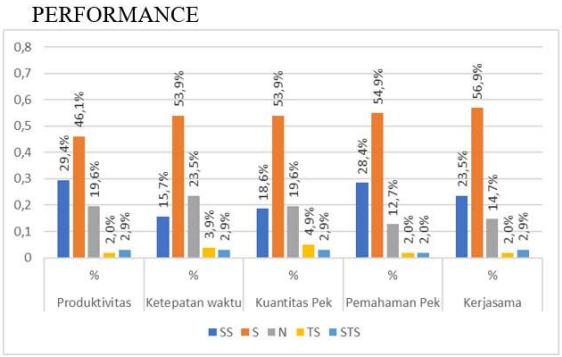


Figure 6. Descriptive Analysis Performance

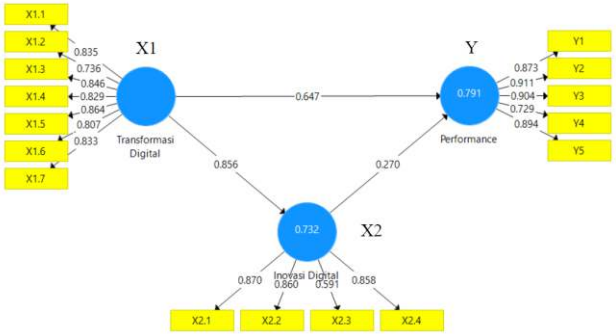


Figure 7. Path Diagram

From these figures, shown that indicators are varies. Then, relationship between three variable is shown in Figure 7 analyzed by SEM-PLS using SmartPLS. We have to check the variable if its valid or reliable or not by validity and reliability test. Condition of valid indicators checked by loading factor > 0.5 means valid and cross corelation test. For reliability test, variable is reliable by checking Croanbach Alpha and Composite Reliability > 0.6. By checking to figure 5 and table 5, concluded that indicators and variables are valid and reliable .

Table 5. Respondent' Gender

Variable	Croanbach Alpha	Comp. Reliability
X2	0.810	0.877
X1	0.920	0.936
Y	0.914	0.936

Table 6. Goodness Fit of Model

Variable	R^2
Digital Innovation (X2)	0.732
Performance (Y)	0.791
$Q2 = 1 - (1 - R_1^2)* (1 - R_2^2)$	
$Q2 = 1 - (1 - 0.732)* (1 - 0.791)$	
$= 0.944$	

After stated valid and reliable, we calculate R^2 and Q^2 to know the ability of exogenous variables to explain the diversity of endogenous variables, or in other words to know the magnitude of the contribution of exogenous variables to endogenous variables as shown at table 6. Q-Square predictive relevance (Q2) of 0.944 or 94.4%. This can show that the diversity of data is able to be explained by the entire model by 94.4%, meaning that the model is able to explain well the data owned. While the remaining 5.6% was explained by other factors that were not involved in this study.

Table 7. Hypothesis Effect

Direct Effect					
Hypo	**Path**	**Coef**	**T- Statistic**	**p-values**	**Conclusion**
H3	X2 → Y	0.270	2.132	0.034*	Supported
H2	X1 → X2	0.856	17.727	0.000*	Supported
H1	X1 → Y	0.647	5.106	0.000*	Supported
Indirect Effect					
H4	X1→ X2 → Y	0.231	1.978	0.049*	Supported

*p-value significant ≤ 5%

From Table 7 inform that digital innovation to performance (X2 → Y) has significant effect based on p-value < 5% and coefficient has positive value, so hypothesis accepted and higher digital innovation, greater performance. Digital transformation to performance (X1 → Y) has significant effect based on p-value < 5% and coefficient has positive value, so hypothesis accepted and higher digital transformation, greater performance. Digital transformation to performance (X1 → X2) has significant effect based on p-value < 5% and coefficient has positive value, so hypothesis accepted and higher digital innovation, better digital innovation. it can be seen that direct effect and indirect effect are both significantly positive, where Digital Transformation on performance has a positive relationship, and digital innovation is partial mediation. So it is concluded that Digital Transformation has a positive relationship with performance, but with the existence of Digital Innovation, the relationship between Digital Transformation and Performance is getting better for using Contract Procurement Management System (CPMS) in Ciputra Group.

6. CONCLUSIONS

From the above point, it is concluded that good performance can be obtained through digital transformation of 0.647 (point 1), but by adding support for digital innovation as mediation, performance is stated to be getting better by 1,105 (points 2 and 3). So that the existing theories and hypotheses are supported and accepted, where there is a positive relationship between digital transformation and performance supported through digital innovation as an intermediary where in this research through digital innovation web cpms program applied in Ciputra Group, and Ciputra Group is said to be successful in digital transformation and does not fail.

This research is expected to benefit related parties, especially for Ciputra Group that it can be an evaluation and become a reference to increase digital innovation and maximize the digital innovation developed, namely the Contract Procurement Management System (CPMS) both in terms of quality, ease of online activities and connectivity, the features of the digital program are made more user-friendly so that performance in the department becomes better. Suggestions for further research can be applied with other digital innovation programs using reference models, variables, and indicators in this study. In subsequent studies, it is possible to have different results from the results of this study because the number and answers of respondents affect the test results. To get better results, in subsequent studies can add variables and indicators because the more factors studied, clearer the results will be.

REFERENCES

Ahmad, S., Zulkarnain, N., dan Khairushalimi, F. (2016). Assessing the Validity and Reliability of a Measurement Model in Structural Equation Modeling (SEM). *British Journal of Mathematics & Computer Science*. Vol. 15, Issue 03, page 1-8. E-ISSN: 2231-0851.

Asbari, M., Purwanto, A., dan Santoso, P.B. (2020). Pengaruh Iklim Organisasi dan Kepemimpinan Transformasional Terhadap Produktivitas Kerja Inovatif Pada Industri Manufaktur di Pati Jawa Tengah. *Jurnal Produktivitas 7 (2020)*. E-ISSN: 2621-5098

Darwin, M. (2020). Indirect Effect Analysis on Structural Equation Modeling Comparative Study of Using Amos and SmartPLS Software. *Nucleus*. Vol. 01, Issue 02, page 50-57.

Hery. (2019). *Manajemen Kinerja*. Jakarta: Grasindo.

Haryono, S., dan Wardoyo, P. (2014). Structural Equation Modeling (H. Mintarjda (ed.)). *PT. Intermedia Personalia Utama.*

Febrianty., Revida, E., Simarmata, J., Suleman, A., Hasibuan, A., Purba, S., Butarbutar, M., dan Saputra, S. (2020). Manajemen Perubahan Perusahaan Di Era Transformasi Digital. *Yayasan Kita Menulis*. ISBN: 978-623-7645-99-3.

Khin, S., dan Fei Ho, T. (2018). Digital Technology, Digital Capability and Organizational Performance: A Mediating Role Of Digital Innovation. *International Journal of Innovation Science.* Vol. 11 No. 2, pp. 177-195. E-ISSN: 1757-2223.

Kurniawan, A. (2021). Pengaruh Transformasi Digital Terhadap Kinerja Bank Pembangunan Daerah di Indonesia. *Jurnal Ilmu Keuangan dan Perbankan (JIKA)*. Vol 10, No. 02, page 164-166. E-ISBN: 2655-9234.

Mihardjo, L. W. W., Sasmoko, Alamsjah, F., dan Elidjen. (2019). Digital Leadership Role In Developing Business Model Innovation And Customer Experience Orientation In Industry 4.0. *Management Science Letter*. Vol. 9, Issue 11, pp. 1749-1762, E-ISSN: 1923-9343.

Nambisan, S., Wright, M., dan Feldman, M. (2019). The Digital Transformation Of Innovation And Entrepreneurship: Progress, Challenges And Key Themes. *Research Policy*. https://doi.org/10.1016/j.respol.2019.03.018.

Ortiz-Guzman, Navarro-Acosta, Florez-Gracia, dan Vincente-Ramos. (2020). Impact Of Digital Transformation on The Individual Job Performance Of Insurance Companies In Peru. *International Journal of Data and Network Science* 4 (2020) 337-346.

Prietno, R. (2018). *Validitas Dan Reliabilitas Data*. Jakarta: Web Page http://www.jendelastatistik.com/2016/11/validitas-dan-reliabilitas-data.html.

Saputra, N. (2021). *Transformasi Digital dalam Perspektif Manajemen Strategis*. Jakarta: Universitas Binus.

Wichmann, J., Sandkuhl, dan K., Wißotzki, M. (2020). *Architecting the Digital Transformation*. Germany: Springer, Cham.

Yuliantri, Ni Putu., dan Pramuki, Ni Made W. (2021). The Role of Digital Transformation and Digital Innovation to SMEs Performance in Bali-Indonesia. *International Journal of Science and Management Studies (IJSMS).* Vol. 4 Issue 6 page 8-13. E-ISSN: 2581-5946.

Yasa, Ni Nyoman K., Ekawati, Ni Wayan., dan Rahmayanti, P. L. (2019). The Role of Digital Innovation In Mediating Digital Capability On Business Performance. *European Journal of Management and Marketing Studies*. Vol. 4, Issue 02, page 111-128. E-ISSN: 2501-9988.

Youssef, C., dan Lebdaoui, H. (2020). *The Impact of Digital Transformation on SMEs Organizational Performance: The Mediating Effect Of Digital Innovation*. Irlandia: Conference EURAM.

WORKLOAD ANALYSIS AS ALLOCATION OF OPTIMAL WORKFORCES EVALUATION ON UNLOADING COAL PROJECT USING NASA-TLX

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ABSTRACT

Determining policies for workforce planning is one of the most important issues in the organization, because planning result from the wrong analysis can ultimately lead to an over or under supply of workforces. PT XYZ is a company that has core businesses in loading and unloading coal and sea transportation. In providing the coal unloading services using four cranes with operating hours of 24 hours and 7 days, PT XYZ allocating 40 crane operator which are divided into 5 operator groups where each group consist of 8 crane operators with manning scale 2 operators for 1 crane. PT XYZ using shift work system where there are 3 shifts per day and each shift consists of 8 hours of work. Data of unloading activity working hours and manhours of operators which obtained from 2019 to 2021 indicating that there are large gaps between manhours and unloading activity working hours with average of operator utilization rate from 2019 until 2021 is 30% per year. Due to workloads have a detrimental effect whether they are too much or too low, in this study the researchers would like to find how much workload of the PT XYZ crane operator obtained in the current working system using the NASA-TLX method. The results showed that the crane operator's workload condition was still below the maximum workload value which was considered acceptable. By considering the crane operator's workload conditions, the evaluation of the optimal workforce allocation can be determined to be 5 crane operators for each group or with manning scale of 5 operators for 4 cranes. The recomanded allocation is generating the level of operator utilization up to by 21% per year.

Keywords: Workload, NASA-TLX, Workforces Allocation

1. INTRODUCTION

Determining policies for workforce planning is one of the most important issues in the organization, because planning result from the wrong analysis can ultimately lead to an over or under supply of workforces (Assi and Effanga 2021). Overstaffing is often associated with increased budgetary burdens on the firms (Ahmed 2007; Al-Kayed 1999). Nevertheless, understaffing could also be as expensive as overstaffing due to decreased of productivity or inability of the company to meet customer needs and agreed commitment (Ahmed 2007; Fenn 1995). There are several method to analyse workforces allocation for the company such as trend analysis, ratio analysis, managerial judgement and mathematics model (Dessler 2020). However,

it is important to find out human factors in determining number of worforces allocation. Human factors validation consequently includes the evaluation of workload and its implications for safe and efficient operation (Braarud 2020). Therefore, the company need to measure worforces workload as consideration before determining or evaluating workforces allocation.

One of the most widely used measurement tools to assess subjective workload of individuals operating in high-risk, time sensitive industries is the National Aeronautics and Space Administration Task Load Index (NASA-TLX). The NASA-TLX is a six-item scale that was initially developed to measure workload in laboratory-based aviation settings and has since been applied to workload measurement in other sectors such as nuclear energy, transportation, and increasingly in health care (Hart and Staveland 1988; Hwang et al. 2008; Mazur et al. 2012; Tubbs-Cooley et al. 2018). The subjective report related to perceptions of physical or mental work generally reflects to the nature of the task that demands physical and mental resources (Braarud 2021).

This research take PT XYZ as a case study workload analysis as allocation of optimal workforces evaluation on unloading coal project using NASA-TLX. PT XYZ is a company which was founded in 1997 with core business loading-unloading of coal barges and sea transportation. Currently PT XYZ executing unloading coal project in one of Indonesia power plant. To delivering the project which required 24 hours and 7 days operation, PT XYZ utilize 40 crane operator which devided into 5 groups and 3 shifts to operate 4 crane on eastern and western jetty of the power plant. For 8 hours, 1 crane will be operated by 2 crane operator where in the other overseas ports the manning scale is found different. In Australia, New Zealand, United States and Japan the manning scale is 2 operator for 1 crane, while in Malaysia, Singapore and United Kingdom is 1 operator for 1 crane (Productivity Commission 1998).

Refering to PT XYZ unloading activity data, there are significant gap between unloading activity working hours and manhours of the crane operator. The gap resulting average workforces utilization rate from 2019 until 2021 are below utilization rate of workforces in the general industry. It was found that the average workforces utilization rate is 30% where the most organizations will aim for arround 80% utilization to account for these other tasks and commitments (Jay 2021). Furthermore large sizes of unloading operations often used to lead some workers leaving work early without permission, while still being paid for the full shift and has generally been higher on night and evening shifts because of less supervision which is known as “nick”. As long as this practice has continued, it may indicate lower manning scales or low workforces utilization (Productivity Commission 1998). Based on client information, the projection of tonnage of unloading coal in 2022 ahead also will decrease 27% from 7.000.000 MT to 5.500.000 MT. Therefore evaluation of current workforces allocation of unloading coal project shall be performed by considering workload of workforces as from the earliest studes quickly revealed the deleterious effect of workload that is either too high or too low(Casner and Gore 2010).

2. LITERATURE REVIEW

(Hart and Staveland 1988) defined workload as hypothetical construct that represents the cost incurred by a human operators based on their capacity to achieve a particullar level of performance on tasks with certain demands; (Haga, Shinoda, and Kokubun 2002) defined workload as the degree of processing capacity that is expanded during task performance that describe relationship between resource supply and task demand. (ILO 2016) defined workload hazard conditions are work overload or underload, lack of control pacing, high levels of time pressure. The earliest studes quickly revealed the deleterious effect of workload that is either too

high or too low. Humans who are overburdened with work tend to hurry their performance, commit more errors, yield poor accuracy, become frustrated, uncomfortable, and fatigued, and have poor awareness of their surroundings. However, humans who are underworked can exhibit many of the same symptoms. Low workload has been linked to high error rates, frustration, fatigue, and poor awareness of surroundings as they become bored, as their attention drifts, and as complacency sets in. (Casner and Gore 2010). There are 2 type of workload, mental workload and physical workload.

2.1 Mental Workload.

Mental workload defined as workload which related to human mental or brain. Mental worklod involves the brain work or white collar. The white collar resulting mental activities is heavier than phisical activities or blue collar (Pracinasari 2013). There are two method to measure the mental workload. The first is objective measurement, performed by measuring the variability of heart rate, eye blink or also known as the flicker test and measurement of salivary acid levels and special tools are needed to carry out the measurement. The second method is subjective mesurement. There are several tools to carry out the subjective measurement such as subjective workload assessment technique (SWAT), rating scale mental efforts (RSME), and national aeronautics & space administration task load index (NASA TLX).

One of the most widely used measurement tools to assess subjective workload of individuals operating in high-risk, time sensitive industries is the (NASA-TLX) or National Aeronautics and Space Administration Task Load Index (Hart and Staveland 1988; Hwang et al. 2008; Mazur et al. 2012; Tubbs-Cooley et al. 2018). NASA-TLX consist of six indicators which more details than SWAT and RSME. Therefore NASA-TLX most widely used to measure the workload. The NASA-TLX indicators measure the different aspect which experienced by the respondend specifically mental demand (KM), physical demand (KF), temporal demand (KW), frustation (TS), performance (PK), and effort (U). If the respondend feels that working under pressure represents workload, then temporal demand may best capture the level of his workload, as he sees it. The six indicators combined to accommodate six different ways of experiance of workload. **Table 1** describing NASA-TLX indicators definitions.

Table 1. Six Scales NASA-TLX Indicators

Item	Scale	Descriptions
Mental Demand	Low/High	How much mental activity was required (i.e. thinking, deciding, calculating etc.)? , How much perceptual activity was required (i.e. remembering, looking, searching, etc.)
Physical Demand	Low/High	How much physical activity was required (i.e. pushing, pulling, turning, controlling, activating etc.)?
Temporal Demand	Low/High	How much time pressure did you feel due to the rate or pace at wich the task or task elements occurred?
Frustration Level	Low/High	How insecure, discouraged, irritated, stressed and annoyed during the task?
Performance	Good / Poor	How successful do you think you were in accomplising the goals of the task ?
Effort	Low/High	How hard did you have to work (mentally & physiscally) to accomplish your level of performance

2.2 Physical workload.

Physical workload is a workload that is directly related to the physical or muscle of the human, for example lifting and moving objects (Tarwaka et.al 2004). Government of Indonesia has establish method how to measure the physical workload. The method was regulated on (Keputusan Menteri Pendayagunaan Aparatur Negara 2004) which consist 3 parts as input to determined time to complete the task which related to physical workload of workforces or how many workforce need to complete the task. The 3 parts are workload, average ability standard and processing time.

In most application, the workload measurement was performing to look the workload experianced by the respondend only. (DiDomenico and Nussbaum 2008) presented that existing subjective assessment tools created for one domain appear to be usefull when evaluating multitask situations requiring substantial mental and physical activity. (Young, Zavelina, and Hooper 2008) also presented the measurement of the post-anesthesia nursing workload to evaluate the staff workload which found that the staff shortage that occured in the study increased the workload of the staff causing concerns the level of care quality provided. Nevertheless the both of researchs not providing the optimum allocation of the workforces needed. Workload measurement has been considered to allocate the number of workforces. (Arsi and Partiwi 2012; Rachmuddin 2020; Terranova 2014) performing study to determine workforces allocation with considering workload with subject university, warehousing and engineering services. The object of this study is workforces for unloading coal project which havent been found in other study. Furthermore, there is no standard to allocating number of crane operator especially which considering the crane operator workload.

3. METHODS

Data collection is divided into primary and secondary data. The primary data is obtain from operational activity data of PT XYZ and results of NASA-TLX questionare from respondents, where the respondents or the objects of this study are crane operator. NASA-TLX questionare will be given to the crane operator which consisting of two parts, first is compairing the indicators using Pairwise Comparison. For first part, the crane operators will be asked to choose one most influential of the fiteen pairs of available indicators according to NASA-TLX. The second part is indicator weighting section. In the second part respondent will be asked to provide a percentage for each indicator according to the workload experianced crane operators at work. For the secondary data, data is obtain from PT XYZ. The data includes number of operators, job descriptions as well as direct observation and interview to ensure that the work carried out is similiar with the job description. If there are discrepancies, the task will be added in the data study.

Data processing will be carried out from the data which have been obtained both primary and secondary data. The results of pairwise comparison and weight of six indicators are combined into Weighted Workload (WWL). The next step is calculating the number of crane operator needed based on GOI regulation KEP/75/M.PAN/7/2004. Multiplication of number of jobs carried out in a day and duration of the jobs will be devided with the effective working hours. The results will providing number of workforces needed by the user or the company.

4. RESULTS

4.1 Data Processing

The NASA-TLX meaurement is perform to 40 crane operator of PT XYZ. The WWL of crane operators are summirized in table **Table 2 – 6** respectively**.** Normality test is perform to

determine wheter the WWL data normally distributed. The test method is Kolmogorov-Smirnov using SPSS version 26 which shown on **Figure 1.** The result indicating that the data is normally distributed with mean of WWL is 44,45. The mean of WWL categorized as somewhat high. (Fernandes 2016) stated that workload levels below 50 were perceived as acceptable; (Ramadhan et al. 2014) stated that the normal point of the NASA-TLX is 60, however (Fernandes 2016) also found that high levels of workload (>70) were in some situations perceived as acceptable.

Table 2. WWL Crane Operators Group 1

Operator #	WWL	Workload Category
Group 1		
Operator 1	18	Medium
Operator 2	58	High
Operator 3	49	Somewhat High
Operator 4	48	Somewhat High
Operator 5	33	Somewhat High
Operator 6	54	High
Operator 7	69	High
Operator 8	18	Medium

Table 3. WWL Crane Operators Group 2

Operator #	WWL	Workload Category
Group 2		
Operator 9	9	Low
Operator 10	45	Somewhat High
Operator 11	34	Somewhat High
Operator 12	33	Somewhat High
Operator 13	46	Somewhat High
Operator 14	59	High
Operator 15	58	High
Operator 16	16	Medium

Table 4. WWL Crane Operators Group 3

Operator #	WWL	Workload Category
Group 3		
Operator 17	43	Somewhat High
Operator 18	49	Somewhat High
Operator 19	43	Somewhat High
Operator 20	61	High
Operator 21	31	Somewhat High
Operator 22	58	High
Operator 23	54	High
Operator 24	13	Medium

Table 5. WWL Crane Operators Group 4

Operator #	WWL	Workload Category
Group 4		
Operator 25	76	High
Operator 26	55	High
Operator 27	30	Somewhat High
Operator 28	27	Medium
Operator 29	41	Somewhat High
Operator 30	78	High
Operator 31	56	High
Operator 32	28	Medium

Table 6. WWL Crane Operators Group 5

Operator #	WWL	Workload Category
Group 5		
Operator 33	50	High
Operator 34	59	High
Operator 35	51	High
Operator 36	62	High
Operator 37	51	High
Operator 38	32	Somewhat High
Operator 39	48	Somewhat High
Operator 40	35	Somewhat High

One-Sample Kolmogorov-Smirnov Test

		Beban Kerja
N		40
Normal Parameters[a,b]	Mean	44.4500
	Std. Deviation	16.75150
Most Extreme Differences	Absolute	.109
	Positive	.072
	Negative	-.109
Test Statistic		.109
Asymp. Sig. (2-tailed)		.200[c,d]

a. Test distribution is Normal.

b. Calculated from data.

c. Lilliefors Significance Correction.

d. This is a lower bound of the true significance.

Figure 1. Result of WWL Normality Test

The next step result, processing data using Government of Indonesia (GOI) regulation KEP/75/M.PAN/7/2004. With rotation schedule 4 days morning shift – 2 days off, 4 days afternoon shift – 2 days off, and 4 days night shift – 3 days off, the effective working hours result is 5,6 hours / day or 336 minutes. While the task completion time for four main job to be done by

crane operators which are crane operation, shifting operation, berthing and unberthing operation is 153,41 minutes. The result indicating that current conditions with average unloading activity working hours from 2019 -2021 is 20241 hours and formation 1 crane operated by 2 crane operator, number of crane operator needed is 0,46 or can be rounded up to 1 operator per crane. The processing data using GOI regulation KEP/75/M.PAN/7/2004 shown in **Table 7.**

Table 7. Formation 1 Crane – 2 Operator

Number		Job Assignments Detail	Processing Time		Task Load	Unit of Task Load	Number of Item	Task Completion Time
Task	Step							
1		Crane Operation						
	1	Departing to crane	4,1	minute	1	time / day	1	4,1
	2	Operating crane	144	minute	1	time / day	1	144
	3	Leaving the crane	4,1	minute	1	time / day	1	4,1
2		Berthing Operation						
	1	Departing to jetty	4,1	minute	0,67	time / 12 hour	1	0,1
	2	Mooring activity	10	minute	0,67	time / 12 hour	1	0,2
	3	Leaving the jetty	4,1	minute	0,67	time / 12 hour	1	0,1
3		Shifting Operation						
	1	Departing to jetty	4,1	minute	0,67	time / 12 hour	1	0,1
	2	Mooring - Unmooring	10	minute	0,67	time / 12 hour	1	0,2
	3	Leaving the jetty	4,1	minute	0,67	time / 12 hour	1	0,1
4		Unberthing Operation						
	1	Departing to jetty	4,1	minute	0,67	time / 12 hour	1	0,1
	2	Unmooring activity	10	minute	0,67	time / 12 hour	1	0,2
	3	Leaving the jetty	4,1	minute	0,67	time / 12 hour	1	0,1
							Total	153,41
							Effective Working Hours	336
							Result	0,46

4.2 Evaluation and Recomendation

Referring to KEP/75/M.PAN/7/2004 method with current formation 1 crane being operated by 2 crane operator, the result of operator needed is 0,46. There is gap 0,54 which can be improved or current workload is half of normal standard operator needed. Furthermore, result of crane operator workload is below the acceptable level and normal point of NASA-TLX which stated by (Fernandes 2016) and (Ramadhan et al. 2014). Referring to annual working hours per worker record (Giattino, Ortiz-Ospina, and Roser 2020), the country which implementing 1 operator for 1 crane have high annual working hours per worker, on the other hand the country which implementing 2 operator for 1 crane have low working hour. Indonesia have different record annual working hours per worker where it is lower than country which implementing 1 operator for 1 crane and higher than country which implemanting 2 operator for 1 crane. Considering the both measuements, culture of working hour and GOI rest hour requirement which specified on GOI regulation number 13 / 2003 about Manpower and regulation 11 / 2020 about Job Creation which required 30 minute of rest after 4 hour work, hence the operator needed is 4

operator to operate 4 crane with additional 1 operator for rest rotation. The recomandation of operator needed shown in **Table 8.**

Table 8. Formation 4 Crane – 5 Operator

Number		Job Assigments Detail	Processing Time		Task Load	Unit of Task Load	Number of Item	Task Completion Time
Task	Step							
1		**Crane Operation**						
	1	Departing to crane	4,1	minute	1	time / day	3	12,3
	2	Operating crane	242,896	minute	1	time / day	1	242,896
	3	Leaving the crane	4,1	minute	1	time / day	3	12,3
2		**Berthing Operation**						
	1	Departing to jetty	4,1	minute	0,67	time / 12 hour	2	5,5
	2	Mooring activity	10	minute	0,67	time / 12 hour	2	13,3
	3	Leaving the jetty	4,1	minute	0,67	time / 12 hour	2	5,5
3		**Shifting Operation**						
	1	Departing to jetty	4,1	minute	0,67	time / 12 hour	2	5,5
	2	Mooring - Unmooring	10	minute	0,67	time / 12 hour	2	13,3
	3	Leaving the jetty	4,1	minute	0,67	time / 12 hour	2	5,5
4		**Unberthing Operation**						
	1	Departing to jetty	4,1	minute	0,67	time / 12 hour	2	5,5
	2	Unmooring activity	10	minute	0,67	time / 12 hour	2	13,3
	3	Leaving the jetty	4,1	minute	0,67	time / 12 hour	2	5,5
							Total	340,296
							Effective Working Hours	336
							Result	1,01

6. CONCLUSIONS

The NASA-TLX measurement result indicating that workload of current crane operator distribution or formation is below the acceptable level and normal point of NASA-TLX. In line with NASA TLX, GOI regulation KEP/75/M.PAN/7/2004 method also indicating that curent formation resulting the overstaffing. Based on the result of the study, we conlude that the optimum number of crane operator to operate 4 crane is 5 operator. By allocating the optimum number with current unloading work duration of PT XYZ expected to increase the labour utilization rate up to 21% per year.

Reduction or termination of employees in terms of labor efficiency is something that is often unavoidable in maintaining business continuity or to prevent companies from closing permanently, especially if there is a decline in production. In reducing this employee, the company needs to provide criteria from the crane operator that will be reduced such as age, performance, health and others, so that employees who have good criteria can still be maintained. The company must also prepare a team for the determination of criteria and processes for this reduction of employees as well as compensation funds for employees in accordance with applicable

regulations. For the future workforces planning policy in the current fluctuative business condition, outsourcing workforce can be considered.

Furthermore the reduction of crane operator will have an impact on increasing the crane operator's effective working hours. Of course, this will change the crane operator's behavior or habits and can cause complaints or strike from them due to increased work demands. PT XYZ already has a tonnage bonus scheme. The more unloading is done, the crane operator bonus will also increase. PT XYZ can increase the bonus value to maintain the motivation and performance of existing employees and on the other hand, the company has succeeded in reducing the tonnage bonus fee for 3 people per group or with a total of 15 operators.

It must pinted out, however, that the tonnage of unloading coal is also the main factor of the calculation as well as selection number of crane operator groups. Future studies are needed before generalizations can be made about the effectiveness of the proposed solution such as linier programming and use of outsourcing, as well as post NASA-TLX measurement to the crane operator after the implementation of this study.

REFERENCES

Ahmed, Hiba. 2007. "Improved Operations through Manpower Management in the Oil Sector." *Journal of Petroleum Science and Engineering* 55(1–2):187–99. doi: 10.1016/j.petrol.2006.04.014.

Al-Kayed. 1999. "Civil Service Reform for Sustainable Human." *Jordan Institute of Public Administration for the United Nations Development Program UNDP*.

Arsi, Raras Mayang, and Sri Gunani Partiwi. 2012. "Analisis Beban Kerja Untuk Menentukan Jumlah Optimal Karyawan Dan Pemetaan Kompetensi Karyawan Berdasar Pada Job Description." *Teknis ITS* 1(1):526–29.

Assi, Peter Nga, and Effanga Okon Effanga. 2021. "Optimal Manpower Recruitment and Promotion Policies for the Finitely Graded Systems Using Dynamic Programming." *Heliyon* 7(7):e07424. doi: 10.1016/j.heliyon.2021.e07424.

Braarud, Per Ø. 2020. "International Journal of Industrial Ergonomics An Efficient Screening Technique for Acceptable Mental Workload Based on the NASA Task Load Index — Development and Application to Control Room Validation." 76(June 2019). doi: 10.1016/j.ergon.2019.102904.

Braarud, Per Øivind. 2021. "Investigating the Validity of Subjective Workload Rating (NASA TLX) and Subjective Situation Awareness Rating (SART) for Cognitively Complex Human–Machine Work." *International Journal of Industrial Ergonomics* 86(November). doi: 10.1016/j.ergon.2021.103233.

Casner, Stephen M., and Brian F. Gore. 2010. "Measuring and Evaluating Workload: A Primer." *NASA Technical Memorandum* (July):35.

Dessler, Gary. 2020. *Human Resource Management / Gary Dessler, Florida International University*. 16th ed. Pearson Education, Inc.

DiDomenico, Angela, and Maury A. Nussbaum. 2008. "Interactive Effects of Physical and Mental Workload on Subjective Workload Assessment." *International Journal of Industrial Ergonomics* 38(11–12):977–83. doi: 10.1016/j.ergon.2008.01.012.

Fenn, D. 1995. "Benchmark: The Costs of Understaffing | Inc.Com." *Inc. Magazine*. Retrieved April 29, 2022 (https://www.inc.com/magazine/19951001/2445.html).

Fernandes, Alexandra. 2016. "The NASA Task Load Index for Rating Workload Acceptability

The NASA Task Load Index for Rating Workload Acceptability." (October). doi: 10.13140/RG.2.2.22989.64484.

Giattino, Charlie, Esteban Ortiz-Ospina, and Max Roser. 2020. "Working Hours - Our World in Data." *Published Online at OurWorldInData.Org*. Retrieved July 12, 2022 (https://ourworldindata.org/working-hours).

Haga, Shigeru, Haruo Shinoda, and Mitsuteru Kokubun. 2002. "Effects of Task Difficulty and Time-on-Task on Mental Workload." *Japanese Psychological Research* 44(3):134–43. doi: 10.1111/1468-5884.00016.

Hart, Sandra G., and Lowell E. Staveland. 1988. "Development of NASA-TLX (Task Load Index): Results of Empirical and Theoretical Research." *Advances in Psychology* 52(C):139–83. doi: 10.1016/S0166-4115(08)62386-9.

Hwang, Sheue Ling, Yi Jan Yau, Yu Ting Lin, Jun Hao Chen, Tsun Hung Huang, Tzu Chung Yenn, and Chong Cheng Hsu. 2008. "Predicting Work Performance in Nuclear Power Plants." *Safety Science* 46(7):1115–24. doi: 10.1016/j.ssci.2007.06.005.

ILO. 2016. *Workplace Stress: A Collective Challenge*.

Jay, Shani. 2021. "Employee Utilization: A Guide for HR - AIHR." *Www.Aihr.Com*. Retrieved April 29, 2022 (https://www.aihr.com/blog/employee-utilization/#HR).

Keputusan Menteri Pendayagunaan Aparatur Negara. 2004. "MENPAN_75_2004.Pdf." 71.

Mazur, Lukasz M., Prithima R. Mosaly, Marianne Jackson, Sha X. Chang, Katharin Deschesne Burkhardt, Robert D. Adams, Ellen L. Jones, Lesley Hoyle, Jing Xu, John Rockwell, and Lawrence B. Marks. 2012. "Quantitative Assessment of Workload and Stressors in Clinical Radiation Oncology." *International Journal of Radiation Oncology Biology Physics* 83(5):e571–76. doi: 10.1016/j.ijrobp.2012.01.063.

Pracinasari, Ira. 2013. "Beban Kerja Fisik Vs Beban Kerja Mental. Ergonomic." Retrieved April 29, 2022 (https://www.academia.edu/5132134/Beban_Kerja_Fisik_Vs_Beban_Kerja_Mental).

Productivity Commission. 1998. *Work Arrangements in Container Stevedoring*. Vol. 43.

Rachmuddin, Yunita. 2020. *Analisa Beban Kerja Dengan Modified Full Time Equivalent (M-FTE) Dan Nasa-TLX Untuk Mengoptimalkan Jumlah Engineer Di Bagian Electrical/Instrument Engineering (Studi Kasus Di PT Vale Indonesia Tbk)*.

Ramadhan, Rahadian, Ishardita Pambudi Tama, D. Ph, and Remba Yanuar. 2014. "Analisa Beban Kerja Dengan Memggunakan Work Sampling Dan NASA - TLX Untuk Menentukan Jumlah Operator (Studi Kasus : PT XYZ)." 964–73.

Tarwaka et.al. 2004. "[E-BOOK] ERGONOMI – Untuk Kesetan, Kesehatan Kerja Dan Produktivitas | Ir. Solichul Hadi Achmad Bakri, M.Erg." Retrieved April 29, 2022 (https://123dok.com/document/q5wn11gq-ergonomi-untuk-kesetan-kesehatan-kerja-produktivitas-solichul-achmad.html).

Terranova, Dinantiantie Nilla Taurita. 2014. "Menentukan Jumlah Optimal Karyawan Dengan Metode Nasa-Tlx (Studi Kasus : Departemen Perencanaan & Gudang Material PT.Petrokimia Gresik." *Institut Teknologi Sepuluh Nopember* 101.

Tubbs-Cooley, Heather L., Constance A. Mara, Adam C. Carle, and Ayse P. Gurses. 2018. "The NASA Task Load Index as a Measure of Overall Workload among Neonatal, Paediatric and Adult Intensive Care Nurses." *Intensive and Critical Care Nursing* 46:64–69. doi: 10.1016/j.iccn.2018.01.004.

Young, Gloria, Lyubov Zavelina, and Vallire Hooper. 2008. "Assessment of Workload Using NASA Task Load Index in Perianesthesia Nursing." *Journal of Perianesthesia Nursing* 23(2):102–10. doi: 10.1016/j.jopan.2008.01.008.

THE ROLE OF JOB SATISFACTION AS A MEDIATOR BETWEEN FLEXIBLE WORKING ARRANGEMENTS AND COGNITIVE WORK TO HOME SPILLOVER, AND JOB PERFORMANCE DURING THE TELECOMMUTING IN COVID-19 PANDEMIC

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ABSTRACT

The transition from working from the office to telecommuting or WFH during the COVID-19 pandemic has a unique impact on workers, including how workers utilize work arrangements, the work-to-home spill over, and differences in satisfaction levels that have an impact on performance. This study aims to determine whether job satisfaction mediates the relationship between flexible work arrangements and cognitive work-to-home spillover on performance. Participants consisted of organizational workers performing flexible work arrangements and telecommuting (N = 250). The results showed that job satisfaction significantly mediates the relationship between flexible work arrangements, cognitive work-to-home spillover and performance in telecommuting settings. The results provide a reference for companies and HR management regarding the importance of encouraging internal and external factors for individuals to achieve effective performance in telecommuting settings, especially during this pandemic.

Keywords: Flexible work, Cognitive Work to Home Spillover, Job satisfaction, Job Performance, Telecommuting

1. INTRODUCTION

Human resources are an important factor to achieve the success of an organization. One of the keys to the success of a business organization to achieve an increase in work productivity is the implementation of a management system that considers its workers as the main source of achieving productivity, whereas a management system that focuses on workers, it can form a sustainable organization (Parvin and Kabir, 2011; Richard, 2020). To create strong motivation from workers, organizations must create a positive and cooperative atmosphere that is effective in supporting employee satisfaction, which in turn encourages workers to fully contribute to the achievement of a stable organization and is committed to improving the overall function of an organization (Ali and Anwar, 2021; Parvin and Kabir, 2011). Several previous studies have been conducted to examine the relationship between job satisfaction and employee performance, such as research by Farooqui and Nagendra (2014) which found a positive relationship between job satisfaction and job performance.

The existence of job satisfaction is something important for the organization and the subjective well-being of individuals, moreover, job satisfaction has a major impact on individual

motivation which can then affect productivity and performance. If the individual is happier in his work, then the individual can feel satisfaction in his work (Parvin and Kabir, 2011; Afzal and Farooqi, 2014). One of the strongest predictors of job satisfaction is work-life balance (Jackson and Fransman, 2018). The concept of work-life balance itself is a concept that is quite popular in research because it is a factor that is quite popular among both employees and employers. One of them is a study that explains the relationship between flexible working hours and work-life balance, which finds that autonomy in working time influences lower work stress levels and can increase extrinsic motivation at work compared to following a predetermined working time (Barney and Elias, 2003). 2010).

The practice of flexible working hours is considered beneficial for both workers and employers. Initially, this existence was held to help female employees who have children, so that they can manage their time in life and time at work (Shagvaliyeva and Yazdanifard, 2014). However, over time, flexible working has become one of the benefits offered by the company to both male and female workers. Employees can fulfill their responsibilities in both aspects of work-life, where flexible working can have a positive impact on their job performance (Davidescu et al, 2020; Shagvaliyeva and Yazdanifard, 2014). Flexible working is also considered to be one of the factors to face future work challenges (Davidescu et al, 2020).

There are several studies that have found a positive relationship between work flexibility and performance, and vice versa. Among them is research by Berkery et al, (2017) which finds that in organizations with high absorption, flexible working time provisions can create an environment and/or schedule that is conducive to personal productivity, thereby increasing work performance and productivity. On the other hand, the findings by Kattenbach, Demerouti, and Nachreiner (2010) found that the dimensions of employee performance flexibility were not related to employee performance.

The relationship between flexible work arrangements and job satisfaction has become a popular topic for research, including research by Rehman and Siddiqui (2019) which found that flexible work arrangements significantly correlated with job satisfaction in employees with high work-life balance. Another study that also found a positive effect on job satisfaction was conducted by Origo and Pagani (2008) who found a positive relationship between job flexibility and job satisfaction, where the positive impact of flexibility was greater on satisfaction for the intrinsic aspects of work. Although quite a lot of positive effects were found on flexible work arrangements on job satisfaction, the negative effects were found by the research of Masuda et al., (2012) who conducted a study with participants from various countries. This study found that in the Asian cluster it was found that job flexibility was negatively related to job satisfaction because managers from the Asian cluster interpreted the availability of flexible work as a sign that the company was not committed and did not want to build strong bonds with its employees (Masuda et al., 2012).

In addition to flexible work arrangements and work-life balance, work stress is also quite often studied to see its effect on performance and job satisfaction. One aspect of work stress that is often discussed is Cognitive work-to-home spillover. For example, research by Sok, Blomme, and Tromp (2014) states the negative impact of Work to Home spillover causes lower job satisfaction and lower performance (Sok, Blomme, and Tromp, 2014). This is also supported by other studies. who examined the work-to-home spillover effect on feelings of greater workload, lower life satisfaction, and lower job satisfaction (McDaniel, O'Connor, and Drouin, 2021).

Although there have been several previous studies examining the effect of Flexible Work Arrangements and Cognitive Work to Home spillover on employee performance, there are still various research results on whether there is an effect on employee performance. Often research on the effect of flexible work found a positive effect on job satisfaction. For example, research by De

Menezes and Kelliher (2017) who conducted a survey of 2617 employees in four large organizations found that flexible arrangements were negatively related to performance but were a source of high job satisfaction for employees. This is different from research on the effect of Cognitive Work on Home spillover, where the level of Cognitive work-to-home spillover is low and often has a positive effect on performance and job satisfaction, especially in conditions of a supportive supervisor, creating an adequate balance between work-family and personal life. (Cabrera et al., 2018; Wu et al., 2012; Pedersen et al., 2008; Ruppanner and Pixley, 2012). So researchers want to analyze whether job satisfaction can mediate the influence of flexible work arrangements, and cognitive work-to-home spillovers on employee performance for employees who apply for telecommuting work during this Covid-19 Pandemic.

The application of remote work during the pandemic has made quite a lot of research done to look at levels of job satisfaction, work stress, and productivity. For example, in the telecommuting setting during the Covid-19 Pandemic conducted by Berber et al., (2022), where in his research he found a positive effect of Flexible Work and job satisfaction on the desire to move. Flexible work contributes to increased job satisfaction and, in turn, job satisfaction contributes to decreased turnover intention. Job satisfaction mediates this relationship, and employees who are offered FWA may experience lower levels of turnover intention when they are satisfied with their jobs (Berber et al., 2022).

Although the impact of telecommuting (work from home) itself has been discussed quite a lot, its positive effects such as increased job satisfaction, organizational performance, and commitment, but also found some negative impacts such as allowing reduced opportunities for promotion and increasing family-work conflict (Toscano and Zappala, 2020; Chung, 2018). Research by Golden and Veiga (2005) found a negative influence on job satisfaction because of loss of interaction and feelings of isolation when telecommuting. A survey by the World Economy Forum (2020) of 31 million workers from 21,000 companies also found that there were three conclusions from the impact of WFH during Covid-19 on work stress due to longer working hours, and more emails being sent, and shorter meeting times. (Yoshio, 2020).

In previous studies, there have been several studies that have analyzed the effect of Flexible Work Arrangements and Cognitive Work to Home Spillover on performance, but there are still few studies that have looked at the mediating effect of Job Satisfaction on employees who do telecommuting work during the Covid-19 pandemic. The researcher wants to analyze whether the work satisfaction of employees who are telecommuting can mediate the effect of Flexible Work Arrangements and Cognitive Work to Home Spillover on performance.

2. LITERATURE REVIEW

2.1 Flexible Working, Job Satisfaction and Job Performance

Telecommuting is an alternative work arrangement in which employees perform tasks elsewhere that are normally performed in their main or central workplace, at least for a part of their work schedule, using electronic media to interact with others inside and outside the organization (Bailey & Kurland, 2003). 2002; Baruch, 2001; Feldman & Gainey, 1997 in Gajendran and Harrison, 2007). There is a place substitution involved in telecommuting, and interaction restrictions occur because of the physical and psychological distance involved in that substitution. Usually, the "other place" in the above definition is home, although telework centers and remote offices are alternative locations (Davis & Polonko, 2001; Hill, Miller, Weiner, & Colihan, 1998 in Ganjendran and Harrison, 2007). The home was the primary location for telecommuting in almost all the studies included in this study.

Flexibility is a formal policy set by resource management or informal arrangements related to the company (Dhikron, Aziz Fathoni, M Mukeri Wongs, 2016). Work schedule flexibility is a flexible work arrangement that means choosing a place and time to work, whether formal or informal, which facilitates employees in terms of policies on how long, when, and where employees work (Kezia Sarah, Eunike Alinda, and Deborah, 2014). According to Griffin, work schedule flexibility is a compressed work schedule discussed earlier giving employees time off during "normal" working hours, but they still follow a regular and predetermined schedule on the days when they work. (Moorhead griffin, 2013). Rehman and Siddiqui (2019) found that flexible work arrangements were significantly correlated with employee job satisfaction. Another study that also found a positive effect on job satisfaction was conducted by Origo and Pagani (2008) who found a positive relationship between job flexibility and job satisfaction, where the positive impact of flexibility was greater on satisfaction for the intrinsic aspects of work. This research is also supported by Govender, Migiro, and Kyule (2018) who found that flexible work arrangements increase employee retention, and job satisfaction leads to higher productivity. Based on survey data collected among more than 20,000 Dutch public sector employees by Possenriede and Plantenga (2011) showed that flexible work arrangements, particularly flexible hours, were associated with significant increases in satisfaction with work time suitability and overall job satisfaction.

Many studies have also found a positive relationship between work flexibility and performance. Among them is research by Berkery et al, (2017) which finds that in organizations with high flexible time absorption, flexible working time provisions can create an environment and/or schedule that is conducive to personal productivity, thereby increasing work performance and productivity. Solanki (2013) in his research on employees who apply flexible work arrangements in the UAE also found a relationship between flexible work and employee productivity, work productivity, motivation, and a decrease in employee stress levels. So the first and second hypotheses in this study are as follows:

H1: Flexible Work Arrangements have a positive and significant effect on Job Satisfaction
H2: Flexible Work Arrangements have a positive and significant effect on Employee Performance

2.2 Cognitive Work to Home Spillover, Job Satisfaction, and Job Performance

Job stress is one of the topics that is often researched to see its effect on performance and job satisfaction. One aspect of work stress that is often discussed is Cognitive work-to-home spillover. Conflicts between work and home life arise when employees are unable to switch from work to the non-work domain (Westaby et al. 2016). They then experience tension-based work-to-home conflict, i.e., work-to-home spillover on a cognitive level that results from the "emotional disturbance" of work in home life (Greenhaus and Beutell 1985; Greenhaus and Parasuraman 1987), i.e., stressors from the work domain. generate stressful situations in the home domain. According to spillover theory, negative emotions such as tension, stress, or burnout from the work domain spill over into the home domain despite physical and temporal boundaries between work and home and can hinder employees' ability to disengage from work (Staines 1980; Westaby et al. 2016). Cognitive work-to-home spillover is associated with sleep disturbances, poor sleep quality and dysphoria as well as cardiovascular disease (Cropley and Millward 2009). The conflict between work and home life goes hand in hand with stress, job burnout, and depression (Allen et al. 2000; Eden 2001).

Furthermore, research by Lott (2018), where research was conducted in an out-of-office setting influenced cognitive work-to-home spillover in a German city. From this study, it was found

that with the implementation of this working time flexibility, male employees had significantly more difficulty controlling their working hours so that they cognitively tended to bring work home than female employees (Lott, 2018). Another research by Sok, Blomme, and Tromp (2014) states the negative impact of Work to Home spillover causes lower job satisfaction and lower performance. This is also supported by other studies that examine the work-to-home spillover effect on feelings of greater workload, lower life satisfaction, and lower job satisfaction (McDaniel, O'Connor). and Drouin (2021). Dousin, Collins, and Kler, 2019 in their research also found that the work-to-home spillover has an effect on satisfaction and performance, whereas the spillover effect of the work and home domains, as occurs when an employee brings homework assignments, will interfere with the employee's family life and will produce negative behavior at home in the form of stress and fatigue, which results in employee performance being affected by stress (Dousin, Collins, and Kler, 2019). So the third and fourth hypotheses in this research are:

H3: Cognitive Work to Home Spillover has a negative and significant effect on Job Satisfaction
H4: Cognitive Work to Home Spillover has a negative and significant effect on Employee Performance

2.3 Job Satisfaction and Job Performance

Job satisfaction is an attitude variable that reflects how a person feels, both towards his job as a whole and to various aspects of his job (Spector, 2000; Carvalho, et al., 2018). According to Spector (in Carvalho, et al., 2018), there are nine dimensions of job satisfaction called the nine facets of job satisfaction including salary (pay), promotion opportunities (promotion), and job characteristics (nature of work), appreciation for results. work (contingent rewards), communication (communication), fringe benefits, co-workers, supervision, and working conditions. Given these nine dimensions, it is possible to identify the level of satisfaction of the people involved with the organization. There are several previous studies that found an influence between job satisfaction and employee performance, such as research by Farooqui and Nagendra (2014) which found a positive relationship between job satisfaction and job performance. Another study conducted by Yang, Chen, Lee, and Liu (2021) found a positive correlation between job satisfaction and job performance in high-tech industries. A study by Yuen et al., (2018) conducted on 116 seafaring officers who are employees of six ship management companies shows that job satisfaction fully influences job performance. In the study, it was found that rewards are the main determinants of job satisfaction and seafarers' performance, where policies and strategies to improve job satisfaction and seafarer performance of companies need to pay attention to improving hygiene factors (eg improving working conditions, living and intrinsic and extrinsic rewards) compared to motivational factors. (eg improving job characteristics) to increase job satisfaction. So the fifth hypothesis in this study is as follows:

H5: Job Satisfaction has a direct positive and significant effect on employee performance.

There have been many previous studies looking at the mediating effect of job satisfaction, such as research by Berber et al., (2022), where in his research he found that flexible work contributed to increasing job satisfaction and, in turn, job satisfaction contributed to a decrease in turnover intention. (Turnover intention). Another study with the mediating effect of job satisfaction was also conducted by Suryawan, Ardana, and Suwandana (2021) who found work had a positive effect on turnover intention through job satisfaction as a mediating variable.

From previous research, it was found that there was an increase in job satisfaction that occurred in employees who worked telecommuting and flexibly, but it could also have a negative effect on job satisfaction due to job stress in the form of cognitive work-to-home spillover (Davidescu et al, 2020; Sok, Blomme, and Tromp, 2014; Lott, 2018;). With rewards and benefits that determine the level of job satisfaction, flexible working arrangement and job stress are also important variables that lead to job satisfaction, whereas in previous studies it was found that there was a positive influence between job satisfaction on job performance (Yang, Chen, Lee, and Liu, 2021; Farooqui and Nagendra, 2014). So, the sixth hypothesis in this study is as follows:

H6a: Job Satisfaction Mediates the Effect of Flexible Work Arrangements on Employee Performance.
H6b: Job Satisfaction Mediates the Effect of Cognitive Work to Home spillover on Employee Performance.

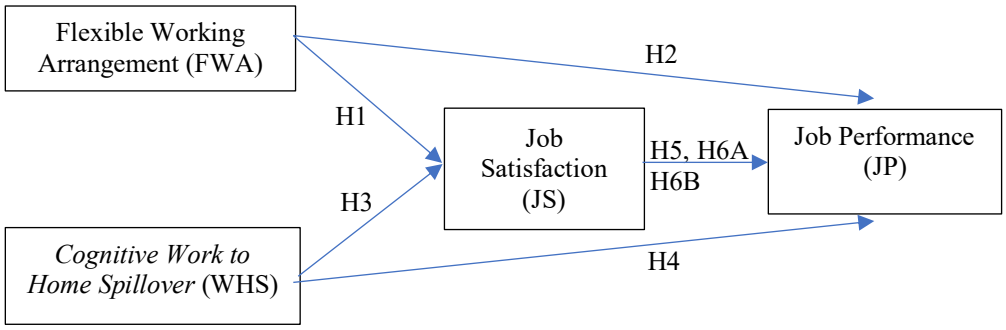


Figure 1. Conceptual Framework of The Study

3. METHODS

The methodological framework used to achieve the objectives of this study was used a quantitative research methodology. Researchers took a minimum of 150 respondents; Researchers determine the number of research samples using power analysis using the G*Power application. Based on the results of the calculation of power analysis, the minimum sample size needed in this study is 103, with an actual power of 0.8, and the statement that researchers must classify individuals into workers who worked with the WFH/telecommuting/hybrid scheme. The characteristics of the respondents that had been taken by the researchers were: (1) currently working for an organization or company. (2) worked with flexible working hours or had the autonomy to set their own working hours. (3) implement the WFH/Hybrid system after the policy during the Covid 19 pandemic.

In this study, the authors proposed four instruments with a total number of 68 indicators, each variable has dimensions that describe the variables to be studied, namely the dependent variable, the independent variable, and the mediator variable. An explanation of each variable and dimension can be seen in the following table:

Table 1. Variable Operational Definition

Variables	Operational Definition	Dimensions	Number of Items
IV: Flexible Working Arrangement	A form of professionally flexible work arrangement, where employees follow rules to work a certain number of hours with greater flexibility or have the autonomy to set their working hours. The employee has the freedom to determine when to start and end his work if the employee can meet the number of working hours that have been regulated in company regulations (Hook and Higgs, 2000).	1. Employees can divide their time between work and family time 2. Employees have the convenience of exchanging work schedules with colleagues when employees are unable to work 3. Employees easily get holidays for family needs 4. Employees can get the freedom to have a side job	18
IV*:* Cognitive Work To Home Spillover	Negative emotions such as tension, stress, or burnout from the work domain spill over into the home domain despite physical and temporal boundaries between work and home and can hinder an employee's ability to disengage from work (Staines 1980; Westaby et al. 2016).	1. Space 2. Time 3. Social role	15
DV : Job Performance	Behavior or Action that is appropriate or in line with organizational goals (Koopmans, 2014)	1. Input 2. output 3. Results 4. Benefit 5. Consequence	25
MV : Job Satisfaction	Attitudes that reflect how a person feels, both towards his job as a whole and to various aspects of his job (Spector, 2000; Carvalho, et al., 2018)	1. External Factors (Job Characteristics, Role Variables, Work-family conflict, Salary (Pay) 2. Internal Factors (Personality, Gender, Age, Cultural and ethnic differences)	10

Researchers distributed questionnaires compiled online using google forms. The method used to get participants according to the characteristics: researchers would distribute a link or questionnaire link so that participants could fill out voluntarily; then the researcher contacted relatives who had the appropriate criteria and asked their willingness to fill out the questionnaire; next, the researcher puts the questionnaire link on social media, such as LinkedIn and Instagram so that more people could know about the information regarding this researched questionnaire link. The questionnaire was then filled out voluntarily by the respondent in accordance with predetermined criteria. The researcher's consideration in using this participant selection method was the ease of implementation. After the target participants had been collected for three weeks, the researcher would select the data that had been entered. After the researcher selected the participant

data that matched the required qualifications, the researcher continued the research process by processing the data have been processed using SPSS and AMOS 22.

Data analysis techniques that had been used in this study include (1) descriptive statistics: in this study, the researcher would present the results of descriptive calculations of the characteristics of the participants. Based on these results, an overview of demographic data had been obtained which includes age, gender, industry company, length of work, time, and place of work. (2) Measurement Model and Structural Analysis using Confirmatory Factor Analysis (CFA) and Structural Equation Model (SEM) method. The software used for structural analysis is AMOS 22 in looking at the relationship between worked time variables arrangement, job satisfaction, cognitive work-to-home spillover, and job performance to see the effect of mediation the researcher used a moderator regression analysis technique.

The pilot test was conducted with an initial 50 respondents. This study uses a factor analysis technique with the Keyser-Meyer-Olkin (KMO) Measure of Sampling Adequacy method and Bartlett's test of Sphericity as a measure of validity and Cronbach's alpha as the reliability measurement. Based on the results, there are a total of 23 indicators that are not valid. Even so, the researcher did not delete invalid items by considering the increasing number of participants, it can make the items more valid (Amalia, Dianingati, and Annisaa, 2022).

4. RESULTS

The data in this study came from primary data in the form of a questionnaire submitted to company employees with 250 respondents. The primary data used is the result of distributing questionnaires to a sample that has been determined by the researcher. This data includes a list of questions about Flexible Work Arrangements, Cognitive Work to Home Spillover, Job Satisfaction, and Employee Performance. The presentation of respondent data is presented as follows:

Table 2. Respondent Profile

Description	Frequency	%
a. Age		
20 - 30	147	58.8%
31 - 40	80	32%
41 - 50	23	9.2%
Total	250	100%
b. Gender		
Male	97	38.8%
Female	153	61.2%
Total	150	100%
c. Working Arrangements		
WFH	137	54.8%
Hybrid	113	42.5%
Total	250	100%
d. Industries		
Information Technology	148	59.2%
Business (trade, service and investment business)	38	15.2%
Banking and Financial	30	12%
others	34	13.6%
Total	250	100%

From Table 2. above, the highest number of respondents is between the ages of 20-30 years, which is 147 respondents, and between the ages of 31-40 years, as many as 80 respondents, then at the age of 41-50 years, as many as 23 respondents. It is known that the respondents are male as many as 97 people, while the respondents are female as many as 153 people. This shows that in this study there were more female respondents than males. The education level of the respondents in this study was dominated by the education level of SMA/SMK with 12 respondents, DIII with 18 respondents, undergraduate education level with 207 respondents, and Master/S2 with 13 respondents. The occupation of the respondents in this study was dominated by the Information Technology sector 59.2 percent with 148 respondents, then the Business sector (trade, services, and investment) with 38 percent or around 15.2 respondents, and then the financial sector with 30 respondents, which was around 12 percent, while other sectors were as much as 34 respondents or about 13.6 percent. The total number of respondents after cleaning the data according to the criteria was 250 respondents, where the workplace settings of respondents in this study were dominated by WFH 54.8 percent with a total of 137 respondents, then Hybrid 42.5 percent or about 113 respondents.

Table 3. Descriptive Statistics

Variable	Min	Max	Mean	Std. Deviation
Flexible Working Arrangement (FWA)	2	5	4.15	.66
Cognitive Work to Home Spill Over (WHS)	1	5	4.14	.67
Job Satisfaction (JS)	2	5	4.12	.65
Job Performance (JP)	1	5	4.14	.64

The researcher conducted a descriptive analysis of each research variable that is attached to Table 3. Based on the table, the participants tend to consider themselves in a flexible work setting (M = 4.15; SD = .66). Participants also rated that they tended to experience the work to home spillover (M = 4.14; SD = .67). Even so, participants feel they have good job satisfaction (M = 4.12; SD = .65), and have a good performance evaluation as well (M = 4.14; SD = .64)

For testing the H1 to H5, the researcher conducted a correlation test between variables. The results of the analysis showed that there was a significant positive correlation between flexible work arrangements and job satisfaction ($t = 1.91$, $p < .05$), as well as job performance ($t = 2.6$, $p < .05$). The results of the analysis also showed that there was a significant positive correlation between cognitive work to home spillover and job satisfaction ($t = 4.87$, $p < .05$), and there was a significant positive correlation to job performance ($t = 1.88$, $p > .05$). There was also a significant positive correlation of job satisfaction to job performance ($t = 5.74$, $p < .05$). After seeing the correlation of each of these variables, it means that mediation testing can be done conducted. The correlation matrix for each variable can be seen in Table 4.

Table 4 Hypothesis Testing H1 to H5

Hypothesis	Hypothesized Part	SLF	t-value	p-value	Remarks
H_1	JS <--- FWA	.139	1.917	.05	Supported
H_2	JS <--- WHS	.509	4.874	***	Supported
H_3	JP <--- FWA	.096	2.662	.008	Not Supported

Hypothesis	Hypothesized Part	SLF	t-value	p-value	Remarks
H_4	JP <--- WHS	.098	1.884	.060	Not Supported
H_5	JP <--- JS	.219	5.741	***	Supported

The mediating role of Job Satisfaction on the influence of Flexible work arrangements, Cognitive Work to Home Spill over on Employee Performance shows that arrangements on employee performance, showed that Job Satisfaction has positive and significant effects on mediating the Flexible Work Arrangements on Employee Performance (t = 3.123 > 0.675) and Job Satisfaction has the positive and significant effects on mediating the Cognitive Work to Home Spill over on Employee Performance (t =1.724 > 0.675) as well. From the description above, it can be concluded that the results of the mediation relationship test are in the following table:

Table 5 Hypothesis Testing on Mediating Role

Hypothesis	Hypothesized Part	*t-value*	*t-table*	Remarks
$H_{6.1}$	JP <--- JS <--- FWA	3.123	0,675	Supported
$H_{6.2}$	JP <--- JS <--- WHS	1.724	0,675	Supported

6. CONCLUSIONS

The results of testing and analysis show that Flexible Work Arrangements have a direct positive and significant effect on Job Satisfaction. The positive influence of Flexible Work Arrangements on Job Satisfaction is determined by the dimensions: Employees can divide their time between work and family time, Employees have the convenience of exchanging work schedules with colleagues when employees are unable to work, and Employees can easily get holidays for family needs and Employees can get the freedom to have a side job. The dimension with the highest value is the dimension of ease of exchanging work schedules with colleagues. This is in line with research conducted by Rehman and Siddiqui (2019) which found that flexible work arrangements were significantly correlated with employee job satisfaction. Another study that also found a positive effect on job satisfaction was conducted by Origo and Pagani (2008) who found a positive relationship between job flexibility and job satisfaction, where the positive impact of flexibility was greater on satisfaction for the intrinsic aspects of work. In this study, job satisfaction is influenced by external and internal factors, most respondents tend to give high scores on indicators containing external factors. This is in line with research by Buzea (2014) which found that external factors such as non-financial rewards, appreciation, and recognition for employees who work telecommuting can increase job satisfaction, which is as important as financial rewards.

A significant and positive relationship between Flexible Work Arrangements and Employee Performance was also found in this study. The dimensions that make up Flexible Work Arrangements are Employees can divide their time between work and family time, Employees have the convenience of exchanging work schedules with colleagues when employees are unable to work, Employees can easily get holidays for family needs and Employees can have the freedom to have side jobs does not significantly affect employee performance. This supports the statement of Berkery et al, (2017) who found that in organizations with high absorption, flexible working time provisions can create an environment and/or schedule that is conducive to personal productivity, thereby increasing work performance and productivity. In addition, another study that also found a positive influence between work flexibility and performance was also conducted by Bran and Udrea (2016) who identified that increasing work flexibility significantly increases performance, motivation leads

to performance, and relation to flexibility leads to superior performance. Surban (2012) also found that working flexibility has a positive impact on labor productivity, in his research he found that investment in increasing labor productivity and employee stability in the labor market, increases employability and adaptability to new global labor conditions.

Based on the obtained data, it showed that the variables Cognitive Work to Home Spillover and Job Satisfaction have a positive and significant causal relationship. The effect of Cognitive Work to Home Spillover on Job Satisfaction is determined by the dimensions: space, time, and social roles. Based on Sok, Blomme, and Tromp (2014) research who looked at the positive and negative impacts of Work to Home spillover on employees who work telecommuting, stated that having support from office colleagues and family can increase job satisfaction. In this study, most respondents agreed that they had a good relationship with their co-workers and did not accept the distribution of tasks from other office colleagues. So job satisfaction is still felt by respondents even though they experience a cognitive work-to-home spillover. This is also consistent with other studies that examined the work-to-home spillover effect on feelings of greater workload, lower life satisfaction, and lower job satisfaction without the support of superiors and colleagues. work (McDaniel, O'Connor and Drouin, 2021).

The results of testing and analysis also found that Cognitive work-to-home spillover and Job Performance have a positive and significant causal relationship. This means that even though they experienced a Cognitive Work to Home Spillover, employees can still improve their performance. Based on research by White et al., (2003), work-to-home spillover has a more negative effect on the performance of employees who already have children. In addition, most respondents in this study were women, where according to Lott et al., (2018) based on the results of their research, most female employees seem to suffer less from negative effects of cognitive work-to-home spillover in telecommuting settings compared to men employees.

This study also found the effect of Job Satisfaction on Employee Performance, which was significant, where the dimensions that formed Job Satisfaction were internal and external factors in the form of job characteristics, role variables, work-family conflict, salary, personality, gender, age, and cultural and ethnic differences have a significant influence on employee performance. This is in line with the research of Farooqui and Nagendra (2014) which found a positive relationship between job satisfaction and job performance. This is also supported by another study conducted by Yang, Chen, Lee, and Liu (2021) which found a positive correlation between job satisfaction and job performance in high-tech industries.

The results of testing and analysis on the mediating role of job satisfaction in Flexible Work Arrangements, Cognitive Work to Home Spillover on Employee Performance show that it has a positive and significant causal relationship. The positive effect of job satisfaction on employee performance is determined by the following indicators: job characteristics. role variables, work-family conflict, salary (pay), personality, gender, age, and cultural and ethnic differences have no significant effect on employee performance. This is in line with previous research which found that an increase in job satisfaction occurred in employees who worked flexibly, but it could also have a negative effect on job satisfaction due to job stress in the form of cognitive work-to-home spillover (Davidescu et al, 2020; Sok, Blomme, and Tromp, 2014; Lott, 2018;). With the consequences that determine the level of job satisfaction from the work arrangement and work stress, job satisfaction was also found to have effects on employee performance (Yang, Chen, Lee, and Liu, 2021; Farooqui and Nagendra, 2014).

REFERENCES

Amalia, R. N., Dianingati, R. S., & Annisaa', E. (2022). Pengaruh Jumlah Responden terhadap Hasil Uji Validitas dan Reliabilitas Kuesioner Pengetahuan dan Perilaku Swamedikasi. Generics: Journal of Research in Pharmacy, 2(1), 9-15. https://doi.org/10.14710/genres.v2i1.12271

Astrauskaitė, M., Vaitkevičius, R., dan Peminas, A. (2010). Job satisfaction survey: A confirmatory factor analysis based on secondary school teachers' sample. *International Journal of Business and Management, 6*(5).

Ali, B. J., & Anwar, G. (2021). An Empirical Study of Employees' Motivation and its Influence Job Satisfaction. *Ali, BJ, & Anwar, G.(2021). An Empirical Study of Employees' Motivation and its Influence Job Satisfaction. International Journal of Engineering, Business and Management*, *5*(2), 21-30.

Aziz-Ur-Rehman, M., & Siddiqui, D. A. (2019). Relationship between flexible working arrangements and job satisfaction mediated by work-life balance: Evidence from public sector universities employees of Pakistan. *Available at SSRN 3510918*.

Berber, N., Gašić, D., Katić, I., & Borocki, J. (2022). The Mediating Role of Job Satisfaction in the Relationship between FWAs and Turnover Intentions. *Sustainability*, *14*(8), 4502.

Berkery, E., Morley, M. J., Tiernan, S., Purtill, H., & Parry, E. (2017). On the uptake of flexible working arrangements and the association with human resource and organizational performance outcomes. *European Management Review*, *14*(2), 165-183.

Barney, C. E., dan Elias, S. M. (2010). Flex-time as a moderator of the job stress-work motivation relationship: A three nation investigation. *Personnel Review, 39*(4), 487-502. doi:http://dx.doi.org/10.1108/00483481011045434

Bakotic, D.; Babic, T.B (2013). Relationship between working conditions and job satisfaction: The case of Croatian ship building company. Int. J. Bus. Soc. Sci. 2013, 4, 206–213. Sustainability 2020, 12, 6086 49 of 53 29.

Bloom, N., Liang, J., Roberts, J., & Ying, Z. J. (2015). Does working from home work? Evidence from a Chinese experiment. *The Quarterly Journal of Economics*, *130*(1), 165-218.

Carvalho, C. R. S. P., Castro, M. A. R., Silva, L. P., & Carvalho, L. O. P. (2018). The relationship between organizational culture, organizational commitment and job satisfaction. *Rebrae*, *11*(2), 201-215.

Chung, H. (2018). Gender, flexibility stigma and the perceived negative consequences of flexible working in the UK. *Social Indicators Research,* , 1-25. doi:http://dx.doi.org/10.1007/s11205-018-2036

Chatzopoulou, M.; Vlachvei, A.; Monovasilis, T. (2015) Employee's motivation and satisfaction in light of economic recession: Evidence of Grevena Prefecture-Greece. Proc. Econ. Financ., 24, 136–145.

Chen Y, and Fulmer IS. Fine-tuning what we know about employees' experience with flexible work arrangements and their job attitudes. Hum Resour Manage. 2017;1–15. https://doi.org/10.1002/hrm.21849

Conradie, W. J., dan de Klerk, J.,J. (2019). To flex or not to flex? flexible work arrangements amongst software developers in an emerging economy. *SA Journal of Human Resource Management, 17* doi:http://dx.doi.org/10.4102/sajhrm.v17i0.1175

Davidescu, A. A., Apostu, S., Paul, A., & Casuneanu, I. (2020). Work flexibility, job satisfaction, and job performance among romanian Employees—Implications for sustainable human resource management. *Sustainability, 12*(15), 6086. doi:http://dx.doi.org/10.3390/su12156086

De Menezes, L. M., & Kelliher, C. (2017). Flexible working, individual performance, and employee attitudes: Comparing formal and informal arrangements. Human Resource Management, 56(6), 1051-1070.

Farooqui, M. S., & Nagendra, A. (2014). The impact of person organization fit on job satisfaction and performance of the employees. *Procedia economics and Finance*, *11*, 122-129.

Gajendran, R., dan Harrison, D. (2007). The good, the bad, and the unknown about telecommuting: Meta-analysis of psychological mediators and individual consequences. *Journal Of Applied Psychology*, *92*(6), 1524-1541. doi: 10.1037/0021-9010.92.6.1524

Ghozali, I. 2006. *Aplikasi Analisis Multivariate dengan Program SPSS*. Semarang: Badan Penerbit Universitas Diponegoro

Ghozali, I. (2018). *Aplikasi Analisis Multivariate Dengan Program IBM SPSS 25 Edisi 25.* Semarang: Badan Penerbit Universitas Diponegoro.

Giovanis, E. (2019) Do the flexible employment arrangements increase job satisfaction and employee loyalty? Evidence from Bayesian networks and instrumental variables. Int. J. Comput. Econ. Econom. 9, 84–115.

Hooks dan Higgs., (2000), *The objective of this study is to test the effect of flex time and standard*

Jackson, L. T. B., dan Fransman, E. I. (2018). Flexi work, financial well-being, work–life balance and their effects on subjective experiences of productivity and job satisfaction of females in an institution of higher learning. South African Journal of Economic and Management Sciences, 21(1) doi:http://dx.doi.org/10.4102/sajems.v21i1.1487

Kattenbach, R., Demerouti, E., & Nachreiner, F. (2010). Flexible working times: effects on employees' exhaustion, work-nonwork conflict and job performance. *Career Development International*.

Kreitner, R. dan Angelo, K. 2005. *Perilaku Organisasi.* Jakarta: Salemba Empat

Lott, Y. (2018). Does flexibility help employees switch off from work? flexible working-time arrangements and Cognitive work-to-home spillover for women and men in germany. *Social Indicators Research,* , 1-24. http://dx.doi.org/10.1007/s11205-018-2031-z

Masuda, A. D., Poelmans, S. A., Allen, T. D., Spector, P. E., Lapierre, L. M., Cooper, C. L., ... & Moreno-Velazquez, I. (2012). Flexible work arrangements availability and their relationship with work-to-family conflict, job satisfaction, and turnover intentions: A comparison of three country clusters. *Applied psychology*, *61*(1), 1-29.

McDaniel, B. T., O'Connor, K., & Drouin, M. (2021). Work-related technoference at home and feelings of work spillover, overload, life satisfaction and job satisfaction. *International Journal of Workplace Health Management*.

Mungkasa, O. (2020). Bekerja Jarak Jauh (Telecommuting): Konsep, Penerapan dan Pembelajaran. Pappenas Working Papers, 3(1).

Monusova, G.A. (2008). Job satisfaction: International comparisons. World Econ. Int. Relat. 12, 74–83. 28.

Origo, F., & Pagani, L. (2008). Workplace flexibility and job satisfaction: some evidence from Europe. *International Journal of Manpower*.

Prasetyo, A., & Sukarni. (2021). Pengaruh Perhatian Orang Tua Terhadap Prestasi Belajar Pendidikan Agama Islam Siswa Kelas XII di SMKN 1 Batam. *Jurnal MUADDIB: Studi Kependidikan dan Keislaman. 11(01), 1-19*. https://dx.doi.org/10.24269/muaddib.v1i1.2721

Prasetyo, A., & Sukarni. (2022). Pengaruh Perhatian Orang Tua dan Peran Guru Terhadap Motivasi Belajar Siswa Masa Pandemi Covid-19. Jurnal Pendidikan Modern, 07(02), 42-54. DOI: https://doi.org/10.37471/jpm.v7i2.347

Purcell, J. dan Hutchinson, S., (2007), 'Front-line managers as agents in the HRM-performance casual chain: theory, analysis and evidence', *Human Resource Management Journal* , 17 (1):3-20

Richards, J. (2020). *Putting employees at the centre of sustainable HRM: a review, map and research agenda. Employee Relations: The International Journal, ahead-of-print(ahead-of-print).* doi:10.1108/er-01-2019-0037

Rivkin, W., Diestel, S., Stollberger, J., & Sacramento, C. (2021). The role of regulatory, affective, and motivational resources in the adverse spillover of sleep in the home domain to employee effectiveness in the work domain. *human relations*, 00187267211052469.

Shagvaliyeva, S., dan Yazdanifard, R. (2014). Impact of Flexible Working Hours on Work-Life Balance. American Journal Of Industrial And Business Management, 04(01), 20-23. doi: 10.4236/ajibm.2014.41004

Siegrist, J., Wege, N., Pühlhofer, F., & Wahrendorf, M. (2008). A short generic measure of work stress in the era of globalization: effort–reward imbalance. International Archives of Occupational and Environmental Health, 82(8), 1005–1013. doi:10.1007/s00420-008-0384-3

Setiawan, N. S. & Fitrianto. (2021). Pengaruh Work From Home (WFH) terhadap Kinerja Karyawan pada Masa Pandemi COVID-19. EDUKATIF: Jurnal Ilmu Pendidikan, 3(5), 3229-3242.

Sugiyono. (2017). *Metode Penelitian Manajemen, Pendekatan: Kuantitatif, kualitatif, Kombinasi (Mixed Methode), Penelitian Tindakan (Action Research), Penelitian Evaluasi.* Bandung: Alfabeta.

Suryawan, I. G. R., Ardana, I. K., & Suwandana, I. G. M. (2021). Transformational leadership, work stress and turnover intention: the mediating role of job satisfaction. *American Journal of Humanities and Social Sciences Research (AJHSSR)*, *5*(1), 146-157.

Sok, J., Blomme, R., & Tromp, D. (2014). *Positive and Negative Spillover from Work to Home: The Role of Organizational Culture and Supportive Arrangements. British Journal of Management, 25(3), 456–472.* doi:10.1111/1467-8551.12058

Spector, P. E (2000). *Industrial & organizational psychology: Research and Practice (2nd ed.).* New York: John Wiley & Sons, Inc.

Toscano, F., dan Zappalà, S. (2020). Social Isolation and Stress as Predictors of Productivity Perception and Remote Work Satisfaction during the COVID-19 Pandemic: The Role of Concern about the Virus in a Moderated Double Mediation. *Sustainability*, *12*(23), 9804. doi: 10.3390/su1223980

Yang, S. Y., Chen, S. C., Lee, L., & Liu, Y. S. (2021). Employee stress, job satisfaction, and job performance: A comparison between high-technology and traditional industry in Taiwan. *The Journal of Asian Finance, Economics and Business*, *8*(3), 605-618.

Yasa, I. W. C., Wibisono, C., Gulo, E. & Prasetyo, A. 2020. Determination Compensation, Leadership, And Organizational Culture on Performance Through Employee Work Satisfaction. International Journal of Psychosocial Rehabilitation, Vol. 24, No. 07, pp. 8758-8764. https://doi.org/10.37200/IJPR/V24I7/PR2700857

Ye, L. R. (2012). Telecommuting: Implementation for Success. International Journal of Business and Social Science, 20-29

Measurement of Customer Dissatisfaction Using Attribute Control Chart Based on Customer Review:A Basis for Developing Service Improvement Recommendations

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ABSTRACT

The cellular telecommunications industry provides communication access and digital needs by prioritizing service quality as its main selling point. In Indonesia, the telecommunications service provider that dominates and has been there for a long time is Telkomsel. To support digital touchpoint activities and provide convenience for users, Telkomsel provides an application called MyTelkomsel on the Google Play Store. On this platform, customer reviews are available, and it is essential to understand the content of negative customer reviews (NCR). They are closely related to the causes of customer dissatisfaction. Customer reviews are one of the standards to inform product development, improve product experience, and keep businesses connected with customers. This study uses the attribute control chart method to monitor the proportion of NCR. The results of monitoring and mapping the causes of customer dissatisfaction with Pareto and Ishikawa diagrams found that the most significant factors causing customer dissatisfaction were poor network quality and expensive internet package prices. From the service application side, poor application performance and an unpleasant experience using MyTelkomsel can cause customer disappointment and even frustration. Applications that are alternatives to getting products and services should be able to support and facilitate the digital activities of their users. Today's cellular operators must also be proactive in developing 5G telecommunications standards to meet consumer needs for fast networks and stable connections. MyTelkomsel, as a digital touchpoints application, can further optimize its performance by updating the application regularly, with good quality control monitoring.

Keywords: Control Chart, Telecommunication Service, Pareto Chart, Fishbone Diagram, Customer Satisfaction

1. INTRODUCTION

Telecommunication companies prioritize the quality of customer service, and the goal is to increase their involvement with the brand, commonly known as customer engagement. Companies can measure customer loyalty to their products by understanding customer engagement. That way,

companies can measure and act based on customer satisfaction levels. Customer satisfaction is an essential part of any business, and one practical way to understand this is by observing customer reviews. In Indonesia alone, the dominating telecommunications operator that has been around for a long time is Telkomsel. This brand meets the needs of mobile users to support their digital and communication activities. Under the auspices of PT Telkom Indonesia, Telkomsel is a subsidiary of a state-owned company whose network has spread widely across Indonesia. As a form of support for its customers, Telkomsel provides the MyTelkomsel application to provide convenience in making credit purchase transactions, internet packages and providing information on attractive offers and promotions to their customers. This application allows customers to browse the Telkomsel POIN reward program more efficiently. MyTelkomsel App has been downloaded over 50 million times on Google Play Store. Most Telkomsel users use this application to facilitate transactions and check the data or voice packages they want to buy. Although the app aims to provide benefits and convenience for its users, some user disappointment is inevitable. On the review page in the Google Play Store, there are many complaints related to application performance, as well as Telkomsel products and services in general, ranging from network quality, high prices, and annoying promotions to problems related to customer service.

Review data collection is an alternative that is currently widely practiced for research purposes. Online reviews provide a new context, namely added value for customers and an additional channel for companies to understand customer engagement(Barari et al. 2020). Customer engagement is how a company creates a relationship with its customer base. The goal is to foster loyalty and brand awareness. As the dominating operator, Telkomsel needs to keep customers engaged throughout their service purchase or usage journey to develop customer loyalty and gather information. It is necessary for Telkomsel to monitor negative customer reviews from customers so that they can find out the factors that cause their dissatisfaction with the services they have received. Therefore, it is necessary to conceptualize these factors and their influence on customer dissatisfaction. These factors can be cognitive such as service failure, overpricing, and fraud, or other triggers, such as emotional factors, such as disappointment and insecurity(Azer & Alexander 2020).

This research uses customer review data from Google Play on the MyTelkomsel application. The data collected are text-based reviews describing users' thoughts about the products and services provided. For each review, the customer gives a star rating (scale of 1-5) and represents the sentiment contained. In this research, a score of 1-3 signifies customer dissatisfaction, while a score of 4-5 falls into the positive review category. The research focuses on customer dissatisfaction, in which some desires must be met or existing problems. Understanding the customer's wishes and fulfilling them with the best quality is imperative (Beheshtinia & Farzaneh Azad (2019), so the business can continue operating and resolve customer problems immediately. This research applies quantitative analysis using attribute control charts to detect customer complaints. This method is quality control to monitor and control a process. The application of control charts contributes to service quality management research by extending previous static assessments (e.g., diagnosing and assessing service quality at a specific time) to continuous real-time service quality management (Kim & Lim 2021). This research applies a control charts diagram to monitor negative reviews on the MyTelkomsel application, find the source of service-related problems, and monitor changes in a process over time. The control chart itself has two types, namely variables and attributes. This research uses the attribute chart P and plots the data in time order. The control chart has a center line for the average value, an upper line for the upper control limit (UCL), and a lower limit line for the lower control limit (LCL). These lines are determined based on historical data. By comparing

the current data with these lines, inferences can be drawn to determine whether the process variation is consistent (under control) or unpredictable (out of control, as it is affected by certain variations).

Furthermore, identifying the factors causing the number of negative reviews will be done using Pareto charts. In addition, Ishikawa diagrams will support the formulation of the causal factors of the problems that arise. By doing so, researchers can conduct in-depth analysis to determine the main factors causing customer dissatisfaction to be evaluated and eliminated.

2. LITERATURE REVIEW

2.1 Telecommunications Industry

Telecommunication can be defined as the transfer of information between individuals or groups over a distance, utilizing various types of technology. Telecommunications is a vital infrastructure that contributes to the success of a business through its ability to facilitate communication between individuals and groups within and outside the organization's premises in any situation (Inegbedion & Obadiaru 2019). The telecommunications sector includes companies that facilitate and facilitate communication on a global scale, whether by telephone, internet, wired or wireless. Telecommunications companies create the infrastructure that allows data in text, audio, and video formats to be sent anywhere in the world. Currently, the largest telecommunications company sectors are telephone (wired and wireless), satellite, and internet service providers. The increase in internet usage has caused mobile instant messaging applications to become one of the biggest threats in the telecommunications industry. To face this threat and maintain market share, companies must consistently improve the quality of their services and operations. Therefore, Global System for Mobile Communication (GSM) operators need to work hard to gain new customers and retain existing customers. Operators must have strategies to improve network quality, conflict resolution, promotion, and pricing structure as antecedents of trust, corporate image, and switching costs (Demir, Budur & Heshmati 2021). In addition, such competitive competitors require telecommunications companies to compete to provide their best products and services to convince and retain customers in the operator brand they choose. Moreover, the trend of cellular phone usage is relatively increasing every year.

2.2 Customer Satisfaction

Customers are the stakeholders of a business in the sense that the value and quality of products and services impact them significantly. For example, passengers traveling by airplane put their safety in the hands of the airline company they choose. Customer Satisfaction describes the level of customer satisfaction with the company's products, services, and capabilities. The most straightforward definition is that customers will be satisfied when they meet their expectations. Customer satisfaction, or dissatisfaction, is the customer's feelings about how their experience with the organization has met their needs(Hill, Roche & Allen 2007). Satisfaction is a leading indicator, while loyalty, sales, and other performance measures become factors that can follow if customers are satisfied.

2.3 Online Review

Reviews contain customers' thoughts on whether their expectations have been satisfied. Significantly, online reviews take the form of textual comments, contextual images, and star ratings (Le et al. 2022). To increase consumer confidence in purchasing the product, consumers rely on written content to compare product attributes' positive and negative aspects. Contextual images provide product presentation to remove ambiguity. In addition, consumers often rely on high star ratings as they indicate overall product quality and brand preference as rated by other consumers.

Managers can learn from these components of online reviews to conduct evaluations to improve achievement targets. Unlike questionnaire-based surveys that are time-consuming and costly, online reviews are a data source with a large amount of information that is more time- and cost-efficient. The information is text-based and describes customer satisfaction with a service. However, due to the high volume of data (Big Data), analyzing repositories requires different skills compared to traditional econometric and statistical methods (Guo, Barnes & Jia 2017).

2.4 Control Chart

Control chart is a graph used to observe process changes over time. It is a graphical presentation with predefined control limits. This method compares the process output statistics (e.g., mean, range, and proportion of nonconformities) with the upper control limit (UCL) and lower control limit (LCL) to check if they conform to the expected and predictable quality levels (Kim & Lim, 2021). Researchers plot data in time order when using the control chart. Control charts always have a center line (CL) for the average, UCL as the upper control limit, and LCL, which is the lower control limit. Historical data determines all these lines. By comparing the current data with these lines, researchers can conclude whether the variation is consistent (under control) or unpredictable (out of control). Specific causes of data variation usually influence out-of-control conditions. Quality control can only occur at the point of input transformation into output, the point of operation, or production. Modern quality assurance is concerned with design quality and conformance quality (Vardeman & Jobe 2016). Using the correct statistical methods when dealing with data and variation is essential for generating fit quality. Any error in the measurement process can reduce the power to detect specific changes in the mean or variance of quality characteristics. Any measurement errors will impact the empirical data insights drawing process. To reduce the occurrence of measurement errors, double-check all measurements to ensure accuracy, make sure the formulas used are correct and perform test runs on measuring instruments.

3. METHODS

3.1 Online Review Data Collection

This research uses customer reviews on the MyTelkomsel application from the Google Play Store as a primary data source for research. In addition, the researcher collects secondary data to support the research from the Annual Report of PT Telkom Indonesia Tbk and the International Telecommunication Union (ITU). Review data are customer feedback, and both positive and negative are essential. However, negative reviews can reveal missing or poor features in the service. Luckily, the Google Play Store provides downloadable data of apps, reviews, and scores for analysis. This access ease researchers to explore customer complaints on the MyTelkomsel app.

3.2 Customer Complaints Index (CCI)

Analysis using control charts in this study aims to find the factors that cause customer dissatisfaction with products and services from Telkomsel. The research was conducted based on customer review data on the MyTelkomsel application on the Google Play Store. Reviews that contain negative sentiments or complaints represent Customer Dissatisfaction. This data is called the Customer Complaints Index (CCI) (Kim & Lim, 2021). CCI contains negative customer reviews (NCR), which are reviews that contain complaints from customers. Then it will be compared with the total reviews or customer reviews (CR). This method ends with calculating and sorting NCR and CR by day or according to the target determined in this study, with eight months of customer review data. The following section will explain the steps to produce a use ready CCI dataset.

3.3 Sentiment Tagging

The sentiment is an attitude, thought, or judgment based on feelings. Sentiment represents a person's opinion on an issue. In practice, the most applied sentiment analysis is sentiment classification. Sentiment classification traditionally refers to the classification of text content based on objective information, while sentiment classification currently refers to classifying text based on personal or subjective information (Zong, Xia & Zhang 2021). Subjective information or writing are personal opinions, interpretations, viewpoints, emotions, and judgments. It differs from objective information, which is fact-based and can be measured and observed. Subjective information is a person's unique interpretation based on subjective observations, and several factors, including various types of bias, influences this information. The openness and freedom of the digital era have made public opinion a powerful weapon in businesses, organizations, and even political campaigns (Hidayatillah et al. 2019). This digital era has also made online media a part that is inseparable from society. Cellular phones and stable internet connections are crucial parts that are also inseparable from daily life to support productivity and communication. Statista and ITU data predict that by 2025 the share of fast fixed-broadband subscriptions (download speeds of more than 10 Mbit/s) is projected to reach 56%. In the telecommunications industry, most of the business is subscriber-based, so consumers are one of the stakeholders. Their sentiment has a significant impact on business continuity. Customers can easily decide to unsubscribe and switch to a provider with a better percentage of positive sentiment.

The most common sentiment classification encountered in studies or research is sentiment polarity or positive-negative classification (Zong et al. 2021). The goal is to determine whether a sentence contains a positive or negative sentiment classification. Besides positive and negative, sentiment classification also considers neutral sentiment as one category. This research only uses two sentiment categories (positive-negative) in classifying. Because the dataset designed is to formulate a customer complaint index, the researcher will only investigate further the negative reviews. This research will use the term sentiment tagging, where the process includes a simple practice of sentiment classification without involving complicated machine learning methods.

3.4 Attribute Control Chart

Researchers use the Attribute Control Chart to track the production of defective items. The chart does not tell why the defect occurred but gives the total or average number per unit. Attributes are discrete quantities or data such as conform/non-conform, pass/fail, or yes/no. Attributes are qualitative, unlike variables (e.g., physical dimensions) which are quantitative. Control system operations and large volumes of information flow support this process in its implementation (Vasilyeva, Koteleva & Ivanov 2018). Control charts exist as a quality control method to support the process and ensure everything is under control. This study uses attribute control charts to detect negative reviews to understand the level of customer satisfaction. To visualize the frequency of negative reviews, researchers design a statistical model by adopting the customer complaints index (CCI) (Kim & Lim, 2021) which is formulated in Eq. (1) as follows.

$$CCI_{i,t} = \frac{N(NCR_{i,t})}{N(CR_{i,t})} \quad (1)$$

NCR represents the number of negative reviews given, while CR is the total number of reviews (negative and positive) for each review *i* and in period *t*. To calculate the proportion of NCR, researchers will use the CCI dataset thus the UCL and CL are also slightly modified which are formulated in Eq. (2) and (3) as follows.

$$CL_i = \frac{\sum_{t=1}^{T} NCR_{i,t}}{\sum_{t=1}^{T} CR_{i,t}} \quad (2)$$

$$UCL_{i,t} = CL_i + L\sqrt{\frac{CL_i(1-CL_i)}{CR_{i,t}}} \quad (3)$$

T is the number of periods, and *L* is the sensitivity parameter. Monitor the CCI to identify any anomalies, such as any values that exceed the UCL. A CCI outside the upper control limit (UCL) indicates that the service is out of control. Therefore, carry a further investigation to find and eliminate the problem. Regarding the type of control chart used, in this case, it is a *P* chart, a control chart used for attributes that show the proportion of non-conforming items in the sample (Oakland 2008).

The use of control charts aims to monitor variation over time. Researchers manually determine the period and L in the control parameter determination process by considering how much review data and how often the company analyzes customer complaints. The smaller the period value (e.g., per day), the more detailed the analysis results are considering the fast-changing service sector. It is possible to analyze customer complaints frequently or routinely. While sensitivity (*L*) is a constant that represents the width of the control limits, as shown in Equation (3), the smaller the value of *L* used (1 - 4), the higher the sensitivity, so that even minor customer complaints can be detected

4. RESULTS

4.1 Customer Review Data

Efforts to understand customers by analyzing customer reviews help companies understand overall customer satisfaction. Reviews are feedback on the business and contain what they want. Before conducting further analysis, the sentiment in the review data needs to be classified first. In this study, customer reviews of the MyTelkomsel application are classified into two categories. The classification uses the sentiment tagging method and refers to the star rating (1 to 5). This rating system applies to every app on the Google Play Store and is a reliable way to detect the polarity of sentiment in a review. A star rating with a score of 1 to 3 is classified as a negative review, indicating that the review content contains customer dissatisfaction with the product or service provided by the operator. Meanwhile, scores of 4 and 5 are categorized as reviews containing positive sentiments. The recap of customer review data organized into these two sentiment categories can be seen in Figure 1.

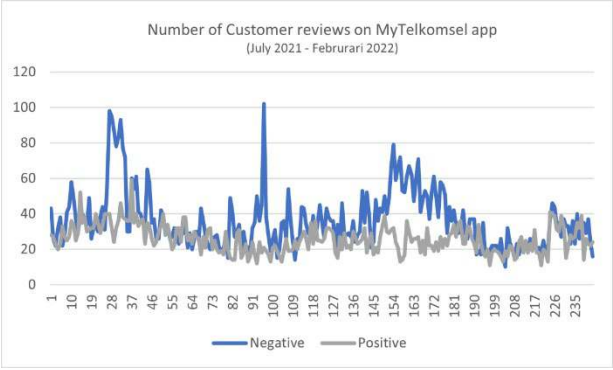


Figure 1. Customer Reviews

Figure 1 is the result of observations based on the total number. Meanwhile, if observed, the graphs in Figures 1 show a spike in negative reviews on certain days. This happening needs to be investigated further to find the factors causing the spike in negative reviews and what the company can do to address the issue. In some cases, negative reviews may contain isolated or obscure issues. But in other cases, negative reviews can point out the company's biggest problems.

4.2 P Control Chart

The p chart is used when a product or service is characterized as defective or non-defective. In the case of measuring customer dissatisfaction, the P diagram plots the proportion of negative customer reviews (NCR) per subgroup. The data collected is the number of NCR in each subgroup, which follows a binomial distribution with an unknown proportion parameter (p).

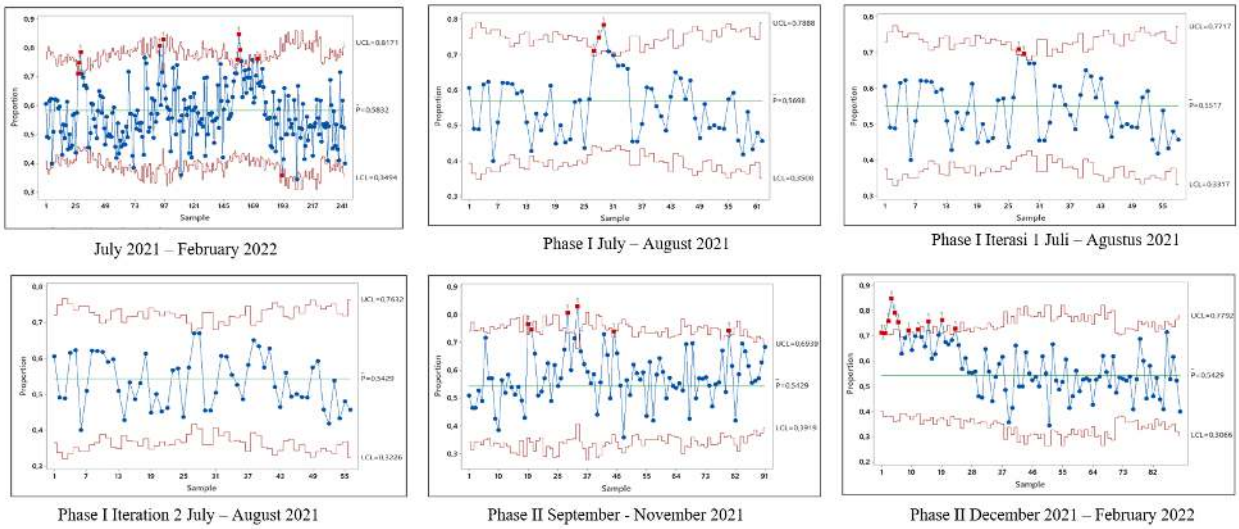


Figure 2. p-chart of NCR

Figure 2 (July – February 2022) shows a control chart for the NCR using a p-chart without any intervention, such as deletion or addition to the review data. The further identification process will involve the p diagram in several phases. In phase I, samples out of control will be removed to determine the CL value. This CL value will be used and locked as a limit to assess process performance and is used in phase II. In the Phase II period, many samples were outside the upper control limit, indicating an increasing number of negative reviews compared to the previous months. Eliminating out-of-control samples from the calculation may be carried out if the specific cause of variation is known. However, not deleting them will have little impact on the control limits if you have sufficient data. An indicator that should be of particular concern is the presence of the sample above the control limit. The higher the number indicates the proportion of NCR is excessive and out of control. Meanwhile, samples at the lower limit or in the LCL area can be ignored. This indicates a low proportion of defects or NCR, and the smaller the proportion, the better.

4.3 Pareto Chart

A Pareto chart is a special form of a combination of a bar chart and a line chart. This chart is a graph showing the frequency of defects and their cumulative impact. Pareto charts are useful for identifying defects that are prioritized based on the highest frequency in order to observe the

overall improvement that can be made. In this study, defects are defined as negative reviews, so the use of Pareto diagrams is to find the NCR frequency. The first step is to track, based on the control chart, which days have excess NCR amounts. Next, calculate the percentage of NCR to make sure once again that the proportion of NCR on those days is out of control. Aspects of products and services are closely related to studies that discuss customer trust, company image, and the cost of switching services to cellular operators (Demir et al. 2021). This is because this aspect is in direct contact with the customer, in contrast to the supporting application aspect, which is an alternative to getting customers' products and services.

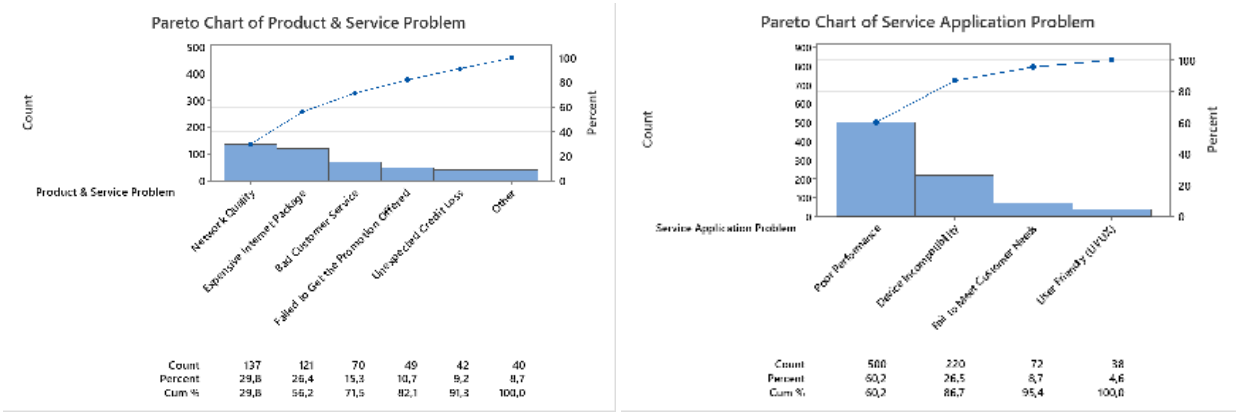


Figure 3. Pareto Chart of Customer Dissatisfaction

Figure 3 shows that the main factor that causes customers to be dissatisfied with cellular operators is network quality issues. While the dissatisfaction aspect from the application side is about poor application performance (poor performance), complaints are mostly centered on the sluggishness of the application and the execution of features that have not been maximized.

4.4 Fishbone Diagram

The Fishbone diagram is a cause-and-effect diagram used to identify the factors that cause customer dissatisfaction by relating them to the results of the Pareto diagram analysis. As the name implies, this diagram presents ideas based on categories that form like a fish skeleton, with customer dissatisfaction problems at the head and causes of problems forming bones at the back of the head.

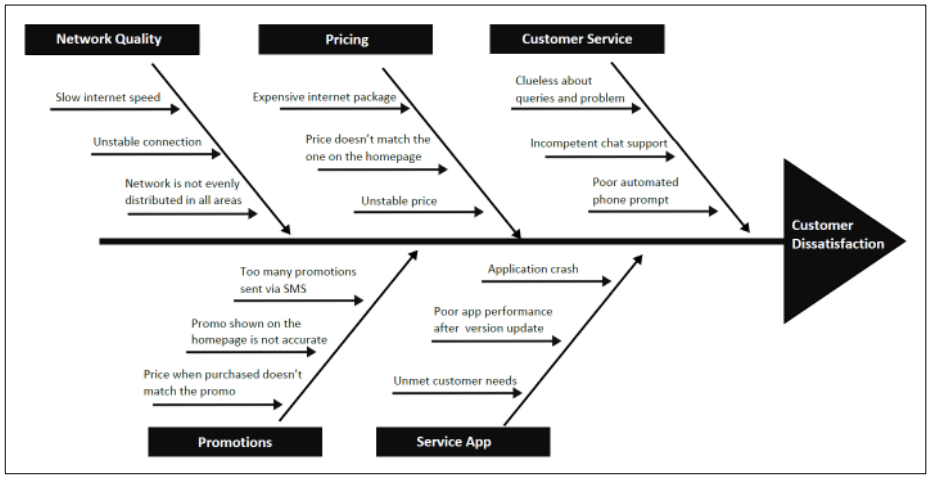


Figure 4. Fishbone Diagram of Customer Dissatisfaction

Causes of problems that are mapped into these five categories (Figure 4) are product and service problems that cellular operators commonly encounter. To take a deeper look and find the root cause, at the bottom of each category is a list of specific reasons customers are dissatisfied with their chosen operator. From this diagram, insights are obtained that can support the decision-making process according to the type of problems encountered. Businesses can carry out product planning and development by involving customers as stakeholders by referring to what customers feel. Customers as stakeholders in the business have the right to get what they want, just as a business will get good sales if it meets customer needs. For example, in the category of network quality problems, customers have the right to get the best service from the provider because this is the main selling point in the cellular telecommunications business. From the price aspect (pricing), Telkomsel, a provider that dominates almost all parts of Indonesia, needs to determine a pricing strategy that can accommodate various groups of people while still maintaining network quality.

6. CONCLUSIONS

Customer review data from the MyTelkomsel application contains customer thoughts, expectations, and opinions about Telkomsel operators. From this data, various insights can be obtained to support the service improvement process. The data extracted specifically is negative customer review (NCR) to obtain this information. The application of control charts to NCR data is useful for monitoring proportions so that excess NCR amounts can be detected and analyzed further. Based on observations with review data from July 2021 – February 2022, every month, the percentage of NCR exceeds 50%, with the highest record in December 2021, as much as 67%. It is certainly not a small number, and as a customer-centric business, operators need to be able to absorb this feedback for service improvement.

In an era that requires high digital connectivity like today, operators must ensure quality in terms of network performance and competitive prices to achieve operational and infrastructure excellence. The next aspect that affects the level of customer satisfaction in terms of service applications is Poor application performance and unpleasant experiences in using the MyTelkomsel. Applications that are alternatives to getting products and services should be able to support and facilitate the digital activities of their users, not complicate the process that previously could be done. Broadly speaking, what needs to be improved are the main technologies that need to be developed. Current 5G telecommunications standards must be developed to meet consumer needs for fast networks and stable and quality connections. This needs to be developed to provide guaranteed network availability and reliability. Meanwhile, in terms of applications, in general, what needs to be ensured is a reliable development team, both from a technical and theoretical perspective. Qualified technical ability is a criterion that must be met. Meanwhile, theoretical aspects can be helpful in supporting research to develop applications according to behavior patterns and user needs.

REFERENCES

Azer, J. & Alexander, M., 2020, "Negative customer engagement behaviour: the interplay of intensity and valence in online networks," *Journal of Marketing Management*, 36(3–4), 361–383.

Barari, M., Ross, M., Thaichon, S. & Surachartkumtonkun, J., 2020, "A meta-analysis of customer engagement behaviour," *International Journal of Consumer Studies*, 45(4), 457–477.

Beheshtinia, M.A. & Farzaneh Azad, M., 2019, "A fuzzy QFD approach using SERVQUAL and Kano models under budget constraint for hotel services," *Total Quality Management and Business Excellence*, 30(7–8), 808–830.

Demir, A., Budur, T. & Heshmati, A., 2021, "Antecedents of trust, corporate image, and switching costs: a case in telecommunication services in the Kurdistan region of Iraq," *International Journal of Mobile Communications*, 19(1), 53–74.

Guo, Y., Barnes, S.J. & Jia, Q., 2017, "Mining meaning from online ratings and reviews: Tourist satisfaction analysis using latent dirichlet allocation," *Tourism Management*, 59, 467–483.

Hidayatillah, R., Mirwan, M., Hakam, M. & Nugroho, A., 2019, "Levels of political participation based on naive bayes classifier," *IJCCS (Indonesian Journal of Computing and Cybernetics Systems)*, 13(1), 73–82.

Hill, N., Roche, Greg. & Allen, Rachel., 2007, *Customer Satisfaction: The Customer Experience Through The Customer's Eyes*, Cogent, London.

Inegbedion, H. & Obadiaru, E., 2019, "Modelling brand loyalty in the Nigerian telecommunications industry," *Journal of Strategic Marketing*, 27(7), 583–598.

Kim, J. & Lim, C., 2021, "Customer complaints monitoring with customer review data analytics: An integrated method of sentiment and statistical process control analyses," *Advanced Engineering Informatics*, 49.

Le, L.T., Ly, P.T.M., Nguyen, N.T. & Tran, L.T.T., 2022, "Online reviews as a pacifying decision-making assistant," *Journal of Retailing and Consumer Services*, 64.

Oakland, J.S., 2008, *Statistical Process Control*, 6th edn., Elsevier.

Vardeman, S.B. & Jobe, J.M., 2016, *Statistical Methods for Quality Assurance: Basic, Measurement, Control, Capability, and Improvement*, 2nd edn., Springer.

Vasilyeva, N., Koteleva, N. & Ivanov, P., 2018, "Quality Analysis of Technological Process Control," *International Journal for Quality Research*, 12(1).

Zong, C., Xia, R. & Zhang, J., 2021, *Text Data Mining*, 1st edn., Springer.

ANALYSIS OF FACTORS THAT AFFECTING COMPANIES AND EMPLOYEES' INTENTION IN INDONESIA TO USE EARNED WAGE ACCESS SERVICES

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ABSTRACT

Earned wage access (EWA) service is an innovation in the field of financial technology which allows an employee to withdraw his salary earlier before the payday. This service began to enter the Indonesian market in 2020 to be able to solve the financial problems of employees in Indonesia and prevent employees from being trapped by illegal P2P lending services. However, after 1 year of penetration of this service, it did not bring results as expected because the adoption rate was very slow when compared to P2P lending services in the first year of penetration. Based on these problems, this study aims to investigate the factors that influence the interest of 2 important stakeholders in the adoption of this service: the decision makers of companies and employees with the Technology Acceptance Model approach with several factors being evaluated: perceived usefulness, perceived ease of use, perceived trust, perceived risk, and user innovativeness. This study uses primary data derived from a survey conducted on 50 decision makers in companies and 54 employees in Indonesia who have or have not had access to use EWA services. The results showed that the user innovativeness factor was the most influential factor for both company decision maker and employee's segmentation. Moreover, other factors that directly influence the company's decision makers are perceived usefulness and perceived trust, while perceived ease of use and perceived risk have an indirect effect. Meanwhile for employee's segmentation, other influencing factors are perceived usefulness and perceived ease of use, while perceived trust and perceived risk have no effect. The results of this study indicate that the innovation acceptance level from prospective consumers is something that needs to be prioritized by the marketing management of EWA service providers where this can be realized by implementing machine learning methods and survey methods.

Keywords: Financial Technology, Earned Wage Access, Technology Acceptance Model.

1. INTRODUCTION

In recent years, one of the industries that has significant development in Indonesia is the financial technology (fintech) industry. Among the many companies engaged in fintech, there is one service that has a significant adoption rate in Indonesia, which is peer-to-peer (P2P) lending services. P2P lending services are financing services to an individual without going through a bank intermediary (Suryono et al, 2021). According to data released by OJK (2021), the number of borrower accounts on P2P lending services in Indonesia reached 68,414,603 in August 2021 or 25% of the total population in Indonesia which indicates a large positive perception in the eyes of the Indonesian people. However, this service is considered to have caused several critical

problems in Indonesia. One of the studies conducted by Suryono et al (2021) regarding the detection of problems with P2P lending services in Indonesia states that one of the problems with P2P lending services in Indonesia is the proliferation of illegal P2P lending services that are disturbing and tormenting the Indonesian people. Although the characteristics of illegal P2P lending services are easy to detect, many people are still using this service due to the economic problems. This is in line with the Hawkins (2020) opinion where financial problem is often faced by middle to low class employees, and this problem makes them have no other option but to apply for loans although this can cause a new problem due to the high interest rates on loans that must be paid.

Seeing the opportunity from these problems, a renewable innovation named Earned Wage Access (EWA) service was born as an alternative to P2P lending which is expected to solve the financial problems of employees by providing access or benefits for employees to claim the part of their salary without waiting for the payment date. According to Hawkins (2020), in the last 3 decades, EWA service is quite popular and attractive for company and employees with lower middle income in the United States because it is beneficial both for the company and the employee. Inspired by the popularity of EWA services in the United States, several fintech companies are now starting to open these services in Indonesia (Shu, 2021). However, after 1 year of penetration of this services in Indonesia, it turns out that the result is far below expectation because the adoption rate is very slow compared to the P2P lending services on their first year of penetration in Indonesia (Ariwulan, 2017). It is very unfortunate considering the large benefits offered by this service in improving financial welfare for people in Indonesia. Based on these problems, this study will conduct to investigate factors that influence the intention of 2 important stakeholders in the adoption of this service: companies as decision makers of the adoption and employees as end users and recommenders for decision makers. The data used in this study is derived from a survey of employees and companies' decision makers that have and have not used EWA services to assess their perceptions of this service. The results of this study can be used by EWA service providers to be able to face challenges in terms of innovation and technology adoption of EWA especially in Indonesia. In addition, the results of this study can also be used to provide recommendations for EWA providers to increase the adoption rate of this services.

2. LITERATURE REVIEW

2.1. EARNED WAGE ACCESS

The significant development of information technology is one of the driving factors for the continuous innovations in the fintech sector. One of the latest innovations that is currently quite popular among lower-middle employees in the United States is earned wage access (EWA) (Hawkins, 2020). Earned wage access is defined as a service that allows employees to collect their salaries early without waiting for payment date. EWA business model has several values that are advantages so that it is quite attractive for both EWA service providers and users (Hawkins, 2020). One of these advantages is that the EWA service provider company avoids the risk of non-performing loans (NPL) where the NPL problem is the most common problem in the P2P lending business model. In addition, EWA service providers also get other benefits such as the access to information from employees such as historical data regarding expenses from an employee so that the data can be processed and used in the future to add insight from the business. From the user's perspective, the main advantage is that employees have access to emergency funds quickly with lower additional costs and easier procedures compared to using loan services at financial institutions. Moreover, employees are also free from debt because the funds they have obtained through EWA services will be deducted from their salaries in the next period. This service is also

considered useful for the company because the company will indirectly receive benefits from implementing this service. One of the benefits obtained by the company is an increase in employee productivity and a decrease in the turnover rate due to the increase of employee financial welfare. Hence, it will also have an impact on improving the employee and company performance so that they can continue to grow in a positive direction.

2.2. TECHNOLOGY ACCEPTANCE MODEL

The Technology Acceptance Model (TAM) is a theoretical model that was first developed by Davis through his PhD research. This model aims to identify the motivation of users in using a system. In the first model, Davis (1986) concludes that there are 3 factors that can explain user motivation: perceived ease of use, perceived usefulness, and attitude toward using. However, in 1989, Davis et al made a modification then tested the latest model on 107 participants to determine the participants' intention to use a system 1 hour the introduction and 14 weeks thereafter. Based on the results of these tests, it was found that the perceived usefulness and the perceived ease of use had a direct relationship to behavioral intention. Therefore, it is necessary to eliminate the attitude toward behavior factor to produce the final version of TAM which can be seen in Figure 1 (Venkatesh & Davis, 1996).

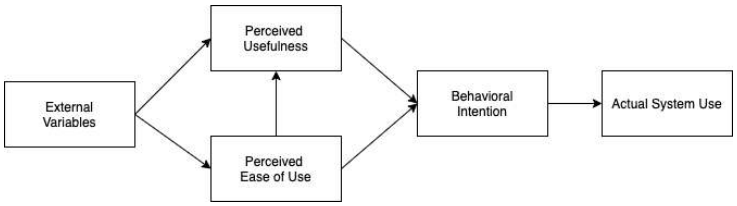


Figure 1. Final Version of the Technology Acceptance Model (TAM)
(Venkatesh & Davis, 1996)

2.3. PERCEIVED USEFULNESS

Perceived usefulness is one of the main factors that considered significant in influencing the intention of users to use a system based on the Technology Acceptance Model (TAM) methodology developed by Davis (1986). This factor is defined as the level of belief of an individual that when using a system, it will improve his performance (Davis, 1986). Referring to several previous studies, for example, research conducted by Theodora et al (2010) regarding the adoption of mobile transaction services in Greece, perceived usefulness is a factor that is proven to influence user intentions in using these services.

H1: Perceived usefulness has a significant effect on the intention of employee or company's decision makers in using earned wage access (EWA) services.

2.4. PERCEIVED EASE OF USE

In addition to perceived usefulness, perceived ease of use is an important factor in the TAM methodology that affects the intention of users to use a system or technology. This factor is defined as the level of belief of an individual that when using a system, will not expend physical and mental effort (Davis, 1986). The research conducted by Singh (2021) regarding digital wallet adoption in India proved that ease of use is a critical factor influencing technology adoption especially financial technology and influencing the perceived usefulness.

H2: Perceived ease of use has a significant effect on the perceived usefulness of employee or company's decision makers in using earned wage access (EWA) services.

H3: Perceived ease of use has a significant effect on the intention of employee or company's decision makers in using earned wage access (EWA) services.

2.5. PERCEIVED TRUST

Perceived trust is defined as the level of trust from an individual regarding the credibility of another parties when the individual interacts with them (Zaman and Khawaja, 2013). This factor is considered important by some research in technology adoption due to the lack of direct face-to-face interaction between users and service providers (Almarashdeh et al, 2019). The statement is also in line with the research on consumer acceptance of mobile payments by Shao et al (2014) where they stated that trust is one of the most considered issues by users when adopting mobile payment services.

H4: Perceived trust has a significant effect on the intention employee or company's decision makers in using earned wage access (EWA) services.

2.6. PERCEIVED RISK

Perceived risk is defined as an individual's level of belief in the risk regarding the dissemination and misuse of both personal and financial information (Tan and Teo, 2000). According to Brown et al (2003) in their research on mobile banking in South Africa, the lower the user's perceived risk of a technology, the higher the probability that the technology will be adopted. In addition to influencing users' intentions to adopt a technology, several studies have also found that perceived risk is a factor that affects perceived trust such as research conducted by Zhai et al (2021) regarding the adoption of peer-to-peer (P2P) lending.

H5: Perceived risk has a significant effect on the perceived trust of employee or company's decision makers in using earned wage access (EWA) services.

H6: Perceived risk has a significant effect on the intention of employee or company's decision makers in using earned wage access (EWA) services.

2.7. USER INNOVATIVENESS

User innovativeness is defined as the degree to which an individual is inclined to try new products, services, or technologies. An individual can be categorized as highly innovative if they are able to try something new that has a high level of uncertainty (Hu et al, 2019). According to Kim et al (2009) in their research of the factors that influence the adoption of mobile payments, user innovativeness is a factor that has an important role in the adoption process of new technologies because it acts as driving force for an individual to adopt the technology. The importance of the user innovativeness factor in the process of adopting a technology has also been investigated in research conducted by Setiawan et al (2021) regarding the adoption of fintech in Indonesia where the results show that this factor is proven to influence the adoption of fintech.

H7: User innovativeness has a significant effect on the intention employee or company's decision makers in using earned wage access (EWA) services.

3. METHODS

The research will be conducted using quantitative methodology with the primary data being questionnaire given to targeted sample: employees and decision makers of the company who have or have not had access to EWA services. The questionnaire will contain indicators that derived from the variables or factors that being tested: perceived usefulness, perceived ease of use, perceived trust, perceived risk, and user innovativeness. The data processing and analyzing

method will be using one of the statistical methods which is Partial Least Square - Structural Equation Modelling (PLS-SEM) that commonly used for exploratory research.

The research model proposed by authors which is based on the Technology Acceptance Model is shown on Figure 2.

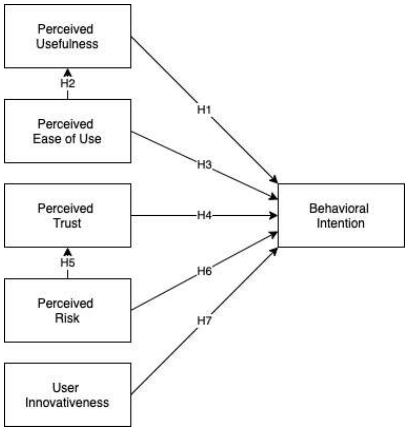


Figure 2. Research Model

According to the 10 times rules proposed by Barclay et al (1995), the minimum number of samples in the PLS-SEM method is 10 times the maximum number of structural paths that lead to a particular construct. Referring to the research model in Figure 2, it can be identified that the highest number of structural paths is 5, so it takes 50 samples to get accurate results in this study.

4. RESULTS

The data collection process is carried out by distributing online questionnaires using Google Forms. From the results of the questionnaire distribution, 50 respondents from company's decision maker segmentation and 54 respondents from employee segmentation are obtained. On the company's decision maker segmentation, 76% of the respondents haven't use earned wage access in their company. Based on the demography distribution, it can be concluded that 58% of the respondent is male, the age range is between 45 – 54 years old, most of them are in the company located in urban area in Indonesia that established in more than 10 years with more than 100 employees.

Meanwhile, on the employee segmentation, 76% of the respondents already registered to use EWA services and 73% of them already used the EWA services. Based on the demography distribution, 67% of the respondent is male, most of them live in urban area in Indonesia, have the age range between 25 – 34 years old and the latest education degree is high school. Moreover, 43% of them have average expenses between 1 – 3 million Rupiah per month.

4.1. MEASUREMENT MODEL EVALUATION

Measurement model evaluation aims to measure the reliability and validity of the constructs which are measured using indicator variables. To evaluate the measurement model, several tests will be conducted namely internal consistency reliability testing with composite reliability parameters, convergent validity testing with outer loading and average variance extracted (AVE) parameters, and discriminant validity testing with Fornell-Lacker criterion. The result for measurement model evaluation for both decision-maker and employee respondent can be seen on the Table 1 and Table 2.

Table 1. Internal Consistency Reliability and Convergent Validity

Respondent	Variables	Indicators	Composite Reliability	Outer Loading	Average Variance Extracted
Decision Maker	Perceived Usefulness	PU1	0.959	0.923	0.855
		PU2		0.912	
		PU3		0.935	
		PU4		0.928	
	Perceived Ease of Use	PEOU1	0.954	0.923	0.873
		PEOU2		0.939	
		PEOU3		0.942	
	Perceived Trust	PT1	0.959	0.938	0.886
		PT2		0.945	
		PT3		0.94	
	Perceived Risk	PR1	0.95	0.948	0.865
		PR2		0.94	
		PR3		0.901	
	User Innovativeness	UI1	0.938	0.915	0.835
		UI2		0.918	
		UI3		0.907	
	Behavioral Intention	BI1	0.963	0.941	0.895
		BI2		0.95	
		BI3		0.947	
Employee	Perceived Usefulness	PU1	0.958	0.941	0.849
		PU2		0.904	
		PU3		0.93	
		PU4		0.911	
	Perceived Ease of Use	PEOU1	0.956	0.949	0.878
		PEOU2		0.949	
		PEOU3		0.913	
	Perceived Trust	PT1	0.955	0.942	0.876
		PT2		0.918	
		PT3		0.948	
	Perceived Risk	PR1	0.947	0.869	0.856
		PR2		0.955	
		PR3		0.949	
	User Innovativeness	UI1	0.939	0.927	0.838
		UI2		0.93	
		UI3		0.889	
	Behavioral Intention	BI1	0.958	0.939	0.884
		BI2		0.942	
		BI3		0.939	

Table 2. Discriminant Validity

Respondent Segmentation	Variables	Perceived Usefulness	Perceived Ease of Use	Perceived Trust	Perceived Risk	User Innovative-ness	Behavioral Intention
Decision Maker	Perceived Usefulness	0.925	0.672	0.787	-0.497	0.602	0.84
	Perceived Ease of Use	0.672	0.934	0.587	-0.234	0.715	0.696

	Perceived Trust	0.787	0.587	0.941	-0.445	0.638	0.839
	Perceived Risk	-0.497	-0.234	-0.445	0.93	-0.325	-0.508
	User Innovativeness	0.602	0.715	0.638	-0.325	0.914	0.79
	Behavioral Intention	0.84	0.696	0.839	-0.508	0.79	0.946
Employee	Perceived Usefulness	0.922	0.871	0.805	-0.322	0.706	0.886
	Perceived Ease of Use	0.871	0.937	0.897	-0.27	0.731	0.907
	Perceived Trust	0.805	0.897	0.936	-0.249	0.731	0.858
	Perceived Risk	-0.31	-0.255	-0.243	0.925	-0.068	-0.232
	User Innovativeness	0.706	0.731	0.731	-0.071	0.915	0.807
	Behavioral Intention	0.886	0.907	0.858	-0.236	0.807	0.94

Based on the Table 1, it can be concluded that both decision maker and employee data are reliable and valid because they have Composite Reliability value ≥ 0.6, all indicators are loaded ≥ 0.7, and Average Variance extracted ≥ 0.5. Moreover, from Table 2, it can be concluded that all variables have their own uniqueness and can capture different phenomena for both decision maker and employee data given that the value of the green column in the table or the square root of Average Variance Extracted of certain variable greater than correlation of that variable to other variable.

4.2. STRUCTURAL MODEL EVALUATION

After ensuring that all the measurement model evaluations are in accordance with their respective desirable criteria, the next step is to conduct structural model evaluation where this test will simultaneously test the research hypothesis. To evaluate the structural model, the first step is to begin with collinearity assessment with VIF indicator. The result of collinearity assessment for both employee and decision-maker respondent can be seen on the Table 3.

Table 3. Collinearity Assessment

Indicators	Decision Maker VIF Value	Employee VIF Value (Before PR2 Removal)	Employee VIF Value (After PR2 Removal)
PU1	3.912	4.706	4.706
PU2	3.64	3.339	3.339
PU3	4.567	4.477	4.477
PU4	4.164	3.591	3.591
PEOU1	3.071	4.787	4.787
PEOU2	4.138	4.788	4.788
PEOU3	4.169	2.936	2.936
PT1	3.769	4.042	3.234
PT2	4.516	3.234	4.154
PT3	3.934	4.154	2.048
PR1	4.578	2.77	2.048
PR2	4.456	5.015	-
PR3	2.629	3.753	4.042
UI1	2.661	3.166	3.166

UI2	3.101	3.345	3.345
UI3	2.806	2.471	2.471
BI1	4.067	3.75	3.75
BI2	4.871	4.168	4.168
BI3	4.369	3.997	3.997

Based on the Table 3, it can be concluded that the decision maker data passed the collinearity assessment test because the VIF value of all indicators was less than 5. However, the employee data had not passed the collinearity assessment test because the PR2 indicator has VIF value more than 5. Therefore, it is necessary to remove the PR2 indicator in the research model for employee respondents to avoid biased results. After removing the indicators, retesting was carried out for employee respondents and the result showed that all the indicators already less than 5, so the next steps can be carried out to conduct the hypothesis testing. To carry on this test, and p-value indicator will be used to measure whether there is significance between the variables. In addition to strengthen the result the effect size test will be carried out to measure which variables or factor that substantially affect the intention of decision maker and employee to use earned wage access services. The result of the hypothesis testing and effect size test can be seen on the Table 4 and Table 5.

Table 4. Hypothesis Testing and Effect Size for Decision Maker

Path	Hypothesis	Path Coefficient	P-Value	Effect Size	Result
Perceived Usefulness → Behavioral Intention	H1	0.329	0.012	0.236	Significant
Perceived Ease of Use → Perceived Usefulness	H2	0.672	0	0.823	Significant
Perceived Ease of Use → Behavioral Intention	H3	0.026	0.819	0.002	Not Significant
Perceived Trust → Behavioral Intention	H4	0.3	0.009	0.233	Significant
Perceived Risk → Perceived Trust	H5	-0.445	0.004	0.247	Significant
Perceived Risk → Behavioral Intention	H6	-0.091	0.158	0.045	Not Significant
User Innovativeness → Behavioral Intention	H7	0.352	0.002	0.391	Significant

Table 5. Hypothesis Testing and Effect Size for Employee

Path	Hypothesis	Path Coefficient	P-Value	Effect Size	Result
Perceived Usefulness → Behavioral Intention	H1	0.319	0.005	0.208	Significant
Perceived Ease of Use → Perceived Usefulness	H2	0.871	0	3.151	Significant
Perceived Ease of Use → Behavioral Intention	H3	0.368	0.002	0.167	Significant
Perceived Trust → Behavioral Intention	H4	0.093	0.33	0.015	Not Significant
Perceived Risk → Perceived Trust	H5	-0.249	0.063	0	Not Significant
Perceived Risk → Behavioral Intention	H6	0.007	0.869	0.066	Not Significant
User Innovativeness →	H7	0.319	0.005	0.223	Significant

Behavioral Intention					

Based on the Table 4, it can be concluded that H1, H4, and H7 are accepted, which means perceived usefulness, perceived trust, and user innovativeness are the factors that significantly affect decision maker's intention of using earned wage access services, meanwhile H3 and H6 are rejected or in other words perceived ease of use and perceived risk are identified to be insignificant factors for decision maker. However, H2 and H5 results showed that both perceived ease of use and perceived risk are significant to the factor the significantly affect the intention of using this service. Therefore, it can be concluded those factors are also affecting the intention of decision maker in using earned wage access services but indirectly.

For the employee segmentation result on the Table 5, it can be concluded that H1, H3, and H7 are accepted so that perceived usefulness, perceived ease of use, and user innovativeness are the factors that significantly affect employee's intention in using earned wage access services, meanwhile H4 and H6 are rejected so that perceived trust and perceived risk are identified to be insignificant factors for employee and based on H5 result, there is also no sign that perceived risk factor indirectly affect the intention of employee in using this service. Furthermore, user innovativeness is found to be the most affecting factor that affecting intention in using EWA services considering that it has the highest effect size results to the behavioral intention for both decision maker and employee segmentation. In the other words, the innovation acceptance level of potential customers is the factor that needs to be most considered by EWA service providers.

6. CONCLUSIONS

Based on the research conducted to examine the factors that affecting intention of using EWA services on 50 decision makers and 54 employees who have or have not had access to using EWA services, it can be concluded that user innovativeness is the factor that most significantly affect the intention in using this service both for the decision maker and employee segmentation. Hence, innovation acceptance level is something that needs to be paid attention especially on the user acquisition process by the marketing management team where it can be realized by implementing machine learning or survey methods. Other significant factors of decision makers segmentation are perceived usefulness and perceived trust where these results could also generate insights for the EWA services providers for example, highlighting usefulness aspects of EWA in the marketing content and forming community for decision makers.

Besides of that, for the decision maker segmentation there are also the factors that influence indirectly: perceived ease of use and perceived risk which can also resulted insights for example by highlighting convenience, security, and information aspects of the marketing content. On the employee segmentation, highlighting the usefulness and convenience aspects of EWA in the marketing content for employees are the recommendations that could be considered given that perceived usefulness and perceived ease of use are the factors that influence their intention in using this service. Meanwhile, EWA services providers do not need to pay attention for the perceived trust and perceived risk factors considering these factors have no direct or indirect effect of the employee intention in using this service.

REFERENCES

Almarashdeh, I., Aldhmour, K., Aljamaeen, R., Alsmadi, M., and Jaradat, G. (2019), The effect of perceived trust in technology, trust in the bank and perceived risk on customer adoption of mobile banking, *Proceedings of 2019 International Conference on Internet of Things, Embedded Systems and Communications* (IINTEC), Tunis, Tunisia, 118-123.

Ariwulan, S. (2017). Perkembangan fintech, benarkah ancaman bagi perbankan?. [online] Alinea.id. Available at: <https://www.alinea.id/infografis/perkembangan-fintech-benarkah-ancaman-bagi-perbankan-b1RUT9mt> [Accessed 18 December 2021].

Barclay, D., Thompson, R., & Higgins, C. (1995). The Partial Least Squares (PLS) Approach to Causal Modeling: Personal Computer Use as an Illustration. *Technology Studies*. 2 (2), 285– 309.

Brown, I., Cajee, Z., Davies, D. & Stroebel, S. (2003), Cell phone banking: predictors of adoption in South Africa—an exploratory study, *International Journal of Information Management*, 23 (5), 381– 394.

Davis, F. (1986), A Technology Acceptance Model for Empirically Testing New End-User Information Systems: Theory and Result, *Thesis Ph.D*., Massachusetts Institute of Technology.

Davis, F. (1989), Perceived Usefulness, Perceived Ease of Use, and User Acceptance of Information Technology, *MIS Quarterly*, 13 (3), 319.

Hawkins, J. (2020), Earned Wage Access and the End of Payday Lending, *101 Boston University Law Review* 706.

Hu, Z., Ding, S., Li, S., Chen, L., & Yang, S. (2019). Adoption intention of Fintech services for bank users: An empirical examination with an extended technology acceptance model. *Symmetry*, 11 (3), 340.

Kim, C., Mirusmonov, M., & Lee, I. (2010), An empirical examination of factors influencing the intention to use mobile payment, *Computers in Human Behavior*, 26 (3), 310– 322.

Ojk.go.id. (2021). Penyelenggara Fintech Lending Terdaftar dan Berizin di OJK per 10 Juni 2021. [online] Available at: https://www.ojk.go.id/id/kanal/iknb/financial-technology/Pages/Penyelenggara-Fintech-Lending-Terdaftar-dan-Berizin-di-OJK-per-10-Juni-2021.aspx [Accessed 23 September 2021].

Setiawan, B., Nugraha, D., Irawan, A., Nathan, R., and Zoltan, Z. (2021), User Innovativeness and Fintech Adoption in Indonesia, *Journal of Open Innovation: Technology, Marketing, and Complexity*.

Shao, M., Fan, J. & Li, Y. (2021), An Empirical Study on Consumer Acceptance of Mobile Payment Based on the Perceived Risk and Trust, *Proceedings of 2014 International Conference on Cyber-Enabled Distributed Computing and Knowledge Discovery*, IEEE, 312– 317.

Shu, C. (2021). Wagely, an Indonesian earned wage access and financial services platform, raises $5.6M. [online] Techcrunch.com. Available at: https://techcrunch.com/2021/06/08/wagely-an-indonesian-earned-wage-access-and-financial-services-platform-raises-5-6m/ [Accessed 23 September 2021].

Singh, P., Kumar, P., & Gupta, D. (2021), The Role of Consumer's Innovativeness & Perceived Ease of Use to Engender Adoption of Digital Wallets in India, *Proceedings of 2018 International Conference on Automation and Computational Engineering* (ICACE - 2018), IEEE, 150– 157.

Suryono, R., Budi, I., & Purwandari, B. (2021). Detection of fintech P2P lending issues in Indonesia, *Heliyon*, 7 (4), 1 – 10.

Tan, M. & Teo, T. (2000), Factors Influencing the Adoption of Internet Banking, *Journal of the Association for Information Systems*, 1 (1), 1– 44.

Theodora, Z., Vaggelis, S., Maro, V., & Rodoula, T. (2010), Predicting the Adoption of Mobile Transactions: An exploratory Investigation in Greece, *Proceedings of 2010 Ninth International Conference on Mobile Business / 2010 Ninth Global Mobility Roundtable*, IEEE, 141– 147.

Venkatesh, V. & Davis, F. (1996), A Model of the Antecedents of Perceived Ease of Use: Development and Test, *Decision Sciences*, 27 (3), 451– 481.

Zaman, S. & Khawaja, K. (2013), Impact of Service Quality Perceived Risk, Perceived Privacy and Security and Perceived Trust on Technology Acceptance Model: An Empirical Study based on Online Banking Sector of Pakistan, *Proceedings of 2013 2nd National Conference on Information Assurance* (NCIA), IEEE, 89– 94.

Zhai, M., Chen, Y., & Wei, M. (2021), Influence of trust and risk on peer-to-peer investment willingness: a bidirectional perspective, *Internet Research.*

RISK MANAGEMENT DESIGN OF MAINTENANCE PROJECT MANAGEMENT WITH OMMP (OVERALL MEASURE OF MAINTENANCE PERFORMANCE) AND MAFMA (MULTI-ATTRIBUTE FAILURE ANALYSIS) APPROACH

(Case Study: Production Department of PT. SC Johnson Manufacturing - Surabaya)

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ABSTRACT

PT. SC Johnson Manufacturing Surabaya is a company engaged in manufacturing by producing mosquito coil products. However, since 2020 there has been a decline in productivity of around 15% of the target. A reduction in engine performance causes this decrease in productivity. Machine performance greatly affects efficiency and effectiveness in the production process. However, machine reliability is often not paid attention to so that the machine is damaged and has the potential to create a risk of work accidents, product defects or other losses. This study uses the OMMP (Overall Measure of Maintenance Performance) method to measure the performance of maintenance management with preventive maintenance and corrective maintenance approaches by considering optimal costs and time. In addition, this maintenance performance measurement will result in more efficient maintenance scheduling. The machine under study is the MMG – 108 stamping machine (printing machine).

Meanwhile, to mitigate risks due to failure of machine maintenance management, MAFMA (Multi-Attribute Failure Mode Analysis) risk identification is used. However, the value of Availability, performance and quality rate is still low, so through the OMMP approach, it is necessary to make improvements from the perspective of maintenance on the dimensions of human resources and economy. The human resources dimension with utilization and overdue task indicators, as well as the work order dimension with planned and scheduled work orders, wrapping, and inventory turnover rate indicators. And the economy dimension with utilization and overdue task indicators, as well as work order dimensions with inventory turnover rate indicators. From the results of MAFMA, the priority of maintenance and repair is on the first rank of punch holder (MAFMA = 0.0350), the second rank for the lower plate (MAFMA = 0.0293), the third rank (MAFMA = 0.0159). This is because, in addition to considering the products' risks, it also feels the effects of machine losses and the company's ability to pay for maintenance.

Keywords: *attribute, failure, effective, maintenance, cost*

1. INTRODUCTION

PT. SC Johnson Surabaya is a company engaged in household cleaning, pest control and body care in Indonesia. Of course, the machines used to require an effective maintenance system to reduce high maintenance costs. PT. SC Johnson Surabaya is trying to carry out maintenance management to make continuous improvements (improvement). However, until now, there seems to be much corrective maintenance because many machines are still damaged or have sudden errors, so management is trying to schedule maintenance or by preventive maintenance approach by adjusting to the machine's condition. In addition, in this corrective maintenance concept, complicated things are rarely done, such as cleaning plates, rolls, between gears, fan belts, and tightening nuts and bolts (Khan & Haddara, 2003). If the operator does these things, the results will not be optimal. But in the company PT. SC Johnson Manufacturing Surabaya in implementing preventive maintenance methods is still less effective; where this is due to a lack of detailed and strategic planning, especially related to spare part replacement, repair priorities, maximum machine workload, procedures for

running the machine after completion of maintenance and other important things so that it is still breakdown often occurs, so that the devices that are in operation are often hampered by the operation process and causes the production rate to fall.

There are several reasons why the results of machine maintenance are not optimal, such as the scheduling of machine maintenance made by PT. SC Johnson Surabaya is not following the theory, so the machine maintenance schedule that has been made does not pay attention to the machine reliability aspect so that the machine's current condition is not a major concern. As a result, it is very natural that there are still frequent breakdowns of existing devices. The large frequency of machine breakdowns impacts high machine maintenance budgets. Determining preventive maintenance scheduling in this company is difficult to do regularly and well. This difficulty is caused by the preparation of preventative maintenance packages that have not been carried out following the theory of preventive maintenance. This study aims to obtain efforts to improve maintenance management on maintenance projects at PT. SC. Johnson Surabaya is ideal with a comprehensive system failure investigation approach, measuring maintenance management performance through the OMMP (Overall Measure of Maintenance Performance) method and evaluating the attributes that cause maintenance management failures with the MAFMA (Multi-Attribute Failure Mode Analysis) approach is appropriate and more productive.

2. LITERATURE REVIEW

2.1 Maintenance

Maintenance is an effort or action taken to maintain the condition of a machine or equipment or make certain repairs with various combinations of methods to an acceptable state (Arunraj & Maiti, 2007). According to Tsang et al. (2009), maintenance is a critical determining parameter of a company in competition in the industrial world. Breakdowns that occur are often caused by a lack of attention to maintenance, especially on equipment or machines that are getting old or obsolete, where this will increase maintenance costs or even have a risk of loss during the production process due to product defects that appear (Jasiulewicz et al., 2021). According to Prabowo et al. (2020), the purposes of maintenance are: (1) extending the usefulness of assets (i.e., every part of a workplace, building, and contents); (2) ensuring the optimum Availability of equipment installed for production or service to obtain the maximum possible return on investment; (3) ensure operational readiness of all equipment needed in an emergency at all times, for example, backup units, fire and rescue units, and others; (4) guarantee the safety of people who use these facilities.

2.2 OMMP (*Overall Measure of Maintenance Performance*)

OMMP is a tool designed to help maintenance practitioners, owners and managers to create and implement strategies for managing company assets (Bertolini et al., 2009). OMMP is also used to measure performance in asset management regarding what has been done, how it has performed so far and how every action taken follows company goals. Some of the perspectives used in OMMP include (Gabbrielli & Islam 2009):

1. Competitive Advantages at the Corporate Level. The definition of competitive advantages in the context of OMMP is a set of unique and difficult to duplicate capabilities, competencies and capacities within the company that provides the ability to compete in the field it faces (Khan & Haddara, 2003).
2. Productivity Perspective, with efficiency measures in the preparation and implementation of maintenance, increasing the productive time of existing machines by reducing repair time, increasing production capacity through reliable machinery, and increasing effective time through reducing administrative time (Wakiru *et al*., 2021).
3. Cost-Effectiveness Perspective. As a major factor in a company's operating expenses, this area often attracts attention when profit margins need to be increased or when overall direct costs need to be lowered (Chang, 2016).
4. Safety Perspective through reducing accident incidents will increase employee productivity and decrease expenses due to accidents, lower insurance premiums, and boost employee

morale, which leads to reduced time for sick leave and increased proactive actions or activities (Muchiri *et al*., 2010)

5. Environmental Perspective. In the concept of sustainability in companies, the environmental perspective becomes important because apart from government regulations or regulations that are getting stricter, it is also due to business ethics related to society (Kiran *et al*., 2016).
6. Quality Perspective. Quality can also state the level of work skills. Human error is often the main factor that causes accidents in the industry. The ability to reduce the error rate caused by humans in the production process can be used as an advantage (Prabowo & Aditia, 2020).
7. Learning Perspective. This perspective is the most important for asset managers—a perspective where large-scale automation and mechanical replacement are technologically impossible (Atmaja, 2013).

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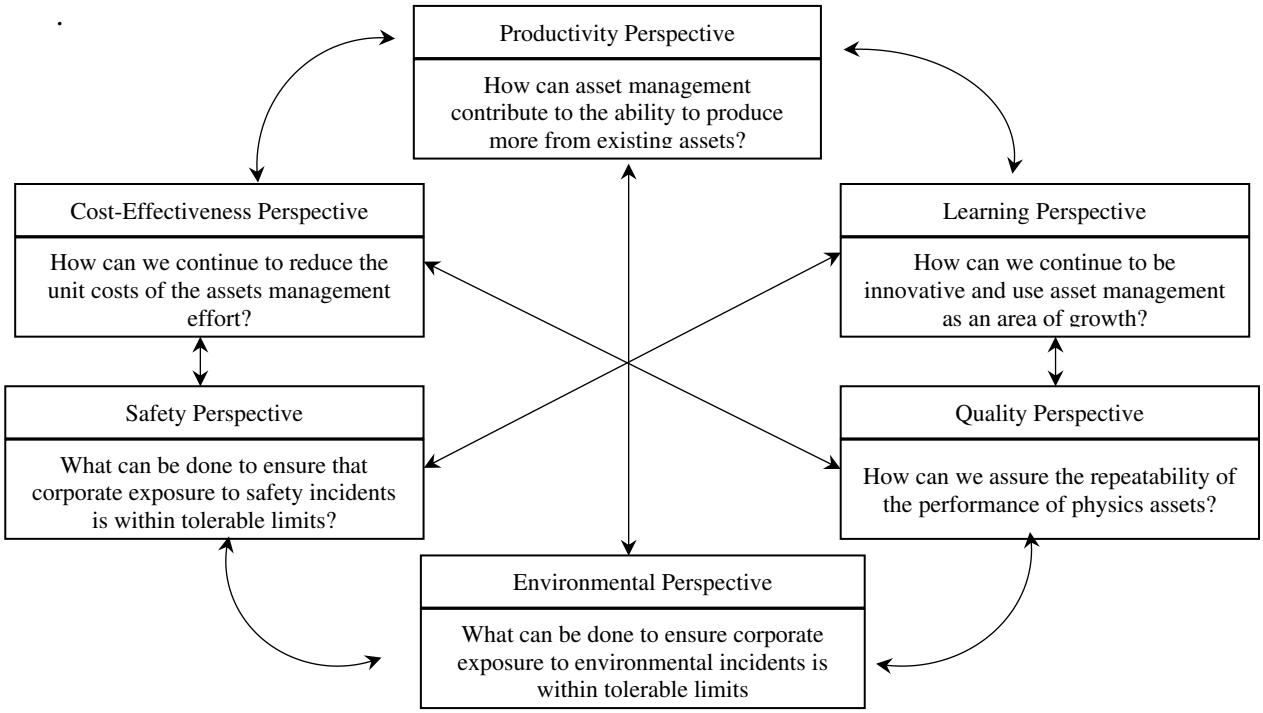


Figure 1. OMMP Perspective (Ellianto & Nurcahyo, 2019)

2.3 MAFMA (*Multi-Attribute Failure Mode Analysis*)

MAFMA is a method that integrates conventional Failure Mode and Effect Analysis (FMEA) by considering economic aspects (Kumar *et al*., 2013). FMEA is an analytical technique by a team or expert to identify potential failure modes and their causes in the manufacturing process. This FMEA process plays a role in determining the function of the process; identifying products and techniques that have the potential to experience failure modes; analyzing the effects of failure on consumers; identifying the causes of loss and the variables in the process used to reduce the occurrence of failures; identification of variables in the process to control the process; give a ranking for each failure mode in determining priorities for corrective action; documenting the results (Oliveira *et al*., 2016).

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3. METODE PENELITIAN

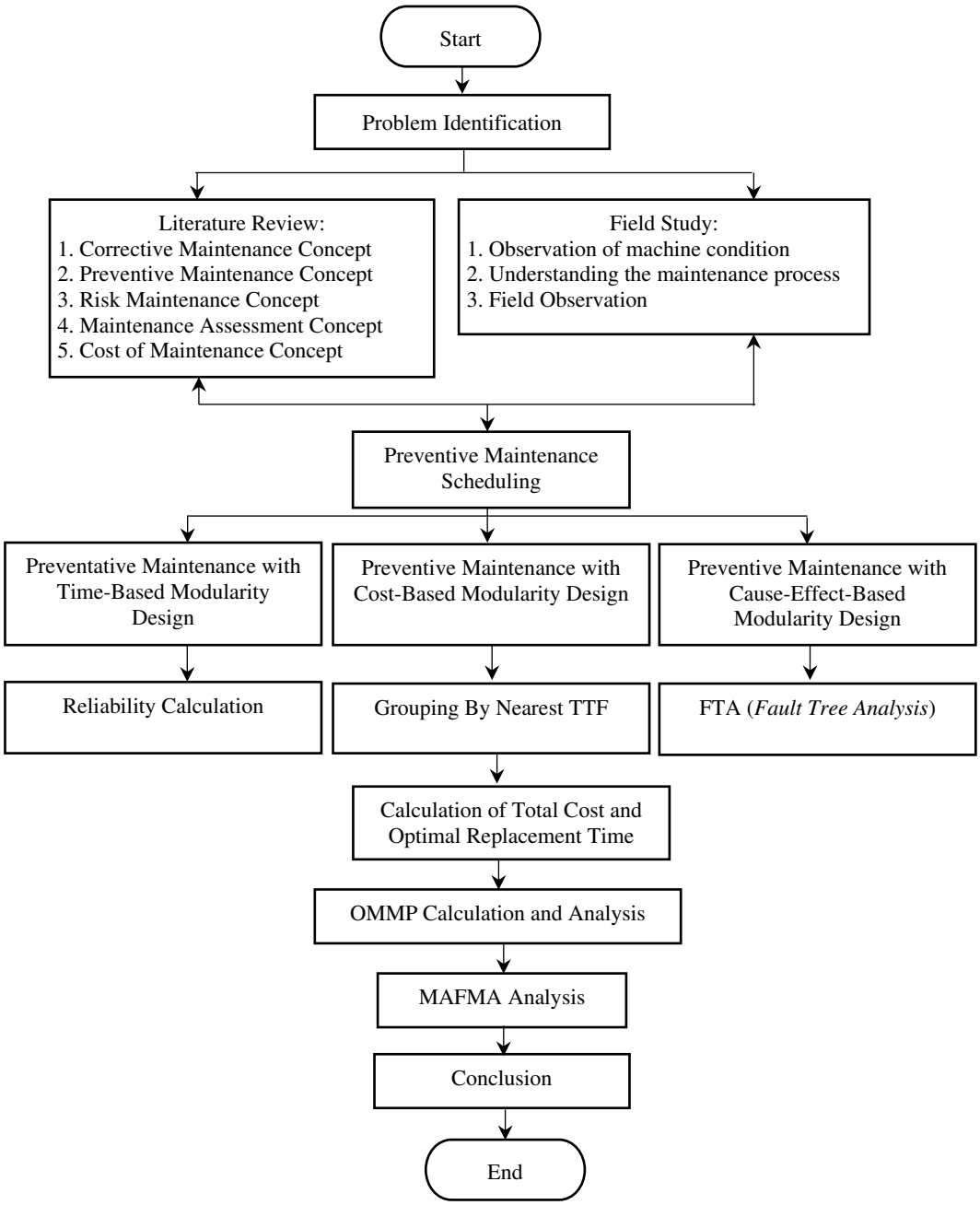


Figure 2. Research Methodology

4. RESULT AND DISCUSSION

4.1 Calculation of Loading Factor and Operation Time

Loading time is the time available per day, while operation time is production time without considering the downtime that occurs (Carpitella *et al*., 2021). From Figure 3, it can be seen that the downtime still looks higher than the planned downtime. This is because machines are still having problems, so they are often stopped for repairs, resets, or other abnormalities resulting in workers waiting or being unemployed. On average, the excess of downtime over planned downtime is more than 58%, so the performance rate is also low, below 80%. Observation data obtained from the company is as follows:

Table 1. Data of Loading Time and Operation Time

No.	Period	Number of Days	Work Hour (minutes)	Planned downtime (minutes)	Loading time (minutes)	Operation Time (minutes)
1.	January	23	11.040	230	10.810	10.132
2.	February	19	9.120	190	8.930	8.334
3.	March	22	10.560	220	10.340	9.455
4.	April	21	10.080	210	9.870	9.329
5.	May	22	10.560	220	10.340	10.047
6.	June	17	8.160	170	7.990	7.776
7.	July	23	11.040	230	10.810	10.204
8.	August	22	10.560	220	10.340	10.158
9.	September	20	9.600	200	9.400	8.891
10.	October	22	10.560	220	10.340	9.928
11.	November	23	11.040	230	10.810	10.634
12.	December	20	9.600	200	9.400	9.291
Total		254	121.920	2.540	119.380	114.179

Sources: PT. SC Johnson Manufacturing Surabaya (2021)

Operation time = loading time – downtime = 10325 – 50 = 10275 …….. (1)

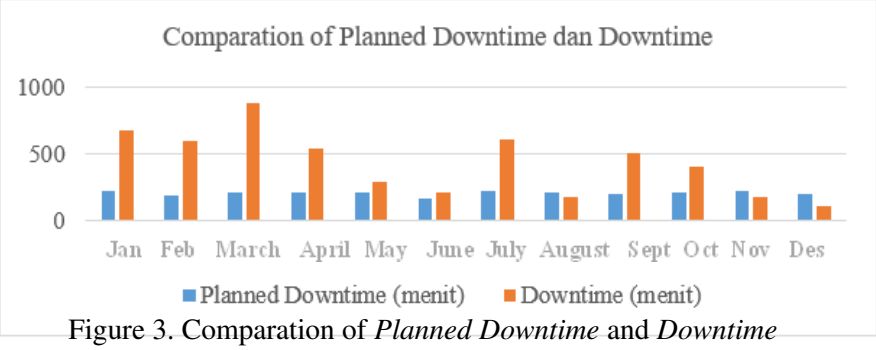


Figure 3. Comparation of *Planned Downtime* and *Downtime*

4.2 Availability Calculation

The availability rate is a ratio that describes the utilization of the available time for machine operating activities (Juharsyah, 2009). In other words, Availability is the ratio of operation time to the loading time.

$$\text{Availability} = \frac{\text{Operation Time}}{\text{Loading Time}} \; x\; 100\% \qquad \text{…….. (2)}$$

Table 2. *Availability Rate*

No.	Period	Loading time (minutes)	Downtime (minutes)	Operation Time (minutes)	Availability
1.	January	10.810	678	10.132	0,94
2.	February	8.930	596	8.334	0,93
3.	March	10.340	885	9.455	0,91
4.	April	9.870	541	9.329	0,95
5.	May	10.340	293	10.047	0,97
6.	June	7.990	214	7.776	0,97
7.	July	10.810	606	10.204	0,94
8.	August	10.340	182	10.158	0,98
9.	September	9.400	509	8.891	0,95
10.	October	10.340	412	9.928	0,96
11.	November	10.810	176	10.634	0,98
12.	December	9.400	109	9.291	0,99
Total		119.380	5201	114.179	

Sources: PT. SC Johnson Manufacturing Surabaya (2021)

4.3 Performance Rate

Performance rate merupakan suatu rasio yang menggambarkan kamampuan peralatan dalam menghasilkan barang atau dengan kata lain *performance rate* menggambarkan berapa banyak produk yang dihasilkan selama waktu produksi (Bangun & Nawawinetu, 2014).

$$\text{Performance Rate} = \frac{\text{Total of Production x Cycle time ideal per unit}}{\text{operation time}} \; x\; 100\% \quad \ldots\ldots\ldots\ldots (3)$$

Tabel 3. Performance Rate

No.	Period	Production (unit)	Operation Time (minutes)	Performance Rate
1.	January	31.673.982	10.132	0,78
2.	February	25.756.227	8.334	0,77
3.	March	27.805.720	9.455	0,74
4.	April	26.738.056	9.329	0,72
5.	May	28.004.667	10.047	0,70
6.	June	27.964.559	7.776	0,90
7.	July	24.684.023	10.204	0,60
8.	August	30.534.040	10.158	0,75
9.	September	23.883.612	8.891	0,67
10.	October	22.205.963	9.928	0,56
11.	November	32.105.772	10.634	0,75
12.	December	31.293.304	9.291	0,84
Total		332.649.925	114.179	0,73

Sources: PT. SC Johnson Manufacturing Surabaya (2021)

4.4 Quality Rate

Quality rate merupakan suatu rasio yang menggambarkan kemampuan peralatan dalam menghasilkan produk yang sesuai dengan standar serta menggambarkan kerugian kualitas berupa banyaknya produk yang rusak terkait dengan peralatan (Santoso, *et.al*, 2018).

$$\text{Quality Rate} = \frac{\text{Number of Production} - \text{Number of Reject}}{\text{Number of Production}} \; x\; 100\% \quad \ldots\ldots\ldots\ldots (4)$$

Tabel 4. Calculate Quality Rate

No.	Period	Number of Production (unit)	Straight Pass (unit)	Rework (minutes)	Quality Rate (%)
1.	January	31.673.982	25.238.184	6.435.798	0,80
2.	February	25.756.227	20.896.055	4.860.172	0,81
3.	March	27.805.720	22.157.462	5.648.258	0,80
4.	April	26.738.056	21.426.045	5.312.011	0,80
5.	May	28.004.667	22.769.382	5.235.285	0,81
6.	June	27.964.559	20.552.951	7.411.608	0,73
7.	July	24.684.023	18.883.052	5.800.971	0,76
8.	August	30.534.040	22.993.624	7.540.416	0,75
9.	September	23.883.612	17.636.412	6.247.200	0,74
10.	October	22.205.963	17.897.443	4.308.520	0,81
11.	November	32.105.772	23.705.828	8.399.944	0,74
12.	December	31.293.304	24.879.508	6.413.796	0,80
Total		332.649.925	259.035.946	73.613.979	

Sources: PT. SC Johnson Manufacturing Surabaya (2021)

4.5 Concept of OMMP (*Overall Measure of Maintenance Performance*)

4.5.1 Data of Machine Downtime

Machine downtime in this study is divided into 2 (two), namely: machine downtime due to preventive maintenance, which is routine maintenance to prevent machine damage and machine downtime due to corrective maintenance, namely unplanned machine maintenance that occurs due

to engine damage, whether emergency or not (Oliveira et al., 2016). Machine downtime data can be seen in Table 5.

Table 5. Data of Machine Downtime

Period	Types of Maintenance	Number of Activity	Downtime (minutes)
January – December 2020	*Preventive*	9	1.266
	Corrective	22	2.643
	Emergency	12	1.874
Total		43	5.783
January – December 2021	*Preventive*	14	1.562
	Corrective	18	2.145
	Emergency	15	1.494
Total		47	5.201

Sources: PT. SC Johnson Manufacturing Surabaya (2022)

4.5.2 Data of Manhour

Person-hours in maintenance activities consist of planned person-hours and actual person-hours. In maintenance, 3 (three) operators are on duty each shift and work for 7 (seven) days. Still, if the maintenance and repair are considered heavy and difficult, 1 (one) additional operator will be required either from the company or outside the company.) to 2 (two) people. The following is the person-hour data which can be seen in Table 6.

Tabel 6. Data of Manhour

Period	Hours (minutes)	Person-hour			Total
		Planned	Preventive	Corrective & Emergency	
2020	403.502	7.048	1.153	1.795	689.744
2021	365.760	6.059	1.579	2.213	703.442

Sources: PT. SC Johnson Manufacturing Surabaya (2022)

4.5.3 Data of Cost

Maintenance costs at the company include preventive and corrective maintenance costs for maintenance of damaged machines. The following is maintenance cost data which can be seen in Table 7.

Tabel 7. Data of Maintenance Cost

Period	Maintenance Cost		Total (Rupias)
	Preventive (Rupias)	Corrective (Rupias)	
January – December 2020	335.771.535	351.639.442	694.797.287
January – December 2021	359.025.752	372.751.645	724.391.087

Sources: PT. SC Johnson Manufacturing Surabaya (2022)

In general, maintenance costs at PT. From year to year, SC Johnson Surabaya increased by about 12% - 17% per year for preventive and corrective maintenance.

4.5.4 Data Equipment Runtime

Equipment Runtime merupakan data yang menyajikan berapa lama mesin beroperasi untuk produksi. Berikut merupakan data *Equipment Runtime* yang dapat dilihat pada Tabel 8.

Table 8. Data of Equipment Runtime

Period	*Equipment Runtime* (munites)
January – December 2020	128.624
January – December 2021	114.179

Sources: PT. SC Johnson Manufacturing Surabaya (2022)

4.5.5 Data of Inventory Cost

Inventory costs are obtained based on the accumulation of storage media and the wages of operators responsible for maintaining inventory. The following is inventory cost data which can be seen in Table 9.

Table 9. Data of Inventory Cost

Period	Biaya *Inventory* (2020) (dalam Rupiah)	Biaya *Inventory* (2021) (dalam Rupiah)
January	15.463.744	17.792.882
February	16.830.162	17.443.205
March	14.893.022	15.736.018
April	15.604.284	16.055.838
May	14.634.442	15.433.549
June	16.882.054	17.430.556
July	15.928.384	16.083.299
August	16.694.106	16.846.205
September	18.745.372	19.983.442
October	16.827.532	17.037.085
November	14.539.421	16.273.654
December	12.463.120	12.654.306
Total	189.505.643	198.770.039

Sumber: PT. SC Johnson *Manufacturing* Surabaya (2022)

4.6 Validation of Key Performance Indicator (KPI)

This Key Performance Indicator (KPI) validation stage is used to determine the KPI on the Overall Measure of Maintenance Performance (OMMP) method following the real conditions of maintenance at the company being studied. At this stage, a questionnaire is given to be filled out to parties who already understand the maintenance system at PT. SC. Johnson Manufacturing Surabaya.

Tabel 10. Validation of Key Performance Indicators

Perspective	Dimension	Code	Key Performance Indicator	Valid
Maintenance Administration	*Workforce*	A11	*Manpower Efficiency*	Ya
		A12	*Overtime*	Ya
		A13	*Utilization*	No
		A14	*Predictive and Preventive Maintenance Coverage*	Yes
	Work order	A21	*Overdue Task*	No
		A22	*Work order, Planned and scheduled*	No
		A23	*Work order turnover*	No
	Service operation	A31	*Degree of scheduling*	Yes
		A32	*Breakdown repair hours*	Yes
	Maintenance Intensity	A41	*Maintenance hours applied*	Ya
Maintenance Effectiveness	*Plan condition*	B11	*Breakdown frequency*	Yes
		B12	*Equipment downtime caused by a breakdown*	Yes
		B13	*Evaluation of preventive maintenance*	Yes
	Plan performance	B21	*Equipment availability*	Yes
		B22	*Length of running*	Yes
		B23	*Emergency* person-hours	Yes
		B24	*Emergency and other unscheduled task*	Yes

			s	

Tabel 10. Validation of Key Performance Indicator (continuous)

Perspective	Dimension	Code	Key Performance Indicator	Valid
Maintenance	*Economy*	C11	*Cost of maintenance hours*	Yes
		C12	*Preventive cost as a percent of breakdown cost*	Yes
		C13	*Inventory turnover rate*	No
	Service cost	C21	*Breakdown severity*	Yes
		C22	*Scheduled service cost*	Yes
		C23	*Maintenance cost per unit production*	Yes

Sources: PT. SC Johnson *Manufacturing* Surabaya (2022)

4.7 Maintenance Measurement

The SWOT approach will provide information related to the ideal strategic maintenance management related to sustainable maintenance, which includes: (1) Develop, namely determining objectives, strategic plans, measurements and critical success factors to achieve the expected competitive advantage; (2) Create, namely making tools, skills, capacities and processes needed to implement strategic plans; and (3) Embed, namely embedding changes that occur in the company to focus efforts on achieving and improving the existing strategic plan.

Tabel 11. Strength Analysis from the Maintenance Perspective

No.	Perspective	Strength
1.	Productivity	A large producer in Indonesia in the manufacture of customer goods, especially insecticide products
		A multinational company with a network of similar companies and large holding companies
		Have reliable and experienced technical and maintenance personnel
		It has high-performance and built-up engines.
2.	Cost-Effectiveness	Products sold domestically are relatively the same and compete with competing companies, while competitors offer products at low prices for export products.
		The company has experienced increased profits over the last five years.
3.	Safety	The company pays attention to and applies work safety to all employees.
4.	Environmental	The company's activities cause no losses, and implementing waste management follows standards.
5.	Quality	Product quality is competitive or even better than products produced competitively.
6.	Learning	The company implements ISO 9001 and 14001 systems.
		The company has a good and comprehensive concept of developing employee skills and careers.

Tabel 12. Weakness Analysis from the Maintenance Perspective

No.	Perspective	Weakness
1.	Productivity	Some materials have to be imported and are expensive.
		For machine maintenance, you often have to bring experts from other countries.
2.	Cost-Effectiveness	High maintenance costs because many machines are built-up so spare parts are imported, and experts must be imported from abroad
3.	Safety	Work accidents still occur because there is still a shortage of PPE for contract workers, a lack of work safety instructions and signs and a lack of training for contract workers.
4.	Environment	When there is a change in fuel for production from gas to coal, a lot of fly ash can contaminate factories or even people's homes.
5.	Quality	The product rejects rate is still high.
		There are still many variations related to product standards produced by contract workers.
6.	Learning	ISO 9001 and 14000 applications are still not implemented optimally and according to procedures
		There are still many employees who still think that training is not too important.

Tabel 13. Opportunity Analysis from the Maintenance Perspective

No.	Perspective	Opportunity
1.	Productivity	The company is the largest producer of insecticides, especially mosquito coils, in Asia.
		There are still many cheap and easy-to-obtain materials in Indonesia to produce products.
		Has product export opportunities due to high demand by several countries such as Thailand, Vietnam, Philippines, Argentina, Mexico and so on
2.	Cost-Effectiveness	Production costs can be lowered by reducing product rejects.
3.	Safety	There are more comprehensive efforts to implement work safety in the company environment.
4.	Environment	There are more comprehensive efforts to implement work safety in the company environment.
5.	Quality	The company's product quality can compete with imported products.
		Many national and international distributors want cooperation because they know the company's quality products.
6.	Learning	The company has international cooperation partners with reputable companies so that it has the opportunity to increase business (corporate leverage)
		The company has access to information exchange from the holding company, which is useful in business competition.

Tabel 4.11 Threat Analysis from the Maintenance Scorecard Perspective

No.	Perspective	Threat
1.	Productivity	Imported raw materials are a challenge in reducing production costs.
		The current productivity can still be increased through the effectiveness of machines and reliable employees.
		There is a potential decrease in employees' ability related to machine maintenance.
2.	Cost-Effectiveness	The price of raw materials is highly dependent on foreign currency exchange rates, affecting the fluctuating production costs.
		Competing companies cooperate with SMEs or other companies on sub-works deemed ineffective and efficient.
3.	Safety	There are sanctions from the government if there is an accident at work in the company.
		Some PPE tools or equipment must be imported in limited quantities, especially during this pandemic.
4.	Environment	Strict implementation of the Kyoto Protocol related to carbon emissions will be tightened.
		Demo from the surrounding community regarding pollution
5.	Quality	There are still customer complaints about product quality, so it needs to be lowered.
		A cost of quality is needed so that it can reduce profits.
6.	Learning	Implementing ISO 9000 and 14000 as mandatory requirements for product exports will cost a lot, becoming an organizational culture and a good working attitude.
		Workers who are comprehensively trained often move to other companies

4.8 Strategic Asset Review at Functional Level

A strategic asset is an ability or capacity that enables the company to achieve its strategic objectives. The objective is the ability or power to achieve corporate goals. Strategic investments are defined at the functional or tactical level of an organization. This is the last level in the hierarchy of objectives to be performed in the MSC structure. Areas at the operational level can include assets in the form of people, physical assets, information and even knowledge assets of the company. The following are the indicators used at this level, namely:

1. Productivity Perspective
   How asset management contributes to increased productivity
   Objectives: (a) periodic verification of machines and machine support devices; (b) complete PMS (Planned Maintenance System) and Kanban Card; (c) repair of the printer (stamping).
   Indicator: Complete Kanban Card.

2. Cost-Effectiveness Perspective
   How unit costs can be reduced on an ongoing basis, and what is the best way to manage assets.
   Objectives: (a) repair of printing machines (stamping), wrapping and packaging machines; (b) repairing the printing machine elements (stamping) including Dies, Punch, Punch Holder, Stripper, Lower plate, Backing plate, Die Pad, Guide post, shank; (c) the exact calculation of the need for spare parts and technical personnel at the work site.
   The indicators are: (a) the use of 6 (six) printing machines (stamping), with 1 (one) stand-by; (b) no engine failure; (c) increased machine speed and accuracy; (d) periodic checks on printing machines (stamping), wrapping and packaging machines.

3. Quality Perspective
   How to ensure that the performance of physical assets always produces quality output.
   Objectives: (a) make a report on the actual cost for each production machine and equipment; (b) make MTBF, MTTR & Availability of each machine; (c) weekly review of BPR (Big Problem Report); (d) complete the equipment list; (e) verification of process parameters; and (f) marking and standardization of process indicators.
   Indicators: (a) cost analysis of each machine-implemented; (b) analysis of MTBF, MTTR & Availability of implemented machines; (c) no repeated damage occurs; (d) a complete list of machine maintenance; and (e) updated equipment list.

4. Learning Perspective
   How to innovate in asset management so the company can grow and develop.
   Objectives: (a) training PLC, CNC, sensors & transducers, assembly language and machine drawings; and (b) QCC training, Circle Leader.
   Indicators: (a) all production machine operators have attended PLC, CNC, sensor & transducer training, assembly language and machine drawings; and (b) all production employees have attended QCC training.

5. *Safety Perspective*
   Aktivitas apa yang dapat dilakukan untuk memastikan bahwa keselamatan dan kesehatan pekerja masih pada batas interval aman.
   Tujuan: (a) implementasi "*Tag Out*" sistem ketika terjadi *stop machine;* dan (b) *training* dan sosialisasi *safety awareness.*
   Indikator: (a) sistem terimplementasi di lapangan; dan (b) semua karyawan sudah mengikuti *training*

6. *Environmental Perspective*
   Apa yang harus dilakukan oleh perusahaan agar segala aktivitas yang dilakukan masih berada pada batas aman di lingkungan sekitar perusahaan.
   Tujuan: (a) menjaga standar area kerja sesuai ISO 14000 dan *standard green manufacturing*; dan (b) *training environment awareness*
   Indikator: semua karyawan sudah mengikuti *training.*

4.9 MAFMA (*Multi-Attribute Failure Mode Analysis*)

4.9.1 Calculate of FMEA

MAFMA first calculates FMEA with parameters severity, occurrence and detection to generate the RPN value.

Table 12. FMEA Analysis on the Maintenance of the MMG-108 Stamping Machine at the Production Department of PT. SC Johnson Manufacturing Surabaya

No.	Part	Function	Failure Mode	Failure Mechanism	Failure Effect	Detection Failure	Risk Reducing Measures
1.	Dies	As a mold that will move along with the machine while it is applying pressure to the material below it, this mold will later form the material or materials as desired by the user.	Inaccuracy and inappropriate installation of dies	Dies vibrate and spin unstable.	Machines are damaged quickly, especially on the bearings and crankshaft, and the stamping dynamo can catch fire due to overload.	Direct visual observation and accuracy of dies installation	- Choosing the right dies size. - Installation by experienced technicians
2.	Punch	As a cutting material that has been molded to be formed according to the mold or design with precision	Punch fitting is incorrect and too loose or too tight.	- Punches experience overhead, movement slows down, and dirt on the edges of the punch accumulates faster. - Can cause work accidents due to waiting temperature and sparks	The imbalance of the shaft's vertical rotation will damage the dynamo and the engine's central crotch.	Checking temperature and pressure punch and disassembling	- Punch installation correctly by experienced technicians - Checking and resetting at least 45 days
3.	Punch Holder	It is not easy to shift or shake as a support for the punch to keep it stable .	The punch holder is too high or too low.	- Loading punch vertically from top to bottom is too fast or too long - Stamping spring is fast broken or delayed	The resulting product is not good or is rejected. In addition, using the machine for too long will result in a shift in the punch holder. .	Checking punch movement and product yield	Trial installation and setting regularly
4.	Stripper	Holds the material you want to cut while passing through the punch or dies. Because the material used is moving, it can cause the pieces to become untidy.	The stripper is not maintained because it is located in the stamping machine and is difficult to reach	There is an abnormal movement problem; the pad's movement becomes static, and the funnel layer will peel off or be uneven.	The resulting product is defective with an uneven shape and will cause the upper and lower die to collide, and the die can break.	Checking and setting stripper regularly.	Stripper checks for every use of the stamping machine in 560 hours
5.	Lower plate	As a gripper of all components in the dies to the maximum, to be tied firmly and set for the table where the pressing or pressing process will occur (bolster table).	The lower plate is in an asymmetrical position, and cavities or gaps between the tripper and the shank can accelerate dies loosening and corrosion.	The dies turn unstable, and the pads frequently wobble with the stripper tilting and bent or uneven places.	- Products produced by stamping will be defective or rejected. - If you don't fix it for a long time, the cylinder stroke will shift or be funny.	Checking and setting the lower plate regularly.	Checking the lower plate in every use of the stamping machine for 400 hours.
6.	Backing plate	As a barrier when the middle punch provides pressure to cut the material used. Because during the process, the other end of the punch will react.	Improper installation of the backing plate can result in the die on the stamping not being able to open, or the die can wear out quickly.	The pressure the backing plan gives is not strong enough, or the backing plate is tilted.	- Punch cutting results are not precise. - The backing plate is too thin and and will quickly cause bari (bubbles on the product)	- Check shaft and movement - Disassembly of parts	- Regular backing plate cleaning - - Backing plate coating -
7.	Pad	As a booster and lifter of the materials used. Because of that, later this pad will help the operator when they want to take the processed material, making it easier. If you don't use a pad, it is feared that the material used will be stuck in the die.	The selection of pad components must be adjusted to stamping, and if the pad installed is too hard, the die will break easily; if the pad installed is too soft, the die will wear out easily.	The pad thrust is low, so the stripping is difficult to cut, and the material sticks to the dies causing the dies to move by hitting the punch.	- The resulting product is uneven or does not fit the mold - Heavy punch performance and easy to wear	- Periodic lubrication of pads - Adjustment of the stripping parts associated with the pad and punch	- Checking the pressure on the pad - Punch pull check on pad

Table 12. FMEA Analysis on the Maintenance of the MMG-108 Stamping Machine at the Production Department of PT. SC Johnson Manufacturing Surabaya (continuous)

No.	Part	Function	Failure Mode	Failure Mechanism	Failure Effect	Detection Failure	Risk Reducing Measures
8.	Guide post	As a fitting in the section between the upper dies (above) and the lower dies, because this tool already exists, users don't need to worry about the position of the die or punch when the die is in use. Furthermore, because its strength is guaranteed, there is no need to be afraid of malfunctions.	The guide post must be installed correctly; improper installation of the guide post and shift of the guide post will result in lower dies, and the punch will work abnormally.	Gude post has an edge with a protrusion of 2 cm, but if the installation is not precise, it will rub against the lower dies and punch and cause wear or corroding.	- The resulting product becomes defective or defective - Lower dies and punches are easy to wear, easy to rock and corrosive	Monitoring of guide post-shift and lower dies and punch tightness	- When a 0.01 cm shift occurs, it must be disassembled and tightened - Observation bearing must be parallel to pork stick
9.	Shank	To place the dies in the center position of the press machine ram.	Shank must be right in the center of the bearing and a locked position; if the shank is not stable, it will cause the axle of the rotor to work slowly and will cause damage to the backing plate and dies.	- Dies will be pushed and shifted by the backing plate because the grip of the shank is always rocking. - The bearing does not lock the punch so that the shank load becomes heavy and impacts the rotor drive and the dies retaining hinge and pad	- The resulting product is defective - Dynamo on fire - Rubber and springs on the stamping machine are easy to stiff and break quickly.	- Control at the time of installation - Checking the shink position at least once a month	- Shanks are installed and inspected by experienced professionals - Giving stamps on the shank

Table 13. Ranking Causes of MMG-108 Stamping Machine Maintenance Failure in the Production Department of PT. SC Johnson Manufacturing Surabaya Based on FMEA

No.	Part	Failure Mechanism	RPN	Rank
1.	Dies	Dies vibrate and spin unstable	178.8	4
2.	Punch	Punches experience overhead, and movement slows down, and dirt on the edges of the punch accumulates faster	198.0	3
3.	Punch Holder	Loading the punch vertically from top to bottom is too fast or too long so that the stamping spring is quickly broken or stretched, and the resulting product is not good or rejects	329.9	1
4.	Stripper	There is an abnormal movement problem, and the movement of the pad becomes static. The funnel layer will be peeled off or unevenly so that the resulting product is defective with an uneven shape and will cause the upper die and lower die to collide, the dies can break.	116.8	9
5.	Lower plate	The dies rotation is unstable, and the pad often shakes with the stripper tilted and the pad becomes bent or uneven so that the stamped product will be deformed or rejected, and if it is not repaired for a long time, the cylinder stroke will shift or be funny.	201.1	2
6.	Backing plate	The pressure applied to the backing plate is not strong enough, or the backing plate is tilted so that the results of the punch cutting are not precise, and the backing plate is too thin will quickly cause bubbles (bubbles on the product).	137.2	6
7.	Pad	The thrust of the pad is low so that the stripping is difficult to cut, and the material sticks to the dies causing the dies to move by hitting the punch so that the resulting product is uneven or does not fit the mold and the punch performance is heavy and easy to wear	122.2	8
8.	Guide post	Gude post has an edge with a protrusion of 2 cm, but if the installation is not precise, it will rub against the lower dies and punch and cause wear or corroding and can cause the resulting product to be deformed or defect, lower dies and punches are easy to wear, easy to rock and corrosive	153.6	5
9.	Shank	Dies will be pushed and shifted by the backing plate because the grip of the shank is always rocking. The bearing does not lock the punch so that the shank load becomes heavy, impacts the rotor drive and the hinge retaining the dies and pads, and can cause the resulting product to be deformed and dynamo to burn. In addition, the rubber and springs on the stamping machine are easy to stiffen and get damaged quickly.	128.6	7

Sumber: Data Hasil Perhitungan dari Pihak Manajemen PT. SC Johnson Manufacturing Surabaya (2021)

4.9.2 MAFMA Calculated

In finding the most significant cause of failure to control, FMEA considers only three criteria: severity, occurrence, and detectability. However, one main factor is no less important to include, namely economic considerations. According to Vaughan (1997), the lack of care for financial aspects is one of the weaknesses of FMEA.

Table 14. Ranking of Causes of MMG-108 Stamping Machine Maintenance Failure in the Production Department of PT. SC Johnson Manufacturing Surabaya Based on FMEA

No.	Part	Failure Mechanism	RPN	RPN Probability	Expected Cost (in 1-time repair)	Expected Cost Probability	MAFMA	Rank
1.	Dies	Dies vibrate and spin unstable	178.8	0,11	1.075.450	0,14	0,0159	3
2.	Punch	Punches experience overhead, movement slows down, and dirt on the edges of the punch accumulates faster	198.0	0,13	875.445	0,11	0,0144	4
3.	Punch Holder	Loading the punch vertically from top to bottom is too fast or too long so that the stamping spring is quickly broken or stretched, and the resulting product is not good or rejects	329.9	0,21	1.280.350	0,17	0,0350	1
4.	Stripper	There is an abnormal movement problem, and the movement of the pad becomes static. The funnel layer will be peeled off or unevenly so that the resulting product is defective with an uneven shape and will cause the upper die and lower die to collide, the dies can break.	116.8	0,07	763.560	0,10	0,0074	5
5.	Lower plate	The dies rotation is unstable, and the pad often shakes with the stripper tilted and the pad becomes bent or uneven so that the stamped product will be deformed or rejected, and if it is not repaired for a long time, the cylinder stroke will shift or be funny.	201.1	0,13	1.759.500	0,23	0,0293	2

Tabel 14. Peringkat Penyebab Kegagalan Perawatan Mesin *Stamping* MMG-108 di Departemen Produksi PT. SC Johnson *Manufacturing* Surabaya Berdasarkan FMEA

No.	Part	Failure Mechanism	RPN	RPN Probability	Expected Cost (in 1-time repair)	Expected Cost Probability	MAFMA	Rank
6.	Backing plate	The pressure applied to the backing plate is not strong enough, or the backing plate is tilted so that the results of the punch cutting are not precise, and the backing plate is too thin will quickly cause bubbles (bubbles on the product).	137.2	0,09	583.480	0,08	0,0066	6
7.	Pad	The thrust of the pad is low so that the stripping is difficult to cut, and the material sticks to the dies causing the dies to move by hitting the punch so that the resulting product is uneven or does not fit the mold and the punch performance is heavy and easy to wear	122.2	0,08	435.545	0,06	0,0044	9
8.	Guide post	Gude post has an edge with a protrusion of 2 cm, but if the installation is not precise, it will rub against the lower dies and punch and cause wear or corroding and can cause the resulting product to be deformed or defect, lower dies and punches are easy to wear, easy to rock and corrosive	153.6	0,10	450.520	0,06	0,0057	7
9.	Shank	Dies will be pushed and shifted by the backing plate because the grip of the shank is always rocking. The bearing does not provide a lock on the punch so that the shank load becomes heavy and impacts the rotor drive and the hinge retaining the dies and pads and can cause the resulting product to be deformed and the dynamo to burn. In addition, the rubber and springs on the stamping machine are easy to stiffen and get damaged quickly.	128.6	0,08	485.060	0,06	0,0052	8

By using the MAFMA method by looking at the MAFMA value, the top three rankings for the causes of maintenance and repair failure of the MMG-108 stamping machine were obtained as follows:

1. First Rank
   The installation of the punch holder is too high or too low (RPN = 329.9) so that the movement of the loading punch vertically from top to bottom is too fast or too long so that the stamping Stucker spring breaks quickly or is stretched and the resulting product is not good or rejects. For this reason, it is possible to install the punch holder carefully and precisely by experienced experts, check the movement of the punch and product results, and carry out periodic installation and setting trials.
2. Second Rank
   The lower plate is abnormal or damaged (RPN = 201.1), so the dies rotation is unstable. The pad often shakes with a tilted stripper, and the pad becomes bent or uneven so that the resulting stamping product will be deformed or rejected, and if it is not repaired for a long time, the cylinder stroke will shift or funny. For that, it can be checked and set on the lower plate periodically.
3. Third Rank
   Dies to vibrate and spin unstable, so the machine is quickly damaged, especially in the bearing and crankshaft, and the stamping dynamo can burn due to overload. However, the company can take several preventive steps, including direct visual observation and accuracy of dies installation, proper selection of dies sizes, and installation by experienced technical personnel.

5. Conclusion

Based on the results of data processing and analysis, it can be concluded that the results of this study are as follows:

1. The level of maintenance performance contained in PT. SC Johnson Manufacturing Surabaya has an availability rate of 0.94, a performance rate value of 0.78 and a quality rate value of 0.8. However, the maintenance performance value is still far below the company's target of at least 0.85. Several perspectives that need to be improved include: (a) the maintenance administration perspective, the workforce dimension with utilization and overdue task indicators, as well as the work order dimension with the planned and scheduled

work order, wrapping, and inventory turnover rate indicators; (b) maintenance perspective on an economy dimension with utilization and overdue task indicators, as well as work order dimension with inventory turnover rate indicator.

2. In measuring the performance of maintenance and repair at PT. SC Johnson Manufacturing Surabaya obtained performance values for (a) productivity perspective where during the 2020 and 2021 periods, the production department has never achieved zero defects, the rework rate is still high where in 2020 it is still 26%, and in 2021 it reaches 22%. This shows that maintenance performance has not been maximized to make the machine 100% ready; (b) cost-effectiveness perspective, maintenance and repairs are very ineffective where the real downtime is much greater than the planned downtime, and the maintenance and repair costs still exceed the planned expenses; (c) quality perspective, taking into account the availability target to be increased to 98% due to high production loading; and maintenance performance should be able to lower the current Mean Time Between Failure (MTBF) or approach the targeted MTBF.
3. From the results of MAFMA, the priority of maintenance and repair is on the first rank of punch holder (MAFMA = 0.0350), the second rank for the lower plate (MAFMA = 0.0293), the third rank (MAFMA = 0.0159). This is because, in addition to considering the risks to the resulting product, it also feels the effects of machine losses and the company's ability to pay for maintenance.

6. Reference

Arunraj, N. S., & Maiti, J. (2007). Risk-based maintenance - Techniques and applications. *Journal of hazardous materials*, vol. 142, no. 3, pp. 653-661.

Atmaja, N. (2013). Analisis Pemeliharaan Kendaraan Taktis dan Khusus di SATBRIMOBDA DIY dengan Metode Reliability Centered Maintenance (RCM). *Jurnal Teknologi Kreatif*, vol. 14, no. 6, pp. 11-20.

Bangun, Y. P., & Nawawinetu, E. D. (2014). Risk Assessment Pada Pekerja Maintenance di PT X. *The Indonesian Journal of Occupational Safety and Health*, vol. 3, no. 2, pp. 170-181.

Bertolini, M., Bevilacqua, M., Ciarapica, F. E., & Giacchetta, G. (2009). Development of risk-based inspection and maintenance procedures for an oil refinery. *Journal of loss prevention in the process industries*, vol. 22, no. 2, pp. 244-253.

Carpitella, S., Mzougui, I., Benítez, J., Carpitella, F., Certa, A., Izquierdo, J., & La Cascia, M. (2021). A risk evaluation framework for the best maintenance strategy: The case of a marine salt manufacture firm. *Reliability Engineering & System Safety*, vol. 20, no. 5, pp. 107-125.

Chang, K. H. (2016). Generalized multi-attribute failure mode analysis. *Neurocomputing*, vol. 175, pp. 90-100.

Ellianto, M. S. D., & Nurcahyo, Y. E. (2019). Implementasi Multi Attribute Failure Mode Analysis pada Proses Produksi Galon Air Minum di PT. XYZ. *Teknika: Engineering and Sains Journal*, vol. 3, no. 1, pp. 31-36.

Gabbrielli, R., & Islam, S. R. (2009). *MAFMA: Multi-Attribute Failure Mode Analysis*. Second Edition. New Jersey. Prentice Hill.

Juharsyah (2009) Penerapan Model Maintenance Quality Function Deployment (MQFD) untuk Meningkatkan Kualitas Pemeliharaan pada Industri Pertambangan. *Jurnal Inovasi Teknologi*, vol. 5, no. 2, pp. 19-30.

Kiran, S., Kumar, K. P., Sreejith, B., & Muralidharan, M. (2016). Reliability evaluation and Risk-based maintenance in a process plant. *Procedia Technology*, vol. 24, no. 4. Pp. 576-583.

Kumar, U., Galar, D., Parida, A., Stenström, C., & Berges, L. (2013). Maintenance performance metrics: a state-of-the-art review. *Journal of Quality in Maintenance Engineering*, vol. 9, no. 4, pp. 149-164.

Muchiri, P. N., Pintelon, L., Martin, H., & De Meyer, A. M. (2010). Empirical analysis of maintenance performance measurement in Belgian industries. *International Journal of Production Research*, vol. 48, no. 20, 5905-5924.

Oliveira, M., Lopes, I., & Rodrigues, C. (2016). Use of maintenance performance indicators by companies of the industrial hub of Manaus. *Procedia CIRP*, *52*, 157-160.

Santoso, I., Sa'adah, M., Sari, E. N., Prameswari, P. A. I., & Agustina, C. R. (2018). The Integration of MAFMA and AHP Methods for Analysis and Risk Mitigation of Pasteurized Milk Production. *Journal of Engineering & Technological Sciences*, vol. 50, no. 5, pp. 703-720.

Tsang, A. H., Jardine, A. K., & Kolodny, H. (2009). Measuring maintenance performance: a holistic approach. *International Journal of Operations & Production Management*, vol. 8, no. 3, pp. 27-42.

Jasiulewicz-Kaczmarek, M., Żywica, P., & Gola, A. (2021). Fuzzy set theory-driven maintenance sustainability performance assessment model: A multiple criteria approach. *Journal of Intelligent Manufacturing*, vol. 32, no. 5, pp. 1497-1515.

Prabowo, R., Singgih, M. L., Karningsih, P. D., & Widodo, E. (2020). New product development from an inactive problem perspective in Indonesian SMEs to open innovation. *Journal of Open Innovation: Technology, Market, and Complexity*, *6*(1), 20.

Prabowo, R., & Aditia, R. (2020). Analisis Produktivitas Menggunakan Metode POSPAC dan Performance Prism Sebagai Upaya Peningkatan Kinerja (Studi Kasus: Industri Baja Tulangan di PT. X Surabaya). *Jurnal Rekayasa Sistem Industri*, *9*(1), 11-22.

Wakiru, J. M., Pintelon, L., Muchiri, P., & Chemweno, P. (2021). Integrated maintenance policies for performance improvement of a multi-unit repairable, one-product manufacturing system. *Production Planning & Control*, 32(5), 347-367.

APPLICATION OF MARKETING STRATEGY TO TENANTS AT XYZ AIRPORT BASED ON MARKET BASKET ANALYSIS

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ABSTRACT

Airport management in Indonesia is arguably not optimal, because it still relies on the aeronautical business segment as its main income. With a percentage of aeronautical revenues of 60% and non-aeronautical revenues of 40%. In fact, airport management in other countries now relies more on the non-aeronautical business segment, such as what was done by Changi Airport and Incheon Airport where the average percentage of Aeronautical revenue is only 34% and Non-Aeronautics reaches 66%. To increase non-aeronautical revenues, a Market Basket Analysis was carried out to obtain a marketing strategy that could be applied to the retail business of XYZ Airport. Market Basket Analysis is carried out using the data mining association rule method with the FP Growth algorithm. By setting the threshold parameter of the association rule in the form of a Minimum Support value of 30% and a minimum value of rule confidence of 50%, the results of data processing using the FP Growth algorithm produce 25 rules. From the resulting rules, a marketing strategy is made with the main objective of increasing the chances of cross-selling. Marketing strategies that can be applied based on the results of the market basket analysis include adjusting the position of the product layout and selling products in the form of bundling packages.

Keywords: Market Basket Analysis, Association Rule, Cross-Selling, Marketing Strategy

1. INTRODUCTION

Basically, there are two types of business processes that become the airport's income, namely Aeronautical Business and Non-Aeronautical Business. Based on the Decree of the Minister of Transportation Number: KM 29 of 1997, it is stated that the Aeronautical Business is a service business that is directly related to aviation activities and Non-Aeronautical Business is a business in the form of services for airport support activities (Kemenhub, 1997).

Airport management revenue from Aeronautics depends on the number of planes coming to the airport and the number of passengers it transports. The attractiveness of destinations such as tourist attractions, or business areas is the biggest reason for someone to travel. Meanwhile, the non-aeronautical business requires more extra marketing strategies so that airport service users such as passengers want to spend money on services and facilities provided at the airport, such as eating at restaurants, buying souvenirs at retail stores, and so on.

If you only rely on the Aeronautical Business segment, then airport revenues only depend on the attractiveness of the destination and the capacity of the airport itself. For the location of the

airport in an area with low tourist interest, the aeronautical business income is also low. Meanwhile, if the airport area is a destination with high tourist interest, the aeronautical business income will also increase. However, no matter how high the interest of tourists to visit an area, if the airport's capacity is limited, then the income of the Aeronautics Business will also be limited.

Airport management in today's modern era, generally non-aeronautical business segment revenue earns higher income than revenue sourced from aeronautical business segment (Perng et al., 2010). Meanwhile, in Indonesia, airport managers tend to rely on the Aeronautics business segment.

The following is a comparison of the revenue of the Aeronautics business in Indonesia which is represented through PT. Angkasa Pura I (Persero) and overseas represented by Changi Airport and Also Incheon Airport are shown in Table 1.

Table 1. Comparison of Aeronautical and Non-Aeronautical Revenues of PT. Angkasa Pura I (Persero), Changi Airport and Incheon Airport

Airport Management Company	Income Type	2015	2016	2017	2018	2019
PT. AP1	**Aeronautical Business**	60%	59%	63%	60%	58%
	Non-Aeronautical Business	40%	41%	37%	40%	42%
Changi *Airport*	**Aeronautical Business**	29%	31%	32%	40%	39%
	Non-Aeronautical Business	71%	69%	68%	60%	61%
Incheon *Airport*	**Aeronautical Business**	36%	35%	34%	34%	33%
	Non-Aeronautical Business	64%	65%	66%	66%	67%

Source : (AP1, 2016-2020; Changi, 2016-2020 & Incheon; 2016-2020)

It can be seen from Table 1. the average percentage of Aeronautical revenue of PT. Angkasa Pura I (Persero) by 60% and non-Aeronautical revenues by 40%. Meanwhile, for overseas airports such as Changi Airport and Incheon Airport, the average percentage of Aeronautical revenue is only 34% and Non-Aeronautical revenue is 66%.

So that airport managers in Indonesia must think about increasing revenue from the Non-Aeronautical business segment by paying attention to business management such as promotions, services, tenant cleanliness, supporting facilities, and so on. In addition, what can be done to make the right marketing strategy decisions is to analyze past sales transaction data (Agrawal et al., 1993 & Agrawal et al. 1996). In the retail business, there is a habit of consumers buying more than one type of product in one transaction (single transaction). So from this tendency will form a pattern of shopping habits (customer buying habits). The pattern of shopping habits in one transaction is called Market Basket Analysis (Ansari, 2019 & Li et al., 2014). Market basket analysis is able to analyze consumer buying habits by finding associations between various items

purchased by consumers in their shopping baskets (Han et al., 2012). Mansur and Kuncoro (2012) proved in their study that market basket analysis is a reliable method in understanding customer buying behavior . Mansur and Kuncoro (2012) also say that the output of market basket analysis is several rules that indicate the existence of products that are purchased together .

Lintang (2016) explains that market basket analysis is often used by various businesses as a decision-making process . Where the resulting decisions can be used by the Airport Manager to provide recommendations or proposed marketing strategies to assist tenants in conducting product analysis to make sales more appropriate, conduct more targeted promotions, and others, so as to increase retail tenant income. If the income of tenants / business partners increases, from the airport management side, of course, they will get a higher share of revenue.

2. LITERATURE REVIEW

Market Basekt Analysis

One of the methods proposed by R. Agrawal, et al to be used in conducting Market Basket Analysis is by making association rules between products (sets of items) with certain minimum confidence (Agrawal et al., 1993 & Santosa et al, 2018) . Association Rule is a data mining method that aims to extract information or knowledge in the form of Frequent itemset from a data set (in this case Market Basket Data) and generate association pattern rules from this Frequent itemset with some minimum confidence.) certain (Agrawal et al., 1993; Li et al.,2014 & Santosa et al, 2018). The information or knowledge generated from the data mining process is used in decision making (Santosa et al, 2018) .

R. Agrawal, et al (1993) explained that problems in data mining using the Association Rule can be divided into two sub-factors, namely "support" is the percentage of item combinations in the database and "confidence" is the strong relationship between items in associative rules . The equation to calcul ate the support and confidence values of the form A→B is written as the following equation.

$$Support\ (A \rightarrow B) = P\ (A \cup B) \quad (1)$$

$$Confidence\ (A \rightarrow B) = P\ (B|A) \quad (2)$$

$$Confidence\ (A \rightarrow B) = P\ (B|A) = \frac{Support\ (A \cup B)}{Support\ (A)} \quad (3)$$

Support shows the frequency of rules in transactions or the number of transactions that contain items both in antecedent and consequent (Arafah et al., 2015 & Santosa et al, 2018). A high support value means the rule involves a large portion of the database. The frequency of occurrence of an itemset is the number of transactions containing that itemset. It is called support because it measures the level of data support for the validity of the developed rules (Santosa et al, 2018) . Support is usually expressed as a percentage (%) or sometimes in the number of occurrences.

Confidence shows the percentage of transactions containing A that also contains B or confidence can also be referred to as the ratio between the number of transactions covering all items in the antecedent and consequent with the number of transactions covering all items in the antecedent (Santosa et al, 2018) .

A high value for the consequent indicates a strong association rule, but this can also be deceptive because if the antecendent and/or consequent have high support, a high confidence value will be obtained even if the antecendent and consequent are independent of each other. For example, if almost all customers buy bananas and almost all customers buy instant noodles, then the confidence value will be high regardless of whether there is an association or not between the two (Santosa et al, 2018) .

one of the better ways to see the strength of an association rule is through the lift ratio (Santosa et al, 2018) . lift ratio is the ratio between confidence for a rule divided by its benchmark confidence, which is assumed to be independent and consequent (Santosa et al, 2018) . Some references add Lift Ratio as a function that can reduce the possibility of bias between the two standard measurements – the minimum support limit and the minimum confidence limit (Han et al., 2012) .

The lift ratio of an association rule A→B can be defined as follows :

$$lift\,(A \rightarrow B) = P\,(B|A) = \frac{Support\,(A \cup B)}{Support\,(A) \times Support\,(B)} \quad (4)$$

In equation 4, if the Lift value is less than 1, the occurrence of X is negatively correlated with the occurrence of Y. If the Lift value is more than 1, X and Y are positively correlated. If the Lift value is equal to 1, X and Y are independent and uncorrelated (Han et al., 2012) . A lift ratio value greater than 1 indicates the benefits of this rule. The higher the lift ratio value, the greater the strength of the association (Santosa et al, 2018) .

3. METHODS

Data Processing

The data used in this study is sourced from transaction data of retail tenant sales at XYZ Airport as many as 690,601 transaction data with 10,438 product variations. Then from 10,438 product variations, product categorization was carried out into 73 product categories.

Then the data processing is carried out using the data mining association rule method and using the FP-Growth algorithm. Then set the threshold for the parameters used in this study by setting the Minimum Support value of 30% and the Minimum Rule Confidence value of 50%, the results obtained are as follows:

Table 2. Result of Association Rule Using FP Growth Algorithm

No	Antecendent	Consequent	Confidence	Support	lift
1	Chocolate snacks, Body Care And Cosmetic	Alcohol	74,85	30,13	1,17
2	Tobacco, Chocolate snacks	Alcohol	73,99	32,26	1,16
3	Alcohol, Body Care And Cosmetic	Chocolate snacks	73,21	30,13	1,19
4	Alcohol, Chocolate snacks	Tobacco	73,08	32,26	1,12
5	Tobacco, Alcohol	Chocolate snacks	72,31	32,26	1,18
6	Chocolate snacks	Alcohol	72,01	44,15	1,12
7	Chocolate snacks	Tobacco	71,13	43,60	1,09
8	Body Care And Cosmetic	Alcohol	69,72	41,16	1,09
9	Alcohol	Tobacco	69,66	44,62	1,07
10	Body Care And Cosmetic	Tobacco	69,25	40,88	1,06
11	Alcohol	Chocolate snacks	68,92	44,15	1,12
12	Mineral Water	Alcohol	68,72	34,12	1,07
13	Tobacco	Alcohol	68,35	44,62	1,07
14	Alcohol, Chocolate snacks	Body Care And Cosmetic	68,26	30,13	1,16
15	Body Care And Cosmetic	Chocolate snacks	68,18	40,26	1,11
16	Tobacco	Chocolate snacks	66,79	43,60	1,09
17	Mineral Water	Tobacco	66,53	33,03	1,02
18	Mineral Water	Chocolate snacks	66,46	33,00	1,08
19	Chocolate snacks	Body Care And Cosmetic	65,67	40,26	1,11
20	Alcohol	Body Care And Cosmetic	64,27	41,16	1,09
21	Mineral Water	Body Care And Cosmetic	63,34	31,45	1,07
22	Tobacco	Body Care And Cosmetic	62,63	40,88	1,06
23	Chocolate snacks	Mineral Water	53,83	33,00	1,08
24	Alcohol	Mineral Water	53,27	34,12	1,07
25	Body Care And Cosmetic	Mineral Water	53,26	31,45	1,07

The confidence parameter in the rule generated from the FP Growth Algorithm (Table 2), is the largest with a confidence value of 74.9 from the rule {Body Care And Cosmetics, Chocolate Snack} →

{Alcohol Drinks}. While the smallest confidence parameter value is 53.3 from the rule {Body Care and Cosmetics} → {Mineral Water}.

Meanwhile, the support value meets the applied criteria, which is greater than 30 (support≥30). Lift Ratio value is greater than 1 (Lift > 1), which means that all rules are positively correlated.

4. RESULTS

One of the benefits of implementing market basket analysis is to increase the chances of cross-selling. Cross-selling implies that "a consumer buys several goods or services that are often unrelated in one transaction, where the purchase is based on knowledge of the customer's needs" (Boone and Kurtz , 2016).

The purpose of cross-selling is to reduce customer churn and increase switching costs (Kamakura et al., 2003), so that cross-selling provides an opportunity for retail tenants to increase the income of existing customers. When consumers buy various product categories, there will be a possibility that consumers will buy more product categories at each purchase opportunity (Kumar et al., 2008). Of course, the products that will be cross-selling are products with strong association rules and a positive correlation resulting from market basket analysis of transaction data at XYZ Airport tenants.

From Table 2 regarding the results of the Association Rule using the FP Growth Algorithm, a marketing strategy can be made that can be applied to increase the chances of cross-selling in retail tenants at XYZ Airport as follows:

A. *Positioning the Product Layout*

Placing the order of products is not trivial, because the results of product placement in the retail business certainly greatly affect the perception of potential buyers as a whole on the products being sold (Lamb et al., 2011). Rules that have strong associations are indicated by high confidence and support values, examples such as the top 5 rules in table 2 include:

1) "Chocolate snacks", "Body Care And Cosmetic" "Alcohol"
2) "Tobacco", "Chocolate snacks" "Alcohol"
3) "Alcohol", "Body Care And Cosmetic" "Chocolate snacks"
4) "Alcohol", "Chocolate snacks" "Tobacco"
5) "Tobacco", "Alcohol" "Chocolate snacks"

From the sample of the top 5 rules, it is known that they consist of four products, including Body Care And Cosmetics, Chocolate snacks, Alcohol and Tobacco. So that the four products can be placed close together with an example scheme such as the following:

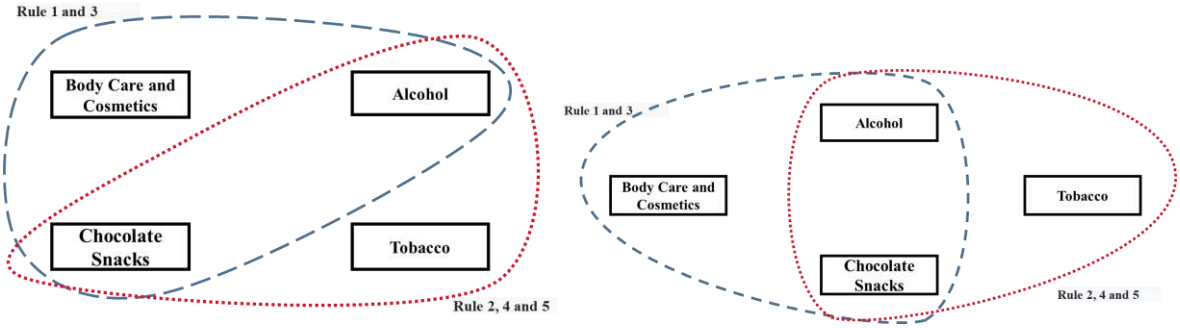


Figure 1. Example of a placement scheme for the four products based on the top 5 rules

In Figure 1(a) it is divided into 2 area segments. The first product segment is occupied by “Body Care and Cosmetics” and “Chocolate Snacks” products, while the second product segment is occupied by “Alcohol” and “Tobacco” products. In this scheme, when a consumer passes through the first area segment, it will be easier to see the four products directly after being among the tenants, so that the possibility of cross-selling based on the top 5 rules has the same great opportunity.

While the example in the schematic of Figure 1(b) is divided into 3 area segments. When in the area segment, the opportunity for cross-selling is only in rules 1 and 3. Because consumers in rules 1 and 3 are the type of consumers who like "Body Care and Cosmetics" products. For consumers who don't like the "Body Care and Cosmetics" product, they will ignore the first area segment and go straight to the second area segment, where they will see the "Alcohol" and "Chocolate Snacks" product choices. Then the possibility of cross-selling occurs with rule numbers 2,4 and 5.

B. *Bundling Package Sales*

Several products can be sold simultaneously to increase revenue in the form of Bundling Packages. Products to be sold simultaneously must have strong association rules and have a positive correlation. Then from the bundling package, tenants can also provide discounts or other product bonuses, so that the bundling package is more attractive to buyers.

Referring to the top 5 rules in table 2, recommendations for product bundling packages can be made as follows:

1) “Body Care And Cosmetic”, “Chocolate snacks” and “Alcohol” (source : rule 1 and 3)
2) “Chocolate snacks”, “Tobacco” and “Alcohol” (Source : rule 2, 4 and 5)

6. CONCLUSIONS

Market Basket Analysis using the association rule data mining method will produce a rule between two or more products that are associated with each other. Rules with high support and confidence values, and having a lift value > 1 are rules that have strong associations and are positively correlated. With the resulting rule from two or more products, the purpose of implementing this market basket analysis is to increase the chances of cross-selling or the purchase of two or more products in a single transaction.

An example of managerial implication in the form of a marketing strategy that can be applied in a retail business is setting the position of a product layout that has strong associations and is positively correlated so that consumers can get these products directly in one place. Furthermore, you can also create product bundling packages for sale. Product bundling packages using products must also have strong and positively correlated associations.

Of course there are many more managerial implications that can be made into a marketing strategy or otherwise. In this case the author provides an overview of how the results of market basket analysis can be used as a basis for decision making in making marketing strategies, so as to increase income in the form of switching costs and can minimize the risk of churn to consumers (Kamakura et al., 2003).

REFERENCES

Agrawal,R. , Imielinski, T. dan A. Swami. (1993), "Mining *Association Rule*s between sets of items in large databases". *In Proc. SIGMOD International Conference on the Management of Data*-May 1993, pages 207-216.

Agrawal, R. , Manilla, H. , R. Srikant, H. Toivonen A.I dan Verkamo. (1996), "Fast Discovery Of *Association Rule*". *In Fayyad et al* [9], pages 307-328.

Ansari, S.Z. (2019), *Market Basket Analysis : Trend Analysis Of Association Rules In Different Time Periods*, Dissertation Master, NOVA Information Management School Instituto Superior de Estatística e Gestão de Informação -Universidade Nova de Lisboa, Lisboa.

AP1 (PT. Angkasa Pura I) (2016), *Building National Pride Through The Development of Airport Infrastructure* ,Annual Report 2016 , PT. Angkasa Pura I (Persero), Jakarta .

AP1 (PT. Angkasa Pura I) (2017), *Proud To Serve The Nation* , Annual Report 2017 , PT. Angkasa Pura I (Persero), Jakarta .

AP1 (PT. Angkasa Pura I) (2018), *Growing Steadily to Enter Global Class Standard,* Annual Report 2018 , PT. Angkasa Pura I (Persero), Jakarta.

AP1 (PT. Angkasa Pura I) (2019), *Strengthening Business And Portfolio, Improving Passenger Comfort,* Annual Report 2019 , PT. Angkasa Pura I (Persero), Jakarta.

AP1 (PT. Angkasa Pura I) (2020), *Surviving And Innovating* , Annual Report 2020 , PT. Angkasa Pura I (Persero), Jakarta .

Arafah, A.A dan Mukhlash, I. (2015), "The Application of Fuzzy Association Rule on Co-Movement Analyze of Indonesian Stock Price". *International Conference on Computer Science and Computational Intelligence* (ICCSCI 2015).

Boone dan Kurtz , D.L, (2016), *Contemporary Marketing*, 17th edition, Cengage Learning, Boston.

Changi (2016), *Journey of Transformation,* Annual Report 2015/2016 , Changi Airport Group (Singapore) PTE.LTD, 60 Airport Boulevard .

Changi (2017), *Destination Singapore Changi Airport*, Annual Report 2016/2017 , Changi Airport Group (Singapore) PTE.LTD, 60 Airport Boulevard .

Changi (2018), *Ahead Of The Curve*, Annual Report 2017/2018 , Changi Airport Group (Singapore) PTE.LTD, 60 Airport Boulevard .

Changi (2019), *A Decade Of Distinct*, Annual Report 2018/2019 , Changi Airport Group (Singapore) PTE.LTD, 60 Airport Boulevard .

Changi (2020), *Resilience & Adaptibility* , Annual Report 2019/2020, Changi Airport Group (Singapore) PTE.LTD, 60 Airport Boulevard .

Han, J., Kamber, M. dan Pei, (2012), *Data mining Concepts and Techniques*, 3rd Edition, Morgan Kaufmann ,Waltham.

Incheon (2016), *The Initiatives for our Better Future*, IIAC Social Responsibility Report 2016, Incheon International Airport Corporation, Incheon.

Incheon (2017), *The Initiatives for our Better Future*, IIAC Social Responsibility Report 2017, Incheon International Airport Corporation, Incheon.

Incheon (2018), *Connecting People and Incheon Airpor*t, IIAC Social Responsibility Report 2018, Incheon International Airport Corporation, Incheon.

Incheon (2019), *Connecting People and Incheon Airport*, IIAC Social Responsibility Report 2019, Incheon International Airport Corporation, Incheon

Incheon, (2020), *Connecting People and Incheon Airport*, IIAC Social Responsibility Report 2020, Incheon International Airport Corporation, Incheon.

Kamakura, W.A., Wedel, M., de Rosa, F. dan Mazzon, J.A. (2003), "*Cross-selling* through database marketing: a mixed factor analyzer for data augmentation and prediction", *International Journal of Research in Marketing*, 20(1) (March), 45–65.

Kemenhub (Indonesian Ministry of Transportation) (1997), *Decree of the Minister of Transportation Number: KM 29 of 1997 - Regarding the Structure and Classes of Tariffs for Airport Services at Public Airports,* Minister of Transportation of the Republic of Indonesia, Jakarta

Kumar, V., George, M. & Pancras, J. (2008), "Cross-buying in Retailing: Drivers and Consequences", *Journal of Retailing,* 84(1), pp. 15-27.

Lamb, C.W, Hair, Jr.J.F dan McDaniel, C, (2011), *Marketing*, 11thedition, Cengage Learning, South-Western.

Li, G. and Hamilton, H.J. (2014), "Basic Association Rules" DOI: 10.1137/1.9781611972740.16 [22] M. Robnik-Siknja and I. Kononeko, "Theoretical and empirical analysis of RelifF and RReliefF," *Mach Learn*, vol. 53, pp. 23–69, 2003.

Lintang,D.P. (2016), *Marketing Activities Recommendations Based On Association Rules Application in Minimarket X*, Final Project in Department Of Industrial Engineering - Institut Teknologi Sepuluh Nopember, Surabaya.

Mansur, A. & Kuncoro, T. Product Inventory Predictions at Small Medium Enterprise Using Market Basket Analysis Approach-Neural Networks. Elsevier, Ltd, pp. 312-320, 2012

Perng. S. , Chow. C. dan Liao, W. (2010) , "*Analysis of shopping preference and satisfaction with Airport retailing products*", Journal of Air Transport Management 16 (2010)

Santosa, B and Umam, A, (2018), *Data Mining Dan Big Data Analytics* , 2nd Edition, Penebar Media Pustaka, Yogyakarta.

CRITICAL SUCCESS FACTOR FOR IMPLEMENTING LEAN CONSTRUCTION IN INDONESIA

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ABSTRACT

Lean construction aims to optimize the value from the customer perspective at once minimizing waste in construction project. However, the lean philosophy isn't nicely understood withinside the Indonesian construction project that their complexity and dynamic nature of creation tasks creates much uncertainty so tough to handle. The condition of the Indonesia onstruction industry currently experiencing with large waste of up to 57%, but the added value is only 10%. In addition, contractors who implement lean construction not evenly distributed. This study objective is identify the Indonesian's construction project for critical success factors of lean implementation. In this context, this study reviews on the contractor's perspectives. The research method used the Structural Equation Modeling (SEM) using AMOS program. The first one is used the statistically analysis such as Validity and Reliability test. After passed the analysis, than we use normality test for check what the data is normal distribution. Than the final analysis is the modeling consists of 4 main constructs, namely : leadership, organizational culture and strategy, the government role, and resources. This research hopefully can impact for guiding the construction profssional to implementate the lean construction successfully.

Keywords: lean construction, Indonesia, critical success factor, structural equation modelling, construction industry

1. RESEARCH BACKGROUND

The construction service industry is an important economic sector because it can contribute significantly to Gross Domestic Product (GDP) of Indonesia, absorbs a large workforce and has an important role in national development (Indonesia, 2003). According to BPS data (2009), the construction service industry can also contribute to GDP (Gross Domestic Product), starting in 2004 (6.6%), 2005 (7.0 %), 2006 (7.6% %), 2007 (7.7%), 2008 (8.5%) and 2009 (9.9%). Womack & Jones (1996) states that extra than 30% of project costs are spent on non-value-added activity serving as rework, fabric / material handling, waiting, and the motion of employees and also overproduction. In many large towns withinside the world, waste in construction initiatives is a first-rate issue for corporations withinside the construction industry, together with in Indonesia.

Based on information proven from the Lean Construction Institute, the quantity of waste withinside the construction project states approximately 57%, while the efforts made to generate value added activity mostly 10%. Reducing the part of task as non value added activity is a essential guideline. Experience has proven that non value added dominate maximum processes; generally most effective 3% to 20% of the overall project value. Cost of Quality can also

additionally nonetheless be one of the troubles withinside the world. In many research from other countries, the poor of cost quality (non-conformance), as measured on site, became out to be 10 – 20% of the overall project value. In a completely designated Swedish have a look at of the design-implementation of construction project, it turned into determined that the cost of quality for construction commercial enterprises turned into 6%. In American investigation, they have look at onumerous projects, the cost deviation averaged 12.4% of the overall contract value. The reasons of high-satisfactory troubles are 78% of DED, 17% construction process and 20% material fabrications supply. Based on studies from Alwi et al. (2002) defined that the elevation of overall performance in Indonesia construction company remains very low, that's the motive of excessive waste. Waste is resulting from numerous elements inclusive of ready time for fabric arrival to the task site, task time delays, now no longer following the schedule, waste of uncooked substances at creation sites, and coffee stage of accuracy in supervision.

This paper is actually discussed what is the factor that crucial for lean construction implementation practices. Recognizing the importance of this, an assessment model is needed to test the hypotheses about what are the factors that determine the maturaty of lean construction applications in Indonesia proect variety to validate the research agenda. Furthermore, the model must also be developed to get a clear picture of how the cause-effect relationship as well as the multilevel relationship between constructs and between constructs and indicators. What is the critical success factor of lean construction are identified using statistical analysis. This study is a Confirmatory Factor Analysis (CFA) which aims to confirm the results of general factors in previous studies such as research which is still exploratory to see if these findings are suitable to be applied in Indonesia. To get good results of Confirmatory Factor Analysis and to test hypotheses regarding the relationship between constructs and the relationship between constructs and indicators, it is necessary to use the Structural Equation Modeling conducting the analysis.

2. LITERATURE REVIEW

2.1. Waste in Construction

Lean is a control thinking that specialized in figuring out and disposing of waste throughout the product value stream, extending now no longer simplest withinside the institution however additionally alongside the company's deliver chain network. As defined, lean production was specialized in essential elements of labor glide and the outcomes of dependencies and variotions od activity in a project. Womack & Jones (1996) says that not frequent wastes observed withinside the construction as follows over production, inventory, more processing, motion, defect, waiting, tranportation and human resources.

2.2. Leadership in Lean Construction

Regardless of the development that has been made in growing management talents at the person and organizational degrees, there may still be quite a little room for improvement. Primarily based on a sensible take a look at of the improvement of lean leadership in a Norwegian excessive-tech manufacturer, an included model for the improvement of lean management in a organisation is proposed—development of abilities in a two-dimensional framework, highlighting 4 areas: intervention. There's proof that lean leadership education need to be supplemented with insights and practices from human aid control and organizational development.Consequently, lean experts should be cautious to live in contact with HR experts often positioned in exceptional purposeful departments. Lean management improvement emphasizes the significance of sturdy businesses, and the way amateur or aspiring managers are socialized into one of a kind methods of interacting with others. Consequently, lean leader improvement emerged as a continuous everyday

interest inside the managerial hierarchy, supported via predictable work and career paths. However, as argued by Debnath (2022), therefore, it states that "they ought to walk and communicate" to educate and spread adulthood lean construction hastily during the enterprise (Nesensohn, 2014)

2.3. Culture and Strategy Organization in Lean Construction

Adopting a lean culture is very important for acknowledged lean construction implementation. Lean culture aid humans to realize what's the primary functions of lean exercise and facilitate the lean implementation action. Sarhan & Fox (2013) elucidate the impediment of lean culture for the fulfillment of lean implementation, emphasizing that it is crucial to construct a lean tradition withinside the construction enterpises to resource lean transformation in layout, business enterprise, and initiatives. Provide an expression that maximum constructors do now not have the primary strategies of lean subculture in creative projects. They accentuate the lean subculture in engaging in extra green and profitability in manufacturing employers. Jadhav et al. (2014) make have looked at for limitations of lean implementation and concluded that organizational culture and resources are key parameters influencing the achievement of lean implementation. Consequently, the handiest lean techniques is now no longer enough to reap lean transformation even as there can be a lack of Lean lifestyle helping in construction undertaking.

2.4. Government Role in Lean Construction

The company's reputation and image are heavily reliant on government regulations and ISO standards. If there are no incentives for people to behave in a lean way, or if regulations are too tight, it becomes difficult to create a culture of leanness (Jadhav et al., 2014). Lean initiatives can flourish with government-funded support. So it's important for government bodies to back Lean practices.Lean implementation can be successful in a supportive environment, with government organizations providing incentives. The problems with lean implementation often seem to be related to government regulations. Numerous research have found that there are numerous difficulty to implemate the lean construction in extraordinary international locations due to the government approach.

2.5. Resource in Lean Construction

The lean production idea stresses the importance of continuous erudition mastering for people, groups, and agencies. Personnel wants to gain knowledge of lean concepts if you want to create an educated team of workers which can mirror an enterprise's readiness to adopt lean. Many people believes that acknowledged practice of lean production relies upon at the employees' capability to carry out their diverse features and attain their full ability. There is not sufficient time or money to do what we need to do. Agencies face many challenges regarding facts governance. That is one of the key factors to help ensure the fulfillment and effectiveness of the project. With the aid of supplying monetary help, along with consulting and schooling, we can help expand the workforce needed to perform the assignment. Employees often do not get enough time to make non-stop improvements cause the overall performance of consumer delight (Achanga, 2007).

2.6. Proposed Framework

Modeling the research framework or relationship model that will be used for SEM analysis which is formed based on substance theory established the opinion of previous research with reference to the patterns of relationships that will be formed. Synthesis between previous research

and researchers who will later form the framework of the research model. The relationship is formed based on the research model conducted. Fruitfullness of lean implementation calls for resources to help inside the Lean implementation manner. It need to be referred to that monetary availability alone isn't sufficient for a successful Lean implementation venture to be mixed with management assist (Achanga, 2007). Top management support & commitment has been widely recognized as a managerial and organizational factor. If there is no top management support, there will be no investment decisions, especially regarding company resources and improving the quality and skills of workers. Therefore, fruitfull practices of lean in construction projects cannot be terminated. Beyond top management commitment, the system cannot run properly. In principle, strong leadership and management permeate the company's vision and strategy to generate value (Achanga, 2007). Most leaders are owners, they may not have wise management. As a result, many things are hampered because of the encouragement of a quality strategy from good leadership traits. Behaviors and rewards are then easy to make in managing short-term, sustainable crisis times, while implementing Lean Manufacturing which can create a stronger basis for success by reducing costs and increasing resource use can suffer from persistent delays until better. Therefore, the authors conclude that leadership influences resources as well as organizational culture and strategy.

Lean leadership augmentation is a persistent system that takes vicinity inside the managerial hierarchy, guided way of superiors or sensei. This improvement allows novice or aspiring managers develop exceptional methods of thinking and behaving. This system is supported by means of predictable work and career paths.But, as argues, contemporary Western businesses aren't dependent like Toyota to imitate Toyota's fulfillment via imitating what it does. Although education thru hierarchy can be a usually affordable method. Western groups can also depend in the main on inner or outside management improvement applications.In addition, it's far emphasised that leaders in more mature corporations take a "preset" stance on lean that "the entirety can be advanced" for their very own purposes (AlManei et. al., 2017; Kumar et. al., 2013).

Gao & Low (2014) explained that MOHURD (2010), has promulgated four regulations appropiate to the applications of Lean construction in China. Within the MOHURD file (2010), there are 4 models of presidency coverage on the implementation of Lean creation: restructuring the organizational structure in a lean way; Optimization of resources and creation methods used; near supervision of buying, budgeting and undertaking financing in addition to issuing a series of inner files as guidelines within the implementation of lean constructionIn-intensity analysis of the studies findings of well-knownshows obstacles such as government forms, inconsistency in guidelines, lack of social centers and infrastructure,. Moreover, a few economic constraints which include inflation, expert wages, and corruption also can be associated with authorities problems. So the author can conclude that the role of government has a dating with organizational culture and strategy as well as resources.

Coincide to Sage et al. (2012), deep organizational alternate is a mixture of shifts of people's values, aspirations and conduct with apparent shifts in strategic, techniques, practices and structure systems.It has been cautioned by using hat isn't sufficient to exchange the method, structure, and system, until there is a trade in wondering this is supported with the aid of good enough assets. Attaining successful Lean implementation requires cultural alternate and non-stop improvement. The strategic and coverage elements for projects and organizations include: adopting a Lean culture, Lean as a company approach supported by means of manner of the licensed and authorized Lean implementers, the existance of a luminous advertising and marketing srtategy and marketplace percentage element. Organizational strategy in management is motivated with the aid of aid optimization in the practice of Lean construction.

Firm size can affect the ability to invest in lean construction resources. Large companies face a dilemma in choosing between top-down and bottom-up and centralized and decentralized approaches to lean culture adoption. While decentralized approaches can facilitate organizational culture change, change efforts are complicated and inefficient. The centralized approach is counterproductive when seeking change in the organizational culture. The efficacious practice of lean construction by the company/project depends on the company's vision, leadership support, and commitment rather than resource constraints. Therefore, the writer concludes that resources have an effect on organizational culture and strategy.

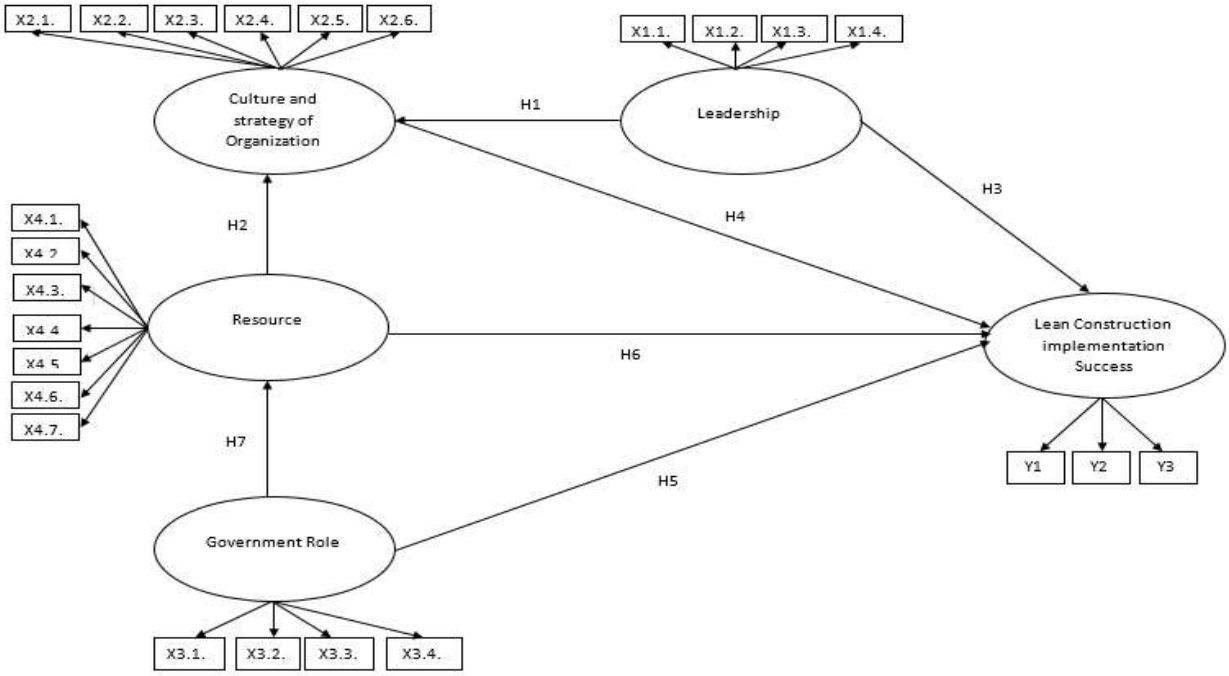


Figure 1. Proposes framework of this research

Primarily based on the literature assessment, it appears that a theoretical model can be developed that expresses the relationship between all of the underlying constructs. This model can be drawn in Figure 1. Following the theoretical model, several hypotheses can be generated as :

Hypothesis 1 : Leadership influance on organizational culture and strategy.
Hypothesis 2 : Resources influence on organizational culture and strategy
Hypothesis 3 : leadership influences the fruitful practice of lean construction.
Hypothesis 4 : organizational culture and strategy influence the fraitful practice of lean construction.
Hypothesis 5 : the role of government influences the success of lean construction
Hypothesis 6 : Resources influence the fruitful practice of lean construction
Hypothesis 7 : The government role affects resources

The next discussion is about the relationship between constructs and indicators. To find out, it is necessary to discuss of each indicator as a measure of the latent construct in the **table 1**

Table 1. Indicator of the research

Code	Source	Indicator
X1.1.	AlManei et.al.., (2017); Kumar et. al. (2013); Leite et. al. (2016);	Management enthusiasim

X1.2.	(AlManei et. al., 2017; Ogunbiyi, 2014)	Adopt customer satisfaction
X1.3.	(Dave et. al., 2013; Kumar et. al., 2013; Leite et. al., 2016)	Systemic thinking of implementation
X1.4.	(Ballard et. al., 2002; Demirkesen & Tommelein, 2016)	Leadership style
X2.1.	(Jadhav et. al., 2014; Leite et. al., 2016)	Corporate insentive
X2.2.	(Swefie, 2013); (AlManei et. al., 2017)	Teamwork
X2.3.	(AlManei et. al., 2017); (Onofrei et. al., 2021)	Desire to invest in lean construction
X2.4.	(Leite et. al., 2016; S. Sarhan & Fox, 2013)	Lean culture adoption
X2.5.	(Dave et. al., 2013; Demirkesen & Tommelein, 2016)	Existence of lean research
X2.6.	(AlManei et. al., 2017; S. Sarhan & Fox, 2013),	Effective communication
X3.1.	(AlManei et. al., 2017; Ogunbiyi, 2014)	Government regulations
X3.2.	(AlManei et. al., 2017; S. Sarhan & Fox, 2013)	Government insentive
X3.3.	(AlManei et. al., 2017; Leite et. al., 2016)	Availability of resources for lean
X3.4.	(Ward, 2015)	There is a facilitator from government
X4.1.	(AlManei et. al., 2017; Demirkesen & Tommelein, 2016)	Workers opinion
X4.2.	(AlManei et. al., 2017; Demirkesen & Tommelein, 2016)	Worker training
X4.3.	(Demirkesen & Tommelein, 2016); (Debnath, 2022)	Effectiveness of human resource management
X4.4.	(AlManei et. al., 2017; Leite et. al., 2016)	Worker Certification and Qualification
X4.5.	(Baviskar, 2015; Nesensohn, 2014; Ward, 2015)	Preserve on technology adoption
X4.6.	(Nesensohn, 2014; Ward, 2015)	Effective implementation of Lean construction method
X4.7.	(Nesensohn, 2014; Ward, 2015)	Transfer of knowledge
Y1	(Womack & Jones, 1996)	There is continuous improvement
Y2	(Nesensohn, 2014); (Olatunji, 2008);	Increased Transparency and decreased variability
Y3	(AlManei et. al., 2017; S. Sarhan & Fox, 2013),	Reduce waste

3. METHODS

After the framework model define, for the statistics anlysis start with reliability and validity checks. Reliability is used to assess the consistency of studies designs and research dimension equipment, and is commonly measured the usage of Cronbach's Alpha as a parameter. As soon as the version has passed the reliability check, a further step could be taken to test version validity the usage of two styles of analysis: dimension and structural version validity. After that information is taken into consideration to be ordinary if skewness is between -2 to +2 and kurtosis is between -10 to +10. After all statistical analysis make fit with the criteria than using numerous Goodness of fit (GOF) criteria and Confirmatory factor analysis, which imply how nicely the model can generate a distinct covariance matrix among the signs.

4. RESULTS

4.1. Pilot Survey

Respondents selected by the researchers are experts from college academics who are researchers or academics in addition to practitioners who have enjoy in running on initiatives. Trying out the consequences of the initial survey is done by an average score test in which the effects have to be > 3 which proven in table 2.

Table 2. Result recapitulation of pilot survey

Indicator	Mean Score	Deviation Standard	Indicator	Mean Score	Deviation Standard
$X_{1.1.}$	5.00	0	$X_{3.3.}$	3	1.414
$X_{1.2.}$	4.571	0.5345	$X_{3.4.}$	3.286	0.951
$X_{1.3.}$	4.2857	0.7559	$X_{4.1.}$	4.429	0.787
$X_{1.4.}$	4.571	0.535	$X_{4.2.}$	3.571	0.976
$X_{2.1.}$	4.429	0.535	$X_{4.3.}$	4.286	0.756
$X_{2.2.}$	4.857	0.378	$X_{4.4.}$	4.571	0.535
$X_{2.3.}$	4.429	0.787	$X_{4.5.}$	4.571	0.787
$X_{2.4.}$	4.857	0.378	$X_{4.6.}$	4	0.816
$X_{2.5.}$	4.286	0.756	$X_{4.7.}$	4.286	0.756
$X_{2.6.}$	3.857	0.9	Y_1	4.43	0.976
$X_{3.1.}$	3.714	1.254	Y_2	3.286	0.488
$X_{3.2.}$	3.429	1.718	Y_3	4.286	1.113

4.2. Main Survey

Concerning the number of samples for SEM analysis, there is no agreement on what is considered reasonable. The recommended number of samples are 100 with a high item of communalities. The survey period was conducted from January 2022 to April 2022. The main survey was conducted using a questionnaire which had passed the preliminary survey stage and use likert skale (0 = very disagree and 5 = vary agree). The study used a sample of 170 respondents spread over 28 construction projects throughout Indonesian areas. The respondent is all the construction professional or staff while they assumed understand about lean construction.

4.3. Validity and Normality test

The validity test in this study is used as degree of accuracy of the objectives measuring tool towards the actual content being measured that the psig must be <0.05. The overall results of the validity are declared **valid**. Normality test is a procedure to find out the research data comes from a normally distributed population or not when the skewness must be ±4 and kurtosis must be ±10. The overall results declared **normal** as show off in Table 3.

Table 3. Result of validity and normality test

Indicator	Pearson Correlations	P sig value	Skewness	Kurtosis
Leadership				
$X_{1.1.}$	0.749	0.00	-1.125	1.174
$X_{1.2.}$	0.724	0.00	-0.934	1.685
$X_{1.3.}$	0.786	0.00	-0.672	-0.074
$X_{1.4.}$	0.738	0.00	-0.696	-0.048
Culture and Strategy Organization				
$X_{2.1.}$	0.625	0.00	-0.381	-0.162
$X_{2.2.}$	0.681	0.00	-0.851	0.608
$X_{2.3.}$	0.751	0.00	-0.561	-0.202
$X_{2.4.}$	0.742	0.00	-1	1.205
$X_{2.5.}$	0.718	0.00	-0.629	0.791
$X_{2.6.}$	0.576	0.00	-0.649	-0.061
Government Role				
$X_{3.1.}$	0.813	0.00	-0.71	0.23
$X_{3.2.}$	0.860	0.00	-0.786	0.277
$X_{3.3.}$	0.805	0.00	-1.013	1.554

$X_{3.4.}$	0.803	0.00	-0.837	0.461
Resources				
$X_{4.1.}$	0.690	0.00	-1.191	1.571
$X_{4.2.}$	0.642	0.00	-0.682	-0.316
$X_{4.3.}$	0.768	0.00	-0.631	-0.238
$X_{4.4.}$	0.752	0.00	-1.108	1.4
X4.5.	0.770	0.00	-0.872	0.089
X4.6.	0.770	0.00	-0.501	-0.228
X4.7.	0.704	0.00	-1.153	1.871
Lean construction implementation success				
Y1	0.825	0.00	-0.721	-0.041
Y2	0.811	0.00	-0.624	-0.046
Y3	0.832	0.00	-1.02	0.51

4.4. Reliability test

Reliability test is a measurement instrument of a qualitative questionnaire which is an indicator of a construct. In the SPSS program to see the reliability of a construct using the value of Cronbach Alpha must be > 0.7. The overall results of the reliability analysis **reliable**.

Table 4. Result of reliability test

Construct	Total data	Total indicator	Cronbach Alpha value
Leadership	170	4	0.74
Culture and strategy organization	170	6	0.771
Government Role	170	4	0.838
Respurce	170	7	0.853
Lean construction implementation success	170	3	0.763

4.5. Expected Outcomes

This research analyze lean construction implementation in Indonesia based on contractor perspective. This research is also trying to develop links between 5 contructs in conceptual model in all kind of Indonesia construction project. The results will allow all stakeholder in Indonesia construction project to develop better decision-making process to implementation of lean construction on study of Indonesia project.

5. CONCLUSIONS

This research objectives is to look the essential success element for implementing lean construction in Indonesia construction projects. The opportunity to handling research at the relationships between all of the important success component (as construct) has been diagnosed as a research gap. In the end, the use of empirical records, a theoretical version has been set up as the inspiration for the Structural Equation Modelling (SEM). The outcomes of the evaluation show that the fruitful practice of Lean construction in Indonesia is encouraged through four elements, namely: organizational tradition and approach elements, leadership, the position of presidency and assets. Each of these factors is measured by means of signs with a total of 24 signs.

REFERENCES

Achanga, P. C. (2007). *Development of an impact assessment framework for lean manufacturing within SMEs*. Cranfield University.

Alinaitwe, H. M. (2009). Prioritising Lean Construction Barriers in Uganda's Construction Industry.[1] H. M. Alinaitwe, "Prioritising Lean Construction Barriers in Uganda's Construction Industry.," J. Constr. Dev. Ctries., vol. 14, no. 1, 2009. *Journal of Construction in Developing Countries*, *14*(1).

AlManei, M., Salonitis, K., & Xu, Y. (2017). Lean implementation frameworks: the challenges for SMEs. *Procedia Cirp*, *63*, 750–755.

Alwi, S., Mohamed, S., & Hampson, K. (2002). Waste in the Indonesian construction projects. *Proceedings of the 1st CIB-W107 International Conference-Creating a Sustainable Construction Industry in Developing Countries*, 305–315.

Ballard, G., Tommelein, I., Koskela, L., & Howell, G. (2002). Lean construction tools and techniques. *Chapter*, *15*, 227–255.

Baviskar, P. (2015). *Critical success factors for effective implementation of lean assessment tools/framework in manufacturing industries.*

Bicheno, J., & Holweg, M. (2000). *The lean toolbox* (Vol. 4). PICSIE books Buckingham.

Dave, B., Koskela, L., Kiviniemi, A., Tzortzopoulos, P., & Owen, R. (2013). *Implementing lean in construction: Lean construction and BIM [CIRIA Guide C725]*.

Debnath, G. (2022). *Key Success Factors of NGO Leadership that Leads to Sustainable and Effective Development : A Case on BRAC , Bangladesh LEADS TO SUSTAINABLE AND EFFECTIVE DEVELOPMENT : Expert Projects Publishing House publishing On behalf of : „ Alexandru Ioan Cuza " Uni*. *June*. https://doi.org/10.33788/rcis.77.8

Demirkesen, S., & Tommelein, I. D. (2016). Lean management methods for design and construction: Built-in-quality and safety-by-design. *Advances in Civil Engineering Conference Istanbul (ACE2016)*, 1–8.

Gao, S., & Low, S. P. (2014). From Lean Production to Lean Construction. In *Lean Construction Management* (pp. 27–48). Springer.

Howell, G. A. (1999). What is lean construction-1999. *Proceedings IGLC*, *7*, 1.

Jadhav, J. R., Mantha, S. S., & Rane, S. B. (2014). Exploring barriers in lean implementation. *International Journal of Lean Six Sigma*.

Krafcik, J. F. (1988). Triumph of the lean production system. *Sloan Management Review*, *30*(1), 41–52.

Kumar, S., Kumar, N., Luthra, S., & Haleem, A. (2013). Enablers of lean six sigma implementation in business environment: A review. *Growth*, *5*, 14–16.

Leite, H., Bateman, N., & Radnor, Z. (2016). Lean implementation and sustainability: a classification model of the main organizational barriers and enablers. *Production and Operations Management Society Conference*, 1–10.

Nesensohn, C. (2014). *An innovative framework for assessing lean construction maturity*. *February*, 410.

Ogunbiyi, O. E. (2014). *Implementation of the lean approach in sustainable construction: a conceptual framework*. University of Central Lancashire.

Olatunji, J. (2008). Lean-in-Nigerian construction: State, barriers, strategies and "go-to-gemba" approach.". *Proceedings of the 16th Annual Conference of the International Group for Lean Construction, Manchester, UK*, 16–18.

Onofrei, G., Fynes, B., Nguyen, H., & Azadnia, A. H. (2021). Quality and lean practices synergies: A swift even flow perspective. *International Journal of Quality and Reliability*

Management, *38*(1), 98–115. https://doi.org/10.1108/IJQRM-11-2019-0360

Radhika, R., & Sukumar, S. (2017). An overview of the concept of lean construction and the barriers in its implementation. *International Journal of Engineering Technologies and Management Research*, *4*(3), 13–26.

Sage, D., Dainty, A., & Brookes, N. (2012). A 'Strategy-as-Practice'exploration of lean construction strategizing. *Building Research & Information*, *40*(2), 221–230.

Salem, O., Solomon, J., Genaidy, A., & Minkarah, I. (2006). Lean construction: From theory to implementation. *Journal of Management in Engineering*, *22*(4), 168–175.

Sarhan, S., & Fox, A. (2013). Barriers to implementing lean construction in the UK construction industry. *The Built & Human Environment Review*.

Swefie, M. G. (2013). *Improving project performance using lean construction in Egypt: a proposed framework*.

Ward, S. A. (2015). *Critical success factors for lean construction intervention*. University of Dundee.

Womack, J. P., & Jones, D. T. (1996). Beyond Toyota: How to root out waste and pursue perfection. *Harvard Business Review*, *74*(5), 140–151.

Measurement of the Level of Community Readiness and Satisfaction on the Implementation of the e Lampid Application in the City of Surabaya

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ABSTRACT

Public services are important and a necessity for the community. Public services must be carried out optimally and follow technological developments. The Surabaya City Government continues to innovate in governance that utilizes information and communication technology. One of the innovations made by the Surabaya City Government is the e Lampid application. The e Lampid application aims to increase community satisfaction by providing convenience for population administration services for the people of the city of Surabaya. This study aims to determine the level of readiness and satisfaction with the implementation of the e Lampid application in the city of Surabaya. This study uses three methods, namely Technology Acceptance Model 3 (TAM 3), SERQVUAL and Kano Methods. The TAM 3 model aims to explain and estimate user acceptance of a technology product. The SERQVUAL method is a method for measuring service quality which is also known as the Gap and is closely related to the satisfaction model. The Kano method is an index of service user satisfaction that is needed to determine the level of satisfaction of service users by taking into account the level of satisfaction of the services provided by the Surabaya City Government.

Keywords : Public Service, e Lampid, TAM 3, Servqual, Kano.

1. INTRODUCTION

Public service is all forms of public service activities carried out by central agencies, in the regions and within the state or regional state-owned enterprises in the form of goods or services in an effort to fulfill the needs of the community (Maryam, 2016). There are two types of services needed by humans, namely personal services and administrative services, one of which can be found in public services provided by the government to the community (Hassel, 2005).

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The use of e-government is an effort in the administration of government that utilizes information and communication technology, with the aim of increasing the ease of population administration services for the people of the city of Surabaya. This e Lampid application is based on the Surabaya Mayor Regulation Number 5 of 2013 concerning Guidelines for the Use of Information and Communication Technology in the Implementation of Regional Government

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The Surabaya City Government through the Department of Population and Civil Registration of the City of Surabaya created an application or breakthrough in order to provide population administration services for the people of the City of Surabaya. The form of the

application is a 6 in 1 application (Maintaining birth certificates, death certificates, moving in and moving out for Indonesian citizens. As well as marriage certificates and divorce certificates for non-Muslims online) or better known as the e Lampid application (electronic stillbirth). move come).

2. LITERATURE REVIEW

Service according to the Big Indonesian Dictionary (KBBI) is an effort to help prepare or take care of what other people need. Meanwhile, according to (Oneir, 2010:16), service is an activity carried out by a person or group of people on the basis of material factors through certain systems, procedures, and methods in the framework of efforts to fulfill the interests of others in accordance with their rights. Service is essentially a series of activities, therefore service is a process. As a process, services take place regularly and continuously covering all people's lives in society. In principle, the quality of service focuses on efforts to fulfill the wishes and desires of consumers, as well as the accuracy of their delivery to balance the expectations of customers.

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Understanding service quality according to Tjiptono (Tjiptono, i2014: 260) is the level of excellence (excellence) that is expected and control over these advantages to meet the wishes of consumers. In other words, there are 2 main factors, namely the expected service and the perceived service.

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3. METHODS

This paper uses three methods including the TAM 3 method, the Servqual method and the Kano method. The TAM 3 method is to measure how ready the community is to accept the e Lampid application, while the Servqual method and the Kano method are to measure how satisfied the community is with the implementation of the e Lampid application.

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4. RESULTS

Experience has been proven to have a positive effect on Perceived Ease of Use in implementing e Lampid. The results of this study do not support the results of previous research conducted by Amoroso (2009) which did not find a positive relationship between experience and perceived ease of use, but on the other hand the results of this study support the results of Bhilawa's (2010) research which found a positive relationship between experience (experience) and perceived ease of use. So it can be concluded, people will find it easy to use e Lampid when they are used to Tecnology

Experience has a positive effect on Perceived Usefulness in implementing e Lampid. The results of this study support the results of previous research conducted by Chau and Hu (2001) which found a relationship between experience and perceived usefulness, and also support the results of research conducted by Kurniawati et al. (2017) who found a positive relationship between experience and perceived usefulness in using e Lampid. So it can be concluded, people will feel the magnitude of the usefulness of e Lampid when they have experience using other information technologies.

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6. CONCLUSIONS

Suggestions submitted to the Department of Population and Civil Disabilities of the City of Surabaya is that it is necessary to improve the socialization and introduction of the e Lampid application to the people of the City of Surabaya, so that the needs and desires of the community can be fulfilled and the people of the City of Surabaya can use and operate the e Lampid application. implemented by the Surabaya City Government.

REFERENCES

Tiwari, S.; Singh, P. E-Commerce: Prospect or Threat for Environment. Int. J. Environ. Sci. Dev. 2011, 2, 211–217

Olphert, C.W.; Damodaran, L.; May, A.J. Towards digital inclusion—Engaging older people in the 'digital world'. In Proceedings of the Accessible Design in the Digital World Conference, Dundee, UK, 23–25 August 2005

Zhang, M., Huang, L., He, Z. and Wang, A.G. (2015), 'E-service quality perceptions: an empirical analysis of the Chinese e-retailing industry,' Total Quality Management.

For books:

Harrington, D. (2009). *Confirmatory Factor Analysis.* New York: Oxford University Press

For journal articles and conference proceedings:

Antono, A. (2011). Orientasi Pelayanan Publik Melalui Pendekatan New Public Service Untuk Mengatasi Problem Kesehatan Pada Program Jamkesmas di Kecamatan Kembaran Kabupaten Banyumas. Jurnal Pembangunan Pedesaan Volume 11 Nomor 1, Juni 2011.

Asep, Isyanto, P., & Irma, E. (2012). Analisis Kepuasan Pelanggan terhadap Loyalitas Konsumen

Rental DVD Pada Perusahaan Jasa Rental DVD Club Cabang Tuparev-Karawang. Jurnal Manajemen Vol. 09 No. 4 Juli 2012.

Then your reference section will look like:

Sinambella, (1992). Ilmu dan Budaya Perkembangan Ilmu Administrasi Negara. Jakarta : PT Bumi Aksara

Moenir, (2015). Managemen Pelayanan Umum di Indonesia. Jakarta : PT Bumi Aksara.

Wulandari, dkk. (2015). "*Aplikasi Informasi Lokasi Jalan Rusak Berbasis Web dan Android*", Vol.1, No.1 April 2015

Maryam, N.S (2016). Mewujudkan Good Govermance Melalui Pelayanan Publik. Jurnal Ilmu Politik dan Komunikasi, VI (1), 12-27

Hayat, (2017). " Manajemen Pelayanan Publik. Depok : PT. Raja Grafindo Persada.

Hessel, (2005). Manajemen Publik. Jakarta : PT. Grasindo

Crescenzi, A. (2005). User Acceptance of Electronic Meeting Technology in The Semiconductor Research Corporation. Thesis unpublished, Faculty of The School of Information and Library Science, Chapel Hill, North Carolina University.

Davis, F.D. (1989). Perceived usefulness, Perceived ease of use, and User Acceptance of Information Technology. MIS Quarterly, 13 (3), 319–40.

Davis, F.D., Bagozzi, R.P., Warshaw, P.R. (1989). User Acceptance of Computer Technology: A Comparison of Two Theoretical Models. Management Science, 35 (8), 982-1003.

Straub, D., Keil, M., & Brenner, W. (1997). Testing the Technology Acceptance Model Across Cultures: A Three Country Study. Information & Management, 33, 1-11.

Sun, H., Zhang, P. (2006). Causal Relationships between Perceived Enjoyment and Perceived Ease of Use: An Alternative Approach. Journal of the Association for Information Systems, 7 (9), 618-645.

THE EFFECT OF SOCIAL RESPONSIBILITY ON FINANCIAL PERFORMANCE: ANALYSIS OF FAMILY FIRMS LISTED ON INDONESIA STOCK EXCHANGE IN 2013 – 2020

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ABSTRACT

This study aims to examine the influence of social responsibility disclosure with financial performance in Indonesian companies. The population and samples used in the study are family firms listed in Indonesia Stock Exchange that publish annual reports from 2013 to 2020, except companies in the financial industry, as many as 146 company with a total of 1,168 observations. The method used to test the hypotheses in the study was a multiple regression model. This study uses content analysis to measure social responsibility disclosure (CSD) as an independent variable with reference to the Global Reporting Initiative (GRI) Content Index. Financial performance is a dependent variable which is represented by the proxy of return on asset, return on equity, debt to equity, and Tobin's Q ratio in measuring firm value. This study also uses corporate governance as control variable. This research found that CSD has a significant effect on firm's financial performance and firm value. The result shows that CSD had positively influenced a firm's performance. The findings may be used as a reference for the manager to effectively and efficiently manage CSD, leading to a better firm's performance.

Keywords: social responsibility disclosure, corporate social disclosure, corporate financial performance, family firms.

1. INTRODUCTION

Global awareness of CSR has increased the need for high-quality CSR disclosures so that consumers and investors can expand product considerations to various aspects, such as the environment, health, and labor protection. Guidelines for implementing CSR for public and private companies refer to internationally recognized standards, such as ISO 26000 by the International Organization for Standardization (ISO) and the Global Reporting Initiative (GRI) developed by the Global Sustainability Standards Board (GSSB). The government in Indonesia compiles regulations and stipulates that companies engaged in natural resources are required to implement and report on CSR activities. In addition to responding to institutional pressures, companies in Indonesia also invest a large amount of resources in CSR activities in the hope of improving the

company's financial performance. Like other developing countries, especially in the East Asia region, family businesses or companies still dominate the ownership structure in Indonesia (Brahmana et al., 2019). Given that family businesses generally have tighter control and monitoring and are oriented towards value creation, any CSR action or implementation of this type of family company approaches a more transactional and profit-sensitive nature.

While CSR is regulated and required by law, its intensity and the stakeholders it targets depend on the actions of the company. The company has the freedom to choose the type of social and or environmental activities, how many programs, or which stakeholders, delegate full authority to the manager. Loose CSR regulations combined with governance issues in Indonesia can provide interesting insights for studies of a developing country. CSR that is well implemented by the company is an effective way to improve the company's performance, so that there is a positive relationship between CSR activities and the company's financial performance (CFP). Several previous studies assessed the implementation of CSR by conducting content analysis using GRI standards, or using the CSR index, as well as combining CSR disclosure points from international standards with other studies. Therefore, the purpose of writing in this study is to determine the impact of CSR on the financial performance (CFP) of selected family firms listed on the Indonesia Stock Exchange (IDX) based on financial parameters and to find out the impact of CSR on the company's financial performance (CFP).

2. LITERATURE REVIEW AND HYPOTHESIS DEVELOPMENT

Institutional Theory and Corporate Social Responsibility in Indonesia

Institutional theory includes arguments from a stakeholder perspective and legitimacy theory. The concept underlying institutional theory is that firms are called upon to respond to industry regulations and competitive norms and values (Scott, 2004). From an institutional perspective, the scope of the study is relatively broad because CSR reporting is positioned within the responsibility system in which business, government, legal and social institutions operate (Matten and Moon, 2004). Firms are embedded in a variety of political, economic and social institutions that influence their behavior (Campbell 2004) and are driven by the need to respond to environmental pressures. This concept is also well tested in the CSR literature by proposing that the benefits of CSR outweigh the costs (Waddock and Graves, 1997).

According to institutional theory, there are many sources of external pressure, namely regulatory, normative and cognitive pressures (Scott, 2004). Indonesia itself established an independent organization in 2005 to develop and promote companies conducting CSR reporting, namely the National Center for Sustainability Reporting (NCSR). NCSR is a member of The Global Reporting Initiative (GRI) which compiles international standards for CSR measurement and reporting, therefore CSR disclosure in Indonesia also refers to GRI. The name of the latest GRI guide revision is GRI Content Index. GRI Content Index has 148 disclosure indicators that are categorized into several aspects of CSR activities which contain CSR disclosure indicators that will be used in this study. The implementation of CSR in Indonesia requires companies in the field of natural resources or those related to natural resources to carry out Social and Environmental

Responsibilities in Article 74 Paragraph (1) of the PT Law. The mechanism for implementing CSR is described in Government Regulation Number 47 of 2012 Article 1 Paragraph (4).

Corporate Social Responsibility Disclosure and Financial Performance

Given the relationship between CSR and financial performance (CFP), companies tend to be more motivated to act with greater social awareness, address social or environmental problems that they create themselves and/or engage directly in social and environmental programs that can benefit society in general (Porter and Kramer, 2011). CSR activities that improve financial performance also reduce the possibility of these investments reducing shareholder value (Moser and Martin, 2012). Several studies on the relationship between CSR and CFP show a positive relationship between CSR and CFP, although the magnitude of this effect and the causal relationship are still widely debated (Freedman and Jaggi, 1988).

Niehm et al., (2008), conducted a study on 221 small and mostly rural family companies, showing that CSR orientation is beneficial for company performance; they emphasize the role of owner-family values and attitudes on CSR behavior, highlighting the relevant relationship to the surrounding community and, thus, the tendency to engage in dialogue with community constituents. Beck, et al., (2018) conducted a cross-country study of the relationship between CSR and performance, confirming the expectation that CSR and corporate performance have a positive relationship. On the one hand, there is an emphasis on the long-term orientation typical of family firms (Zellweger, 2017), which is likely to result in more ethical behavior (Long and Mathews, 2011). It is also a consequence of the family-centered goals and values that characterize family firms, which in turn contribute to influencing their strategic decisions (De Massis 2013).

In measuring the level of spatial performance there are various ratios used. One of them can be seen through the ratio of return on assets (ROA) as an indicator of how much profit the company can generate through its assets. The results of Kaur and Dave's research (2020) show that when a company scores better in CSR initiatives, it can be more profitable with their assets, which means a higher ROA value. ROE measures how efficiently a company generates profits from funds contributed by shareholders. Kaur and Dave (2020) show that the better the CSR score, the higher the resulting ROE. The DER ratio represents the company's long-term leverage. This is in line with signaling theory, where disclosure of information is needed by investors and other stakeholders to better assess the strength of the company in the future (Miller, 1999). Research by Feng et al. (2018) found that companies that have good CSR values have leverage that describes good financial performance. Based on a review of previous studies, several hypotheses can be drawn as follows:

H1: There is a significant positive relationship between CSR and ROA

H2: There is a significant positive relationship between CSR and ROE

H3: There is a significant positive relationship between CSR and DER

Firm value is an indicator seen by investors in investing, usually in the form of stock value. According to Liu and Zang (2017), company value generally reflects the company's ability to all company stakeholders (shareholders, creditors, managers, employees, and the government). Companies that have high corporate values tend to be more socially responsible through CSR

disclosure (Jo and Harjoto, 2012). Higher firm value will increase stakeholder trust and relationships (Lenz et al., 2017). Therefore, the hypotheses that can be taken are:

H4: There is a significant positive relationship between CSR and Firm Value

Based on the descriptions and explanations that have been presented, the research framework is as follows:

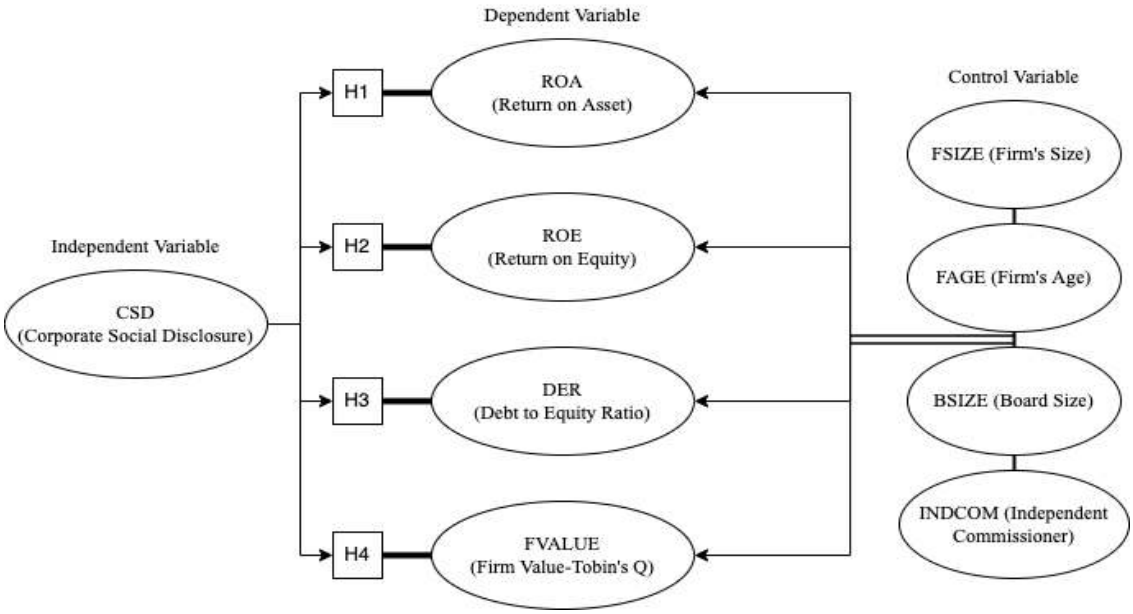


Figure 1. Research Framework

3. METHODOLOGY

This study uses secondary data and purposive sampling method. The criteria used in sampling are non-financial institution companies listed on the IDX during the study period, companies with 20% or more share ownership by family members, and companies that publishes annual reports and company sustainability reports in 2013 to 2020 with reports ending every December 31. The final samples are 146 with 1,168 observations. Table 1.1 show this research sample selection:

Table 1.1 Research Sample Selection

Description	Samples of Company	Observation
The number of companies listed on the IDX in 2020	787	6296
Companies in the financial sector	(105)	(840)
Number of companies with share ownership of family members less than 20%	(494)	(3952)
Number of companies that have incomplete data	(42)	(336)
The number of companies used as research samples	**146**	**1168**

The CSR score (CSD) assessment is calculated by adding up the CSR disclosures owned by the company in the financial statements in accordance with the GRI Content Index framework then

divided by 148 CSR disclosure indicators based on the GRI Content Index. Content analysis are used to measure social responsibility (CSR) disclosure as an independent variable with reference to the Global Reporting Initiative (GRI) Content Index. CSR disclosure data is obtained manually from each company's CSR report using content analysis by assigning a score (1) for each disclosure and a score (0) for indicators that are not disclosed based on the GRI Content Index. The formula is as follows.

$$CSD = \frac{\sum Corporate\ CSR\ Disclosure}{\sum All\ CSR\ Disclosure\ Indicators\ of\ GRI\ Content\ Index} \quad (1)$$

Financial disclosure is a dependent variable which is represented by the proxy of profit after return on asset (ROA), return on equity (ROE), debt to equity (DER) ratio, and Tobin's Q ratio (FValue) in measuring firm value. This study also uses corporate governance as control variables such as: company size (FSize), company age (Fage), number of board of commissioners (BSize), and the size of independent commissioners (Indcom).The model used to determine the relationship of CSR disclosure to financial performance (CFP) is as follows.

$$CFP\ (\gamma 1) = \beta_0 + \beta_1 CSD_{it} + \beta_2 FSize_{it} + \beta_3 FAge_{it} + \beta_4 Bsize_{it} + \beta_5 Indcom_{it} + u_{it_{i=0}}$$
$$CFP\ (\gamma 2) = \beta_0 + \beta_1 CSD_{it} + \beta_2 FSize_{it} + \beta_3 FAge_{it} + \beta_4 Bsize_{it} + \beta_5 Indcom_{it} + u_{it_{i=0}}$$
$$CFP\ (\gamma 3) = \beta_0 + \beta_1 CSD_{it} + \beta_2 FSize_{it} + \beta_3 FAge_{it} + \beta_4 Bsize_{it} + \beta_5 Indcom_{it} + u_{it_{i=0}}$$
$$CFP\ (\gamma 4) = \beta_0 + \beta_1 CSD_{it} + \beta_2 FSize_{it} + \beta_3 FAge_{it} + \beta_4 Bsize_{it} + \beta_5 Indcom_{it} + u_{it_{i=0}} \quad (2)$$

where
CFP (γ1): represents Model 1. the CFP as measured by ROA
CFP (γ2): represents Model 2. CFP as measured by ROE
CFP (γ3): represents Model 3. CFP as measured by DER
CFP (γ4): represents Model 4. CFP as measured by FValue
(β0) is a constant value; (β1: β5) is a parameter for the independent variable
CSD: CSR disclosure value
FSize: company size
Fage: date of analysis subtracted by inception date
Bsize: board size
Indcom: number of independent commissioner divided by board size
u_{it}: error term; i: company, t: time

After modelling the data and getting the estimated parameters, statistical testing to be performed are multiple regression model. After all of the testing are done and the model is fit, the analysis on influence of social responsibility disclosure (CSD) with financial performance (CFP) can be derived.

4. RESULTS

Descriptive Statistics

CSR disclosure value (CSD) as independent variable in this study has an average value of 0.3711357. The company that disclosed the highest CSR was JPFA with a CSD value of 1.1216. The company with the lowest CSD value of 0.0270 is EMTK. The company's performance (CFP) was measured using the dependent variable ROA, having an average value of 0.0360398. The company with the highest and lowest rate of return on assets is FMII, which is 0.3250026 and PKPK -0.5790084. ROE shows the lowest profitability value of -2.8956 also owned by PKPK company. Then the company with the highest ROE value is MFMI of 0.563198. The last measure of financial performance is DER which has an average value of 1.164838, respectively having a minimum value of 0.0347921 and a maximum of 3.978692 owned by RBMS and TMAS companies. The last dependent variable is firm value (FValue) which is measured using the Tobin's Q ratio which has an average value of 1.284825. The company that has the largest value is KLBF with a value of 3.963009. And the company with the lowest value of 0.1992484 is owned by RBMS.

Table 1.2 Descriptive Statistics

Variable	Mean	Std. Dev	Min	Max
ROA	.0360398	.0709365	-.5790084	.3250026
ROE	.0626172	.166107	-2.895625	.563198
DER	1.164838	.8249927	.0347921	3.978692
FVALUE	1.284825	.7525948	.1992484	3.963009
CSD	.3711357	.2350376	.027027	1.121622
FSIZE	22.07254	1.783717	17.69893	30.243
FAGE	22.7633	7.893411	8.041096	39.8
BSIZE	3.130137	.9674298	2	6
INDCOM	.4484589	.1290423	.2	.75

Description: ROA: Return on Assets, ROE: Return on Equity, DER (Debt to Equity), FValue: Firm value (Tobins' Q Ratio), CSD: Corporate Social Disclosure (CSR Disclosure Value), FSize: Company Size, Fage: Company Age, BSize: Size of the Board of Commissioners, Indcom: Proportion of Independent Commissioners.

The control variables in this study consisted of FSize (company size), Fage (company age), BSize (board of commissioners), and Indcom (proportion of independent commissioners). The average FSize is 22.07254, with a minimum value of 17.69893 and a maximum of 30.2430 owned by FORU and FMII companies respectively. The average Fage is 22.7633 (or about 22.7 years) with the lowest company age by SIDO at 8.041096 (8 years) and the oldest age being 39.8 (39.8

years), namely BATA. The average size of the board of commissioners (BSize) is 3,130137, with the largest BSize of 6.0 being owned by SRSN and several companies (more than 42 companies including ABBA, ADRO, ASRI etc.) having a BSize of 2.0. The last control variable is the proportion of independent commissioners on the board of commissioners (Indcom) with an average of 0.4484589 with the highest proportion value of 0.75 by GGRM, HERO, and ICBP and the lowest with a value of 0.2 in KBLM companies and SSIA.

Multiple Regression Analysis

Through multiple regression testing, the research results can be used as a hypothesis test that has been determined in the study. In hypothesis testing, the values that can be known are the coefficient of determination, the regression significance value, and the significance value of the independent variable on the dependent. Hypothesis testing on research models 1, 2, 3 and 4 was carried out to see the level of influence of CSD on on ROA, ROE, DER, and FValue with FSize, Fage, BSize and Indcom as control variables.

Table 2.1 Results of Multiple Regression Analysis on ROA and ROE

	Research Model 1 (Dependent Variable: ROA)			Research Model 2 (Dependent Variable: ROE)		
	Coef.	P>|z|	Result	Coef.	P>|z|	Result
CSD	.125049	0.000***	(+) Sig	.2646447	0.000***	(+) Sig
FSIZE	-.0028451	0.120	(-) non Sig	-.0037499	0.258	(-) non Sig
FAGE	.0003585	0.388	(+) non Sig	.0006346	0.378	(+) non Sig
BSIZE	.0042768	0.210	(+) non Sig	.0077965	0.188	(+) non Sig
INDCOM	.0455434	0.078*	(+) Sig	.0822762	0.069*	(+) Sig
_cons	.0114212	0.778		-.0242635	0.738	
Prob>chi2		0.0000			0.0000	
Overall R-Squared		0.2476			0.2672	

***significant at 1% level, **significant at 5% level, *significant at 10% level. Description: CSD: Corporate Social Disclosure (CSR Disclosure Value), FSize: Company Size, Fage: Company Age, BSize: Board of Commissioners Size, Indcom: Proportion of Independent Commissioners

It can be seen in the table, the coefficient of determination (R2) of research Models 1 to Model 4 shows values of 0.2476, 0.2672, 0.0278, and 0.0232 respectively. This means that the independent variables and the control variables of the study can explain changes in the research dependent variable by 24.7 percent, 26.7 percent, 2.7 percent and 2.3 percent for each research model. Furthermore, the value of Prob>Chi2 of research model 1 and 2 shows a value of 0.0000, the value of Prob>Chi2 of research model 3 is 0.0692, and the value of Prob>Chi2 of research model 4 is 0.0183, this indicates that there is a difference in the level of significance of the influence of the independent variables and the control variables of the study on the dependent variable.

It can be seen in the table, that the research Model 1 CSD has a significant positive effect on ROA with a significance of 1%. Meanwhile, the control variable FSize has a non-significant negative result on ROA. Furthermore, for Fage and BSize the results were non-significantly

positive. And for Indcom the results are positive with a significance of 10% on ROA. Based on research model 1, the CSD variable has a coefficient of 0.0114 which reflects that for every 1 unit change in CSD, the ROA will change by 12.5 percent. Furthermore, for every change of 1 unit of Fage, ROA will experience a change of 0.04 percent, a change of 1 unit of BSize will have an impact on a change of 0.43 percent of ROA, and for every change of 1 unit of Indcom, ROA will experience a change of 4.55 percent. In Model 2, the CSD variable to ROE is 0.2646, which means that every 1 unit change in CSD will result in a 26.46 percent change. Every 1 unit change in Fage will result in a 0.06 percent change in ROE. A change in BSize of 1 unit will result in a change in ROE of 0.78 percent and a change in Indcom every 1 unit will result in a change in ROE of 8.23 percent. Furthermore, it can be seen based on Table 2.2 (continued) the results of the regression equation Model 3 and the regression equation Model 4:

Table 2.2 Results of Multiple Regression Analysis on DER and FVALUE

	Research Model 3 (Dependent Variable: DER)			Research Model 4 (Dependent Variable: FVALUE)		
	Coef.	P>|z|	Result	Coef.	P>|z|	Hasil
CSD	-.2887262	0.005***	(-) Sig	.2129959	0.048**	(+) Sig
FSIZE	.0488689	0.072*	(+) Sig	-.0643587	0.010***	(-) Sig
FAGE	-.0023756	0.764	(-) non Sig	-.0067894	0.298	(-) non Sig
BSIZE	-.0427463	0.512	(-) non Sig	.0217973	0.685	(+) non Sig
INDCOM	.093109	0.841	(+) non Sig	.8684969	0.027**	(+) Sig
_cons	.3394564	0.597		2.323169	0.000	
Number of Obs				1,168		
Number of Groups				146		
Prob>chi2		0.0692			0.0183	
Overall R-Squared		0.0278			0.0232	

***significant at 1% level, **significant at 5% level, *significant at 10% level. Description: CSD: Corporate Social Disclosure (CSR Disclosure Value), FSize: Company Size, Fage: Company Age, BSize: Board of Commissioners Size, Indcom: Proportion of Independent Commissioners

Model 3 describes the last financial performance, namely DER. In contrast to the two previous financial performance variables, a change of 1 unit of CSD will change the DER of -28.87 percent. Furthermore, a change of 1 unit of CSD will give changes to FSize 4.89 percent and Indcom 9.31 percent. The last research model is to represent the firm value variable. Looking at the regression equation above, it can be seen that for every 1 unit change, CSD will change the FValue by 21.29 percent. Furthermore, the BSize variable can have an impact on changes in FValue by 2.18 percent, and Indcom by 86.85%.

The Effect of Corporate Social Responsibility on Financial Performance

The results of this study support previous research on CSD studied by Kaur and Dave (2020) and Yeon, et al., 2021 which stated that CSD had a significant positive effect on financial performance ROA and ROE and firm value FValue. As the focus of this research, namely family companies listed on the Stock Exchange (with the criteria that there is ownership of 20% or more shares by family members). The significant positive results support the results of the research of

Kuttner and Feldbauer-Durstmuller, (2018) which says that family companies are distinguished by a close relationship between family and company so that it becomes important in bringing a good family name. In a case like this, any damage to the company's image will directly cause damage to the family's image. Therefore, maintaining the reputation of the company and family is an important role in decision making, including CSR involvement (Uhlaner et al., 2004). As well as previous research by Uhlaner et al. (2004) who interviewed 42 small and medium-sized family firms in the Netherlands, the study found that family firms named family exhibit more responsible environmental practices. That way, it can be said that if the company is able to implement CSD well, then not only the company's performance will increase, but also the company's image. Yeon, et al., 2021 showed that there were significant negative results on DER. This means that the higher the CSD disclosure, the lower the company's DER ratio will be. This study shows that the DER variable has a negative effect on CSD. This shows that the better CSD will increase the leverage owned by the company and is in accordance with the signal theory that has been described in the previous chapter. Signal theory states that the information disclosed in the CSD is a signal for investors and other parties to make economic decisions related to the company. In accordance with this theory, good profitability ratios and solvency ratios indicate good financial performance for the company. So with the results shown, the disclosure produces a positive reaction in the market, the disclosure has a positive influence and shows a good signal for especially for stakeholders.

The control variable in this study shows that FSize has a negative effect on ROA, ROE and FValue. However, the results are different on DER's financial performance, which shows that FSize has a significant positive effect. The results of this study support the research by Labelle, et.al., (2015) which found a positive correlation between firm size and DER. Labelle, et.al., (2015) argues that the larger the company, the better the company will manage its debt-to-equity ratio. The next control variable is Fage or firm age which produces a positive relationship on CFP and non-significant negative on DER and firm value. The results of this study are in line with research by Nimtrakoon (2015), which shows that company age has a positive correlation with company performance (CFP), this means that companies that have been around longer or mature can produce higher company performance. Nimtrakoon (2015) argues that mature companies have more mature experience to maintain company performance and sustainability. The size of the board of commissioners (BSize) on CFP gives mixed results of correlation with CSD. Positive results on ROA, ROE and FValue are based on previous studies. One of them, based on research by Esa and Ghazali (2012) and Susilo and Mildawati (2015) found that the size of the board of commissioners has a significant positive correlation with CSR and CFP disclosures. The size of the board of commissioners has a significant effect on CSR disclosure because a large board of commissioners is seen as an effective mechanism to increase information disclosure, and supports companies to have better company performance (operations). Meanwhile, the proportion of independent commissioners (Indcom) provides a significant positive correlation to CFP in this study. This can be because the independent commissioner is not an affiliated party of the company, so that in making decisions, the independent commissioner is neutral and prioritizes the interests of stakeholders, not just shareholders.

5. CONCLUSIONS

Business awareness of environmental sustainability drives better measurement of CSD with available financial reports. Based on the results it was found that CSD had a significant positive effect on the two proxies of financial performance that were used as research samples. This can be proven where the CSD model has an effect on financial performance as illustrated by the profitability ratios, namely ROA and ROE. In addition, CSD also has a significant effect on financial performance which describes the leverage ratio, namely DER. And lastly, CSD also significantly affects the value of the company represented by the FValue proxy. The results of the study show that family companies are more careful in preventing social concerns about potential damage to community constituents by paying attention to CSR disclosures and are proven to pay attention to the company's reputation in order to gain legitimacy in the social environment. It can be concluded that the results of this study are still varied to explain the relationship between the variables used. This study also still obtained insignificant results for several relationships between variables (especially control variables). Consideration of potential factors that can affect the relationship between CSR and CFP can still be done in the future.

Limitation and Further Research

The GRI Content Index can measure and facilitate companies in disclosing CSR performance, but this shows that this study relies on what companies report or voluntary disclosures, making it difficult to measure CSR performance accurately. The results of measuring CSR disclosure may also involve subjective assessments and are limited to the company's annual report or sustainability report. This study only measures and discusses in terms of CSR disclosure, but has not considered the cost factor incurred by the company in CSR disclosure. Finally, the CSR regulations in Indonesia state that this activity must be carried out for companies listed on the Indonesia Stock Exchange so that there is potential for regulatory bias in this study. Future research can also compare the performance of family and non-family companies for a deeper understanding. This research concentrates on the Indonesia Stock Exchange, so that further studies can be extended to emerging Asian markets and compare the results.

REFERENCES

Beck, C., Frost, G. & Jones, S. (2018). CSR disclosure and financial performance revisited: a cross-country analysis, *Australian Journal of Management*, 43(4), 517–537.

Brahmana, R. K., Setiawan, D & Hooy, C. W. (2019). Controlling shareholders and the effect of diversification on firm value: evidence from Indonesian listed firms, *Journal of Asia Business Studies*, 13(3), 362–383.

Campbell, J. L. (2004). *Institutional change and globalization.* Princeton, NJ: Princeton University Press.

De Massis, A., Kotlar, J., Campopiano, G., & Cassia, L. (2013). The impact of family involvement on SMEs' performance: Theory and evidence. Journal of Small Business Management.

Esa, E., Ghazali, N. A. M. (2012). Corporate Social Responsibility and Corporate Governance in Malaysian Government Linked Companies. *Corporate Governance: The International Journal of Business and Society,* 12(3), 292-305.

Feng, Y., Chen, H.H., & Tang, J. (2018). The impacts of social responsibility and ownership structure on sustainable fin

Fiori, G., Donato, F. D., and Izzo, M. F. (2007). Corporate social responsibility and firms performance: An analysis on italian listed companies. Working Paper Series.

Freedman, Martin dan Bikki Jaggi. (1988). An Analysis of The Association between Pollution Disclosure and Economic Performance. Accounting, Auditing and Accountability Journal, Vol. 1, No. 2, 43-58.

Freeman, R. E. (1984). *Strategic Management: a stakeholder approach*. Boston: Pitman.

Friedman, A. L., & Miles, S. (2006). Stakeholders: Theory and practice. New York: Oxford University Press

Ibrahim, N. A., & Angelidis, J. P. (1995). The corporate social responsiveness orientation of board members: Are there differences between inside and outside directors? Journal of Business Ethics, 14, 405–410.

Ibrahim, N. A., Howard, D. P., & Angelidis, J. P. (2003). Board members in the service industry: An empirical examination of the relationship between corporate social responsibility orientation and directorial type. Journal of Business Ethics, 47, 393–401.

Jo, H. & Harjoto, M. (2011). The Causal Effect of Corporate Governance on Corporate Social Responsibility. *Journal of Business Ethics*, 106(1), 53-72.

Kang, W. S., Kilgore, A., & Wright, S. (2011). The effectiveness of audit committees for low and mid-cap firms. Managerial Auditing Journal, 26(7), 623-650.

Kaur, R., & Dave, T. (2020). A Study on the Impact of Corporate Social Responsibility on Financial Performance of Companies in India. *Asia-Pacific Journal of Management Research and Innovation,*16 (3), pp. 229-237

Kuttner, M., & Feldbauer-Durstmuller, B. (2018). Corporate Social Responsibility in Family Firms - Status Quo and Future Directions. International Journal of Business Strategy, 18(1), 47–68.

Labelle, R., Hafsi, T., Francoeur., C & Ben Amar, W. (2018). Family Firms' Corporate Social Performance: A Calculated Quest for Socioemotional Wealth. *Journal of Business Ethics* 148 (3):511-525.

Lenz, I., Wetzel H. A., & Hammerschmidt, M. (2017). Can doing good lead to doing poorly? Firm value implications of CSR in the face of CSI. *Journal of the Academy Mark of Marketing Science.* 45, 677-697.

Lindblom, C. K. (1993). The Implications of Organisational *Legitimacy* for Corporate Social Performance and Disclosure. Conference Paper, Critical Perspectives on Accounting Conference, New York.

Liu, X. & Zhang, C. (2017). Corporate governance, social responsibility information disclosure, and enterprise value in China. *Journal of Cleaner Production*, 142, 1075-1084.

Long, R. G., & Mathews, K. M. (2011). Ethics in the family firms: Cohesion through reciprocity and exchange. Business Ethics Quarterly, 21(2), 287–308.

Matten, D., & Moon, J. (2004). Corporate Social Responsibility Education in Europe. *Journal of Business Ethics*, 54(4), 323-337.

Miller, D. T. (1999). The norm of self-interest. *American Psychologist, 54*(12), 1053–1060.

Moser, D. & Martin, P. (2012). A Broader Perspective on Corporate Social Responsibility Research in Accounting. The Accounting Review, 87(3), 797-806.

Niehm, L. S., Swinney, J., & Miller, N. J. (2008). Community social responsibility and its consequences for family business perfor- mance. Journal of Small Business Management, 46(3), 331–350.

Nimtrakoon, S. (2015). The relationship between intellectual capital, firms' market value and financial performance: Empirical evidence from the ASEAN. *Journal of Intellectual Capital*, *16*(3), 587–618. https://doi.org/10.1108/JIC-09-2014-0104

Porter, M.E. and Kramer, M.R. (2011) The Big Idea: Creating Shared Value. Harvard Business Review, 89, 2-17.

Scott, W. R. (2004). Institutional theory. *Encyclopedia of Social Theory,* George Ritzer, ed. Thousand Oaks, CA: Sage. Pp. 408-14

Suchman, M.C. (1995). Managing Legitimacy Strategic and Institutional Approaches. *Academy of Management Review*, 20, 571-610.

Susilo, S. M., Mildawati, T. (2015). Pengaruh Good Corporate Governance terhadap Luas Pengungkapan Corporate Social Responsibility, *Jurnal Ilmu & Riset Akuntansi,* 4(5).

Uhlaner, L., van Goor-Balk, H., Masurel, E. (2004). Family business and corporate social responsibility in a sample of Dutch firms. Journal of Small Business and Enterprise Development, 11, 186-194.

Waddock S. A. & Graves, S. B. (1997). The corporate social per- formance-financial performance link," *Strategic Management Journal*, 18(4), 303–319.

Wood, D. (1991). Social Issues in Management: Theory and Research in Corporate Social Performance. *Journal of Management*, 17(2), 383-406.

Zellweger, T. (2007). *Managing the Family Business: Theory and Practice*, Cheltenham, UK: Edward Elgar, 527.

FUNDAMENTAL ANALYSIS OF STOCK IN DETERMINING INVESTMENT DECISIONS ON MERGERS AND ACQUISITIONS COMPANY IN INDONESIA STOCK EXCHANGE USING THE FREE CASH FLOW TO EQUITY METHOD IN 2019 – 2021

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ABSTRACT

The purpose of this study is to determine the fundamental analysis of stocks in determining investment decisions on mergers and acquisitions company on the Indonesia Stock Exchange using the Free Cash Flow to Equity Method in 2019–2021. This study aims to determine the effect of the free cash flow to equity method on investment decisions in companies that have conducted mergers and acquisitions listed on the Indonesia Stock Exchange. The population of this study consists of six companies that have carried out mergers and acquisitions. In the sample tested, there are 18 stock intrinsic values calculated using the FCFE method in the period 2019–2021. This study uses a model to examine the relationship between intrinsic value and real stock prices. The Wilcoxon Signed Test is a nonparametric test used to measure the difference between two groups of paired data on an ordinal or interval scale, but the data is not normally distributed. The test results prove that stock fundamental analysis has an effect on investment decisions by using the free cash flow to equity method in companies that have made mergers and acquisitions.

Keywords: Investment Decision, Free Cash Flow to Equity Method, Mergers and Acquisitions.

1. INTRODUCTION

The capital market is one of several investment instruments that are in great demand by local and foreign communities, both individuals and corporations. One of the most popular instruments in the capital market is stocks. Shares according to Darmadji T (2001) are units of value or bookkeeping in various financial instruments that refer to the ownership share of a company. Investors who invest their funds in stocks, of course, have the same expectations if they are invested in other investment instruments, namely the expectation of a surplus/profit (profit) from the investment results. In 2020 there was also a phenomenon that the increase in the number of investors in the capital market as of 19 November 2020 had been recorded at 3.53 million. 5 This number has increased by 42 percent compared to December 31, 2019, which was 2.48 million. Based on KSEI's statistical data, the increase in the number of investors during this pandemic is dominated by domestic investors under the age of 30-40 years (millennials). Investors

are dominated by men with a percentage of 61.14 percent, private employees 52.91 percent, undergraduate graduates 44.4 percent, and having an income of IDR 10-100 million as much as 58.09 percent. Of course, investors expect to make the right decisions in determining investment decisions by predicting stock prices that will occur in the future. Therefore, we need an analytical method that can support the expectations of these investors. In addition, this analysis method is also useful for anticipating the possibilities that can occur, the intention is to use the stock analysis method, if the results of the stock valuation are positive.

There are 2 types of analytical methods that are often used in assessing stock prices. The first is technical analysis where investors analyze stock prices based on price trends that are formed (historical price). While the second is fundamental analysis, which is analyzing stocks based on the company's fundamental factors, such as the company's financial statements, the company's strength in the industry, etc. However, according to Manurung (2009), one way to invest in the IDX is to use a value strategy, namely investors have a very long view or invest in the long term. This view makes investors have to look for stocks that have value stocks. Therefore, with this view, a valuation method is needed to calculate the value of the stock, which aims to assist investors' investment decisions. Although the valuation method can calculate the value stock, it is necessary to test whether the valuation method can produce a valuation value that reflects the expectations of a stock. This test is carried out not to judge that the valuation method is incorrect or wrong, but rather to test the ability of the valuation method in estimating the fair price of shares on the IDX so as to minimize losses that may be suffered by investors.

Currently, there are several useful valuation methods to make it easier for investors to analyze stocks, one of which is the DCF (Discounted Cash Flow Model) approach. Therefore, in this paper the author tries to test the relevance of one of the stock valuation methods, namely by testing the Discounted Cash Flow Model (DCF) method with the Free Cash Flow to Equity (FCFE) valuation approach to stocks on the Indonesia Stock Exchange. The definition of FCFE according to Pinto (2020) is cash flow available to shareholders after all operating costs, interest and principal payments have been paid. In addition, the selection of the FCFE valuation model is because every company must have cash flow which is the result of the company's operational activities, both negative and positive cash flows. so that it better reflects the actual condition of the company. The purpose of writing this paper is to see whether the results of the valuation using the Free Cash Flow to Equity approach have explained the value of shares on the Indonesia Stock Exchange reflecting investors' expectations in determining investment decisions. The object of research in this paper are stocks listed on the Indonesia Stock Exchange. This was chosen, because the shares on the Indonesia Stock Exchange have high liquidity. The object of research in this paper are stocks listed on the Indonesia Stock Exchange. This was chosen, because the shares on the Indonesia Stock Exchange have high liquidity. The object of research in this paper are stocks listed on the Indonesia Stock Exchange. This was chosen, because the shares on the Indonesia Stock Exchange have high liquidity.

2. LITERATURE REVIEW

2.1 Merger and Acquisition

According to Donald M. DePamphilis (2019), companies need to expand or expand their business to achieve efficiency, increase competitiveness, and increase company profits. Mergers, acquisitions, or business combinations are forms of corporate restructuring. In the business world, especially in companies, the term M&A is a fairly well-known term. Merger is one of the company's strategies for the development and growth of the company. Companies in various sectors are merging and acquiring to survive in Indonesia's diverse economic climate. This is one

of the intensive efforts to improve the quality of the company, and is expected to improve business performance after the M&A. Merger is a legal action taken by one or more PTs to merge with another existing PT, after which the merging PTs will be dissolved (Donald M. DePamphilis (2019). Acquisition, on the other hand, is the acquisition of ownership or operational control (Donald M. DePamphilis (2019). Donald M. DePamphilis (2019) states that mergers and acquisitions can be carried out from the perspective of corporate finance and strategic management. From the financial side of a business, M&A is a form of long-term investment decision (capital budget) that need to be considered and analyzed from the perspective of business feasibility. On the other hand, from the perspective of strategic management, mergers and acquisitions are alternative growth strategies through external channels to achieve company goals.

2.2 Fundamental Analysis

In analyzing and assessing stocks in the capital market in general, there are two approaches that are often used by investors, namely fundamental analysis and technical analysis. However, on this research will be conducted using fundamental analysis techniques. Fundamental analysis according to Bodie (2005) is a study of the economy, industry, and company conditions to take into account the value of the company. Fundamental analysis focuses on key data in the company's financial statements to calculate whether stock prices have appreciated accurately. The purpose of fundamental analysis is to determine whether the stock value is underpriced or overpriced. Stocks are said to be underpriced if the stock price in the stock market is less than the fair price or the value it should have (intrinsic value) and the stock is said to be overpriced if the stock price in the stock market is greater than its intrinsic value.

2.3 *Discounted Cash Flow* (DCF)

Damodaran (2015) states that in discounted cash flow valuation, the value of an asset is the current value of the cash flows that will be generated by the asset in the future, discounted at an interest rate that reflects the risk of the asset. This is done because the value of cash flows received in the future is different from the present due to changes in currency values. There are several discount methods that are often used, namely Free Cash Flow to Firm (FCFF) and Free Cash Flow to Equity (FCFE). Valuation using FCFF measures the value of the company, including owners of other claims in the company such as bondholders, but is not as specific as FCFE, where the valuation is carried out only to measure the value of the company in terms of equity, so that it can assess whether the equity is valued by the market as overvalued or undervalued. This study will only discuss the Free Cash Flow to Equity (FCFE) method.

2.4 Free Cash Flow to Equity (FCFE)

According to Damodaran (2015), FCFE is the amount of cash that can be paid by a company to shareholders after deducting all expenses, reinvestment, and debt payments. FCFE is calculated by subtracting net income from investment requirements and adding up all non-cash transactions such as depreciation, then subtracting non-cash working capital and adding net cash from debt issuance. There are 2 approaches to calculating the FCFE value, namely the approach through equity earnings and the approach through operating income. In calculating the FCFE model, it is necessary to calculate growth. In this study, the growth calculation used is Constant Growth. This method, according to Damodaran (2015), is intended to assess companies with a stable level of company growth expectations. Constant growth can be calculated by two approaches, including equity earnings and operating income.

3. METHODS

3.1. Data

The population of this study are 6 companies that have carried out mergers and acquisitions that have been listed on the Indonesia Stock Exchange until January 29, 2022. In the sampling process using the purposive sampling method, the sample criteria are as follows:

- Merger and acquisition companies that have been listed on the IDX/IDX until December 2021.
- Companies that are included in the JCI index for the period 2019 – 2021 (Source: the official website of the Indonesia Stock Exchange)
- Companies that have complete financial reports and have submitted them to the stock exchange every year (from 2018 to 2021).
- Companies that have complete data on stock price movements on the stock exchange from January 2018 – December 2021.

3.2. Data Types and Sources

The type of data used in this research is secondary data. The data is sourced from:

- Corporate actions and financial reports of issuers from 2018 to 2021 issued by the Indonesia Stock Exchange from the official IDX website (www.idx.co.id).
- Monthly stock price movement data from January 2018 to December 2021 from the IDX's official website (www.idx.co.id)
- Looking for weekly SBI data obtained from the official website of Bank Indonesia (www.bi.go.id)
- The data used is data between sample companies from a certain period of time (cross section).
- If the sample company's financial statements use foreign currency values, it must converted into Rupiah currency.

3.3 Intrinsic Value of Stocks

In this study, before determining whether the stock valuation method can explain stock prices on the Indonesia Stock Exchange or not, the intrinsic value of the shares must first be calculated. Finding Intrinsic Value with Free Cash Flow to Equity (FCFE), to use the FCFE method, we must first have data on sample company financial statements from 2018 to 2021. The assumptions in calculating the FCFE value are as follows:

- To calculate the 2021 FCFE value, the 2020 FCFE value is used which is calculated based on the real financial report data in 2020.
- Finding the beta value from January 2018 to December 2021.
- Calculation of FCFE in 2021 using the constant growth method, namely the value of growth is considered to be constant in 2021 and so on which is calculated using the average value of growth from 2018 to 2021.
- The cost of equity (Ke) is calculated using the Capital Asset Pricing Model (CAPM) approach with the assumption that the market risk premium value is the difference between the IHSG expected return and the risk free rate (the rate of SBI auction results).

Based on the data obtained, many companies do not consistently distribute dividends, so the operating income approach is considered more appropriate in calculating the company's FCFE growth value.

FCFE = EBIT (1-Tax rate) – Interest Exp (1-Tax rate) – Capital Expenditure + Depreciation - Non Cash Working Capital + (Debt Repayments – New Debt Issued)

Then in this study, to calculate the FCFE value using the Constant Growth Model approach (fixed growth model).

$$Po = FCFE1 / (To – gn)$$

Po : Current stock price
FCFE1 : Expected year-end FCFE per share
To : Cost of equity of the company
gn : Company FCFE growth rate

3.4 Cost of Equity

In this study we also need to calculate the cost of equity (Ke). To calculate this value, the CAPM model approach is used, namely:

$$Ke = Rf + Equity\ Beta\ [E(Rm) – Rf]$$

Rf is the Risk Free Rate
E(Rm) is the expected return on market index

3.5 Calculation of Growth (g)

In evaluating FCFE, forecasting techniques are needed to predict future valuations. Therefore, a growth value is needed to calculate the company's FCFE value. There are several ways to find the growth value, but in this paper the FCFE growth value search is based on the FCFE model through the operating income (EBIT) approach.

According to Damodaran (2015) there are 3 (three) ways to look for growth value through the operating income (EBIT) approach based on fundamental factors, but the first is based on ROC and net income values. The ROC value can be calculated using the following formula:

$$ROC = EBITt\ (1 - Tax\ rate) / (BV\ of\ Debt + BV\ of\ Equity)$$

ROC : Return on capital
EBIT : Earning before interest & tax
BV of Debt : Book value of debt
BV of Equity : Book value of equity

3.6 Data Testing Method

In this study, a test was conducted on the results of the valuation (intrinsic value) with the stock price formed on the stock exchange. For this reason, the test model used is:

a) Wilcoxon Test Test

This method is used to find the relationship between intrinsic value and stock prices on the stock exchange. In this study, the variables used in this statistical test are as follows:

- Dependent Variable (Y)

In this study, the dependent variable used is stock price. The share price data that will be used is the closing price as of December 31, 2021, December 31, 2020, December 31, 2019.

- Independent Variable (X)

In this study, the independent variable used is the intrinsic value of the stock which is estimated using the FCFE method.

3.7 Statistical Test and Research Hypothesis

In this study, the test will be carried out using SPSS software. The hypotheses used in this study are as follows:

- Ho: There is no significant relationship between the intrinsic value of the stock and the stock price of companies formed on the stock exchange.
- Ha: There is a significant relationship between the intrinsic value of the stock and the stock price of the company formed on the stock exchange.

The hypothetical mathematical equations used are as follows:

- Ho ; b = 0 (There is no significant relationship between the intrinsic value of the stock and the stock price formed on the stock exchange)
- Ha : b > 0 (There is a significant relationship between the intrinsic value of the stock and the stock price formed on the stock exchange)

The level of significance (α) in this study was 5%. If the statistical test results indicate that Ho is accepted (if the Wilcoxon test results show Asymp.Sig (2-Tailed) > 0.05), then the intrinsic value generated from the FCFE valuation method cannot explain stock prices on the stock exchange. Vice versa, if the results of the statistical test show that Ho is rejected (if the Wilcoxon test results show Asymp.Sig (2-Tailed) < 0.05) which means Ha is accepted, then the intrinsic value generated from the FCFE valuation method can explain stock prices in Indonesia. exchange.

4. RESULTS

4.1 Calculation of Intrinsic Value

The process carried out in calculating the intrinsic value is:

1. Beta value of sample company
2. Value of cost of equity sample company
3. The FCFE growth value of the sample companies
4. Projected FCFE value

Table 1. Sample Stock Beta Value

No	Saham	Nama Perusahaan	Beta	Nilai Sig.
1	SRAJ	PT. Sejahteraraya Anugrahjaya, Tbk	0,4	0
2	INDR	PT. Indo-Rama Synthetics, Tbk	1,06	0
3	TURI	PT. Tunas Ridean, Tbk	-0,02	0
4	JSMR	PT. Jasa Marga (Persero), Tbk	1,62	0
5	ANTM	PT. Aneka Tambang, Tbk	2,6	0
6	ASII	PT. Astra International, Tbk	1,28	0

Viewed from table 1, it can be seen that the stock that has the highest beta is ANTM stock with a beta of 2.6, and the lowest beta is SRAJ stock with a beta of 0.4, and there is a negative beta, namely TURI stock with a beta of-0.02. Judging from the results of the beta value of the

shares, it can be concluded that ANTM's shares are the most sensitive shares compared to other shares, SRAJ's shares are the least sensitive shares, and there is a share price that is inversely proportional to the market index of TURI shares.

Table 2. *Cost of Equity* (K_e)

No	Saham	Cost of Equity	Beta
1	SRAJ	6,74%	0,4
2	INDR	12,09%	1,06
3	TURI	3,34%	-0,02
4	JSMR	16,62%	1,62
5	ANTM	24,56%	2,6
6	ASII	13,87%	1,28

From table 2, it can be seen that the greater the beta value of a stock, the greater the cost of equity of the stock. Therefore, it can be concluded that the highest cost of equity value is ANTM, which is 24.56% with a beta value of 2.6, and the lowest is TURI, which is 3.34% with a beta value of -0. 02.

Table 3. *Return on Capital* (ROC) 2018 – 2021

No	Saham	ROC			
		2021	2020	2019	2018
1	SRAJ	4%	0%	-2%	-4%
2	INDR	12%	1%	6%	10%
3	TURI	10%	2%	11%	11%
4	JSMR	2%	1%	5%	5%
5	ANTM	9%	5%	2%	5%
6	ASII	11%	8%	11%	13%

Return on Capital (ROC) Is the company's rate of return on the company's liabilities value.

Table 4. *Reinvestment Rate* 2019 – 2021

No	Saham	Reinvestment Rate			
		2021	2020	2019	
1	SRAJ	-150%	4192%	-186%	
2	INDR	38%	484%	82%	
3	TURI	53%	51%	17%	
4	JSMR	135%	3711%	-336%	
5	ANTM	146%	-1%	202%	
6	ASII	41%	115%	67%	

Reinvestment Rate is the level of the company's ability to develop its business based on company profits.

The growth calculation used is the average growth value from 2019 to 2021. The following is the growth value of the 2019-2021 average growth which is used to calculate the FCFE projection

Table 5. *Growth* (g) FCFE

No	Saham	Growth		
		2021	2020	2019
1	SRAJ	-6%	0%	4%
2	INDR	5%	4%	5%
3	TURI	5%	1%	2%
4	JSMR	3%	24%	-16%
5	ANTM	12%	0%	4%
6	ASII	5%	9%	8%

After calculating the constant growth value for the FCFE calculation, then calculating the FCFE value which is the basis for projections for the 2019 – 2021 FCFE. After calculating, the FCFE value in 2019 – 2021 is as follows:

Table 6. FCFE 2019 – 2021

No	Saham	FCFE 2021
1	SRAJ	-463.797.497
2	INDR	13.453.400.211
3	TURI	1.327.652.405
4	JSMR	2.037.869.927
5	ANTM	16.138.287.769
6	ASII	103.026.169.473

No	Saham	FCFE 2020
1	SRAJ	738.926.321
2	INDR	12.515.045.605
3	TURI	632.822.392
4	JSMR	46.747.423.136
5	ANTM	6.927.285.313
6	ASII	84.855.024.735

No	Saham	FCFE 2019
1	SRAJ	248.125.621
2	INDR	13.161.278.356
3	TURI	711.703.474
4	JSMR	21.887.734.564
5	ANTM	7.589.816.170
6	ASII	116.217.809.044

After all the supporting factors to calculate the intrinsic value of the stock are calculated, the following are the data used to find the intrinsic value:

Table 7. Projection Base Parameters

No	Saham	FCFE 2021	Cost of Equity (Ke)	Growth (g)	(Ke-g)
1	SRAJ	-494.679.151	6,74%	-6%	12,98%
2	INDR	12.863.869.447	12,09%	5%	7,50%
3	TURI	1.263.110.880	3,34%	5%	-1,77%
4	JSMR	1.986.873.280	16,62%	3%	14,06%
5	ANTM	14.352.587.715	24,56%	12%	12,12%
6	ASII	98.483.000.000	13,87%	5%	9,25%

No	Saham	FCFE 2020	Cost of Equity (Ke)	Growth (g)	(Ke-g)
1	SRAJ	737.407.508	6,74%	0%	6,53%
2	INDR	11.988.713.772	12,09%	4%	7,70%
3	TURI	626.550.360	3,34%	1%	2,34%
4	JSMR	37.684.360.160	16,62%	24%	-7,43%
5	ANTM	6.931.423.801	24,56%	0%	24,62%
6	ASII	77.970.520.000	13,87%	9%	5,04%

No	Saham	FCFE 2019	Cost of Equity (Ke)	Growth (g)	(Ke-g)
1	SRAJ	237.644.337	6,74%	4%	2,33%
2	INDR	12.534.212.574	12,09%	5%	7,08%
3	TURI	699.176.760	3,34%	2%	1,55%
4	JSMR	26.046.646.080	16,62%	-16%	32,59%
5	ANTM	7.299.279.843	24,56%	4%	20,58%
6	ASII	107.912.880.000	13,87%	8%	6,17%

After getting the FCFE value for 2019 – 2021 and the components for calculating the intrinsic value, then the data is processed to get the intrinsic value for each sample stock.

Table 8. Stock Intrinsic Value

No	Saham	FCFE 2021	(Ke-g)	Po (Nilai Intrinsik)	Po (Nilai Intrinsik)
1	SRAJ	-463.797.497	12,98%	-3.572.409.371	-3.572.409.371.313
2	INDR	13.453.400.211	7,50%	179.303.161.994	179.303.161.994.470
3	TURI	1.327.652.405	-1,77%	-74.935.469.756	-74.935.469.755.580
4	JSMR	2.037.869.927	14,06%	14.498.920.636	14.498.920.636.432
5	ANTM	16.138.287.769	12,12%	133.172.420.825	133.172.420.824.790
6	ASII	103.026.169.473	9,25%	1.113.212.859.273	1.113.212.859.272.540

No	Saham	FCFE 2020	(Ke-g)	Po (Nilai Intrinsik)	Po (Nilai Intrinsik)
1	SRAJ	738.926.321	6,53%	11.308.885.032	11.308.885.032.112
2	INDR	12.515.045.605	7,70%	162.622.347.932	162.622.347.931.685
3	TURI	632.822.392	2,34%	27.078.894.012	27.078.894.011.880
4	JSMR	46.747.423.136	-7,43%	-629.346.410.484	-629.346.410.483.892
5	ANTM	6.927.285.313	24,62%	28.137.156.730	28.137.156.730.400
6	ASII	84.855.024.735	5,04%	1.684.174.544.954	1.684.174.544.953.930

No	Saham	FCFE 2019	(Ke-g)	Po (Nilai Intrinsik)	Po (Nilai Intrinsik)
1	SRAJ	248.125.621	2,33%	10.651.416.549	10.651.416.549.196
2	INDR	13.161.278.356	7,08%	185.810.658.300	185.810.658.300.367
3	TURI	711.703.474	1,55%	46.024.365.032	46.024.365.031.795
4	JSMR	21.887.734.564	32,59%	67.162.607.942	67.162.607.942.341
5	ANTM	7.589.816.170	20,58%	36.880.186.733	36.880.186.733.326
6	ASII	116.217.809.044	6,17%	1.882.971.530.767	1.882.971.530.767.270

Then how to calculate the intrinsic value is divided by the number of shares outstanding based on the sample company. The intrinsic value per share is obtained after dividing by the number of shares outstanding and then compared with the market price of the shares. The stock price data used is the closing price on every December 31.

Table 9. Intrinsic Value of Shares Per Share

No	Saham	Po (Nilai Intrinsik)	Jumlah Saham Per Lembar	Nilai Intrinsik Per Lembar	Harga Per 31 Desember 2021	Overvalued / Undervalued
1	SRAJ	-3.572.409.371.313	12.000.705.445	-298	310	Overvalued
2	INDR	179.303.161.994.470	65.435.200.000	2.740	4180	Overvalued
3	TURI	-74.935.469.755.580	55.800.000.000	-1.343	1300	Overvalued
4	JSMR	14.498.920.636.432	72.578.710.000	200	3890	Overvalued
5	ANTM	133.172.420.824.790	24.030.760.000	5.542	2250	Undervalued
6	ASII	1.113.212.859.272.540	404.835.531.400	2.750	5700	Overvalued
1	SRAJ	11.308.885.032.112	12.000.705.445	942	204	Undervalued
2	INDR	162.622.347.931.685	65.435.200.000	2.485	3050	Overvalued
3	TURI	27.078.894.011.880	55.800.000.000	485	1300	Overvalued
4	JSMR	-629.346.410.483.892	72.578.710.000	-8.671	4630	Overvalued
5	ANTM	28.137.156.730.400	24.030.760.000	1.171	1935	Overvalued
6	ASII	1.684.174.544.953.930	404.835.531.400	4.160	6025	Overvalued
1	SRAJ	10.651.416.549.196	12.000.705.445	888	268	Undervalued
2	INDR	185.810.658.300.367	65.435.200.000	2.840	2430	Undervalued
3	TURI	46.024.365.031.795	55.800.000.000	825	900	Overvalued
4	JSMR	67.162.607.942.341	72.578.710.000	925	5175	Overvalued
5	ANTM	36.880.186.733.326	24.030.760.000	1.535	840	Undervalued
6	ASII	1.882.971.530.767.270	404.835.531.400	4.651	6925	Overvalued

4.2 Statistical Test

This statistical test was carried out to test how big and significant the FCFE valuation method is in estimating the stock prices of companies conducting mergers and acquisitions, whether the FCFE method can still be used for stock valuation in IDX.

Tabel 10. *Ranks Test*

Wilcoxon Signed Ranks Test

Ranks

		N	Mean Rank	Sum of Ranks
Nilai Intrinsik Saham - Harga Pasar	Negative Ranks	5[a]	7.00	35.00
	Positive Ranks	13[b]	10.46	136.00
	Ties	0[c]		
	Total	18		

After looking at the results of the Ranks Test above, it can be concluded that the Negative Ranks show that there is a negative difference between the Stock Price on December 31, 2021 and the Intrinsic Value of the Shares calculated by the FCFE method. The value in column N shows the number of Stock Prices December 31, 2021 Undervalued. Positive Ranks shows the positive difference between the Stock Price on December 31, 2021 and the Intrinsic Value of the Shares calculated using the FCFE method. The value in column N shows the amount of Stock Price December 31, 2021 Overvalued. Ties shows the similarity in value between the Share Price on December 31, 2021 and the Intrinsic Value of the Shares calculated using the FCFE method, in the results of this test, there is no Fairvalued Share Price on December 31, 2021.

Tabel 11. Test Statistics

Test Statistics[a]

	Nilai Intrinsik Saham - Harga Pasar
Z	-2.199[b]
Asymp. Sig. (2-tailed)	.028

a. Wilcoxon Signed Ranks Test

b. Based on negative ranks.

Based on the output above, it is known that Asymp.Sig. (2-Tailed) is 0.028, so the hypothesis used in this Wilcoxon test is "there is no linear relationship between the intrinsic value of the stock calculated by the FCFE formula and the stock price formed on the stock exchange. "From the statistical results above, it can be concluded that the null hypothesis is rejected, which means that there is a relationship between the intrinsic value of the shares calculated by the FCFE formula and the stock price formed on the stock exchange.

From the results of statistical tests, it can be concluded that the analysis model using the Free Cash Flow to Equity (FCFE) approach can still be used in analyzing the intrinsic value of shares in IDX.

5. CONCLUSIONS

5.1 Conclusion

Based on the results of the analysis and discussion above, several conclusions can be drawn, namely:

- The calculation of the intrinsic value of shares carried out from 18 stocks sampled using the free cash flow to equity (FCFE) Constant Growth Model method resulted in 15 overvalued shares and 3 undervalued shares from 6 companies calculated in the period 2019 - 2021
- The results of statistical testing using the Wilcoxon Test with the null hypothesis "there is no significant relationship between intrinsic value and stock prices formed on the stock exchange", are as follows

Based on the output above, it is known that Asymp.Sig. (2-Tailed) is 0.028, so the hypothesis used in this Wilcoxon test is "there is no linear relationship between the intrinsic value of the stock calculated by the FCFE formula and the stock price formed on the stock exchange. "From the statistical results above, it can be concluded that the null hypothesis is rejected, which means that there is a relationship between the intrinsic value of the shares calculated by the FCFE formula and the stock price formed on the stock exchange.

In this study, we can show the relevance of using the constant growth model to explain the stock price of companies that have been merged or acquired using the Free Cash Flow to Equity (FCFE) method, which has insights from the research that can be used on the Indonesia Stock Exchange. For investors, this FCFE valuation method can also be used to calculate the intrinsic value of company shares resulting from a merger or acquisition. For companies, the FCFE valuation method can also be used to determine stock prices at the time of mergers, acquisitions, and publications of a company. For academics, this research can provide a basis for explaining and applying the FCFE valuation method in analyzing stocks with stock fundamental analysis.

REFERENCES

Becker, D.M. (2022). Getting the valuation formulas right when it comes to annuities. *Managerial Finance 48(3)*, pp. 470-499

Bodie, Zvi; Kane, Alex; Marcus, Alan J. (2005). *Investment*. Singapore: McGraw- Hill.

Damodaran, Aswath. (2015). *Investment Valuation*, New York: John Wiley & Sons, Inc.

DePamphilis, M., Donald. (2019). Mergers, Acquisitions, and Other Restructuring Activities An *Integrated Approach to Process, Tools, Cases, and Solutions (10th edition)*, London: Elsevier, Inc.

Gregory, R.P. (2022). ESG activities and firm cash flow. Global Finance Journal 52,100698

Ivanovska, Nadica. (2014). Fundamental Analysis And Discounted Free Cash Flow *Valuation Of Stocks At Macedonian Stock Exchange*

Jezkova, V., Rowland, Z., Machova, V., Hejda, J. (2020). ` The intrinsic value of an enterprise determined by means of the fcfe tool. *Sustainability (Switzerland) 12(21),8868*, pp. 1-13

Pinto, Jerald E., Elaine, Henry., Robinson, Thomas R., & Stowe, John D. 2020. *Equity Asset Valuation (4th edition)*. New Jersey: John Wiley & Sons, Inc.

RISK MANAGEMENT PLANNING PROCUREMENT OF PARTS AND MATERIALS AT PT X

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ABSTRACT

PT X is a global industrial manufacturing company in automotive sector, its head office located in Japan and various branch companies spread throughout the world. PT X has a Procurement department whose function to maintain supply chain well, but in recent years there have been many disasters and pandemics, such as the earthquake in Japan, floods in Thailand, Covid-19 and in several other places, causing supply chain problems and PT X is aware of the risks that will occur in the future. PT X has never done a thorough risk identification and determined a strategic plan for risk mitigation. Risk identification in procurement from suppliers (upstream) uses the House of Risk (HOR) model for risk management which consists of 2 phases. The first phase is risk identification for risk events (RE) and risk agents (RA) are identified and the severity and occurrence levels are measure and the Aggregate Risk Potential (ARP) is calculated. The second phase is risk management. This research is expected to help PT X to minimize risks and potential risks and ensure the supply chain runs well. From the results of the HOR analysis stage 1 through interviews and discussions, scoring was carried out on each risk event, namely as many as 59 identified risk events including planning, purchasing processes, production & control processes, delivery processes, and the process of returning goods to suppliers. By using the Pareto diagram, 7 potential risk agents (risk agents) must be carried out and prevention must be carried out by evaluating the HOR stage 2 obtained 11 preventive actions (PA) and 8 preventive actions (PA) as priorities that will be recommended to control risks that will occur by taking several general countermeasures, namely improving forecasting, improving internal and external communications, and suppliers monitoring.

Keywords: *Keywords: Risk Management, Procurement, Mitigation Strategy, Risk Analysis, Automotive Manufacturing.*

1. INTRODUCTION

Service company or manufacturing company has a supply chain system which is a series of activities between companies and suppliers to produce and distribute certain products to final customer.

In carrying out its business processes, the procurement department is responsible for ensuring that the supply chain process from suppliers to inventory runs well. Suppliers owned by PT X are spread across the country and abroad with a percentage of 50% (local) and 50% (imported). Various kinds of goods (parts) and raw materials are a priority in procurement. In the process, the procurement department also faces various types of risks and causes of risk in the supply chain, such as disasters that have occurred, namely earthquakes in several countries, factory fires, floods, and the current Covid pandemic. Until now, PT X is aware that it has not carried out a thorough

risk identification and risk management to address the risks that may occur, due to several incidents related to the company's operations that were previously unexpected and sometimes could harm the company.

This study aims to identify risks, then evaluate and determine a strategic plan to mitigate the risks that occur in PT X. The benefits to be obtained from this research to help PT X to identify risks from disturbances that occur and mitigation plan strategies for existing risks to achieve company goals.

2. LITERATURE REVIEW

Pujawan & Mahendrawati (2010) describe the general steps for purchasing goods on a regular basis that planning for the procurement of inventory (stock/inventory) is carried out by the Material Planning section by evaluating the needs and inventory positions on a daily, weekly, and monthly basis. The planning includes the type of goods, the number of goods, the position (level) of inventory, the estimated time the inventory will run out, and the estimated time of the procurement process until the goods arrive at the warehouse (procurement lead time). The next process is to send a Purchase Requisition (PR) document to the Procurement section for the procurement process.

In carrying out any activity to achieve a goal, one must be faced with uncertainty that has an impact on the achievement of the goal. Risk is a state of uncertainty in which some of the possibilities involve loss, injury, disaster, or an undesired outcome (Erkoyuncu, Apa, & Roy, 2015).

Risk management is a process that takes into account all meaningful activities and it can be said that sometimes people start to decide, plan and carry out certain activities as individuals or the wider community (Alexic, Jeremic, Stefanovic, & Dapan, 2009).

In the risk management process according to SNI 31000: 2011, there are several stages or processes which include setting a context, risk identification, risk analysis, risk evaluation, risk treatment, monitoring and review. The following is the risk management process can be shown in the picture

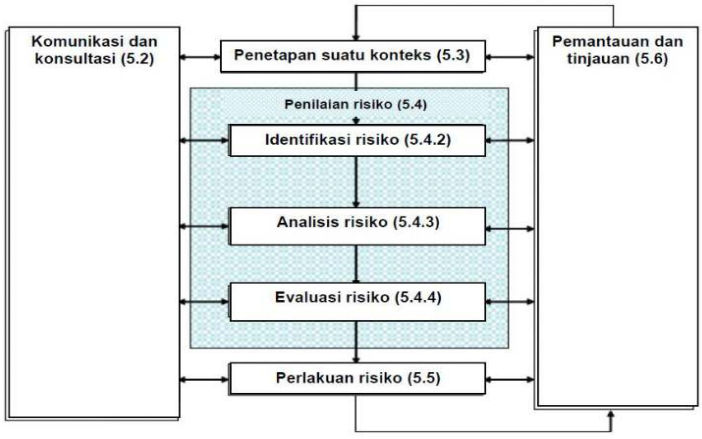


Figure 1 Risk Management Process (Source: SNI ISO 31000:2011)

Risk management is a decision about risk and its subsequent implementation derived from risk estimation and risk assessment (Normain & Jansson, 2004). Risk management is usually described by identifying and analyzing risks and controlling them (Thun & Hoenig, 2011).

There are 5 cycles in risk management, namely risk identification, risk measurement, risk mapping, risk management model, risk monitoring and control (Djohanputro, 2008).
HOR is a modification of the FMEA (Failure Modes and Effects of Analysis) and the quality house model (HOQ) to prioritize which risk sources are first selected for the most effective action to be taken in order to reduce the potential risk from the risk source. House of Risk is a model based on the need for risk management that focuses on preventive measures to determine which risk causes are a priority which will then be given mitigation or risk management actions (Pujawan & Geraldin, 2009). The advantage of FMEA (Failure Mode and Effect Analysis) is an analytical tool that can evaluate reliability by checking the failure mode and is one of the systematic techniques for analyzing failures.
HOR step 1, the identification of risks that may occur in each business process is carried out. This stage can be started by mapping each stage of the business process.

Business Proscesses	Risk Event (Ei)	Risk Agent (Aj) A1	A2	A3	A4	A5	Severity of Risk Event i(Si)
Plan	E1	R11	R12	R13			S1
Source	E2	R21	R22				S2
Make	E3	R31					S3
Deliver	E4	R41					S4
Return	E5						S5
Occurance of agent j		O1	O2	O3	O4	O5	
Aggregate risk potential j		ARP1	ARP2	ARP3	ARP4	ARP5	
Priority rank of agent j							

Figure 2 HOR step 1 (Source: Geraldin et al., 2009)

HOR step 2 focuses on determining what is the most appropriate step to take first by considering the effectiveness of the resources used and the level of performance of the object or project involved.

	Preventive Action (PAk)					
To be treated risk management	PA1	PA2	PA3	PA4	PA5	Agregate Risk Potential (ARPj)
A1	E11	E12	E13			ARP1
A2	E21	E22				ARP2
A3	E31					ARP3
A4						ARP4
A5					Ejk	ARP5
Total Effectiveness of action k	TE1	TE2	TE3	TE4	TE5	
Degree of difficulty performing action k	D1	D2	D3	D4	D5	
Effectiveness to dificullty ratio	ETD1	ETD2	ETD3	ETD4	ETD5	
Rank of priority	R1	R2	R3	R4	R5	

Figure 2 HOR step 2 (Source: Geraldin et al., 2009)

Heizer and Render (2014:255), Pareto Diagram (Pareto Analysis) is a method for managing errors, problems for defects to help focus attention on problem solving efforts. This diagram is based on the work of Vilfredo Pareto, an economist in the 19th century Joseph M. Juran popularized Pareto's work by stating that 80% of a company's problems are the result of only 20% of causes.

Besterfield (2009:78), this Pareto chart is an illustration that sorts the classification of data from left to right according to the order of highest to lowest ranking.

3. METHODS

This chapter will explain the sequence of research that begins in the business process in the procurement section, data collection, data processing, analysis, evaluation, and begins risk mitigation in the procurement section as well as conclusions and suggestions.

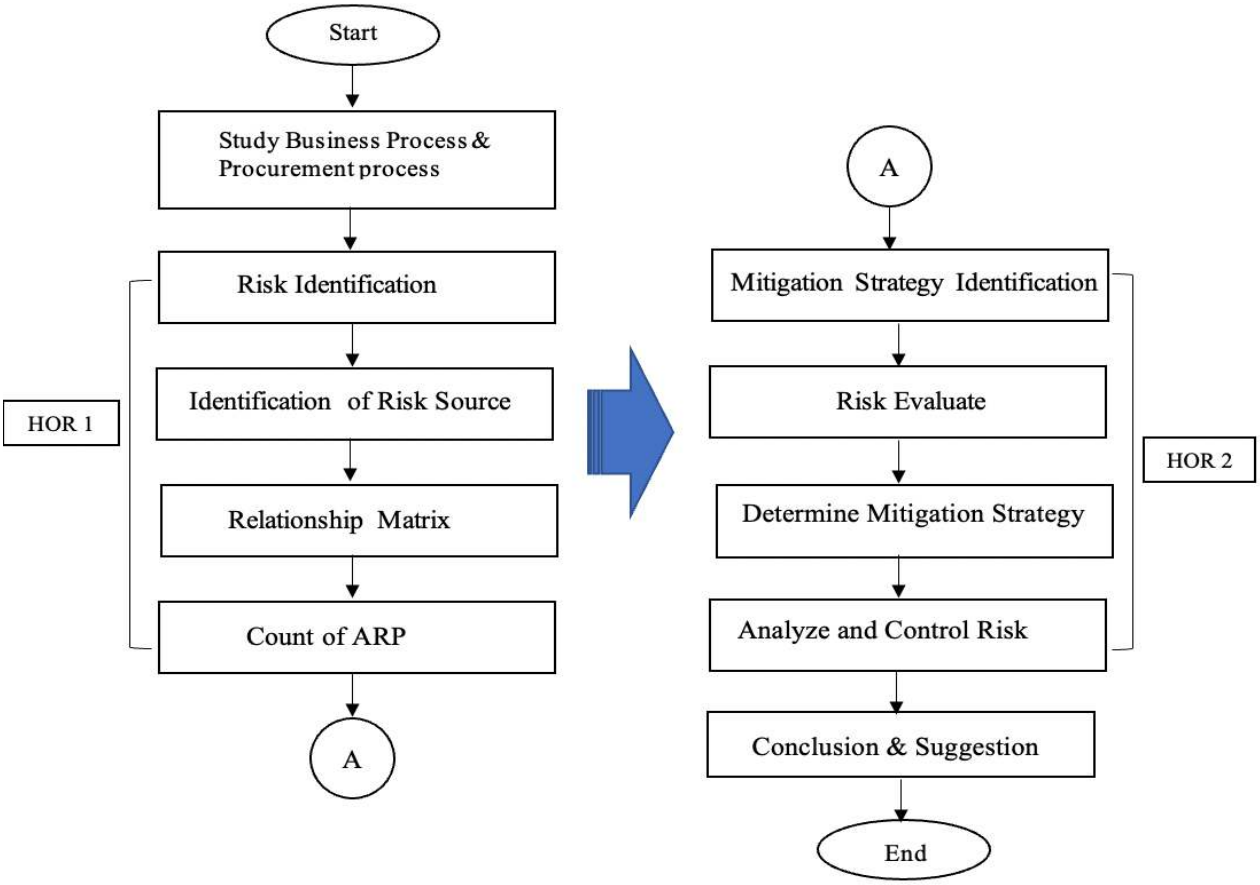


Figure 1. Flowchart

Studying business processes in the procurement and Procurement Process. In this section, a field study is conducted on the condition of the company in the procurement department related to Supply Chain, starting from the process of procuring goods and materials from suppliers and ensuring that goods and materials arrive at their place properly and correctly.

Risk identification and source, use the House of Risk (HOR) method, which is the risk that is identified from risk events in the procurement department such as abnormal conditions that have occurred at PT X, identification of business processes follows the method of determining SCOR, by adopting five management processes: Plan, Source, Make, Deliver and Return.

Step for HOR 1 is identifying the risk, then the identification of the risk trigger (risk agent) is carried out. This identification is to find out what factors can cause risk events to occur by interview or discussion activity. Target respondent from Manager several section such as Production Control, Quality, Procurement, Logistic, Marketing in supplier.

Risk evaluation aims to determine the selection of risk agents from the highest priority level based on the results from phase 1 (HOR) to phase 2 (HOR). From these results will produce a priority order of risk which is given a predetermined score or assessment, namely from large until low.

Mitigation strategy, to determine a mitigation strategy, it is identified from actions that are considered relevant or related to reducing risk triggers (risk agents). For one risk trigger variable (risk agent) more than one action can be taken to mitigate the risk that will occur.

Risk control and analyzed, at this stage the data that has been collected is then analyzed further so that conclusions can be drawn that can answer the objectives of conducting risk management research in the procurement section of PT X.

Risk control is carried out periodically, i.e. risk monitoring and review must be carried out at time intervals as determined by the company.

4. RESULTS

The determination of risk events is adjusted to conditions that often occur during a pandemic and then extends to daily problems and those that often occur before the pandemic so that each sub-process has risk events that arise during a pandemic and daily risk events that arise. before the pandemic

The risk identification process is carried out through interview discussions with several respondents, namely the Procurement manager, Production Control & Inventory Manager, Quality Control Manager related to the procurement of goods. There were 59 risks identified at PT X from several sub-processes as below.

Table 1 Business Process and Sub Process (SCOR)

Business process	Sub-Process
Plan	Forecasting planning
	Inventory
Source	Ordering process
	Supplier evaluation & development
Make	Control production and process
	Inventory, packaging, and inspection process
Delivery	Delivery preparation
	Delivery process
Return	Good return
	Administration and documentation

Determination of Risk Agent is carried out by interviewing several managers of related divisions (Procurement, Production Control and Engineering) and then 21 causes of risk are found, starting from the planning process, receiving process, and the process of delivering goods to customers. Where one cause of risk (Risk Agent) can cause one or more risk events (Risk Event).

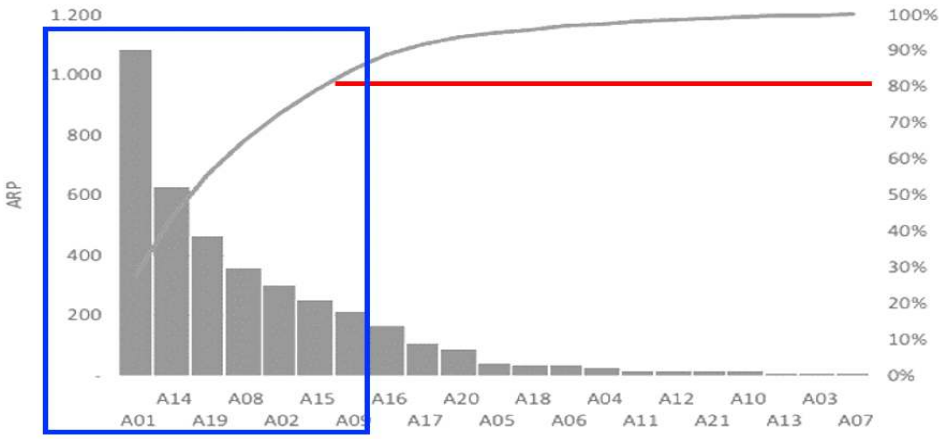


Figure 2. Pareto Diagram for Risk Agent

From the results of the discussion, it was agreed that as many as 80% of all risk agents or as many as 7 risk agents could potentially trigger risk events with the greatest impact as shown in the following Pareto diagram.

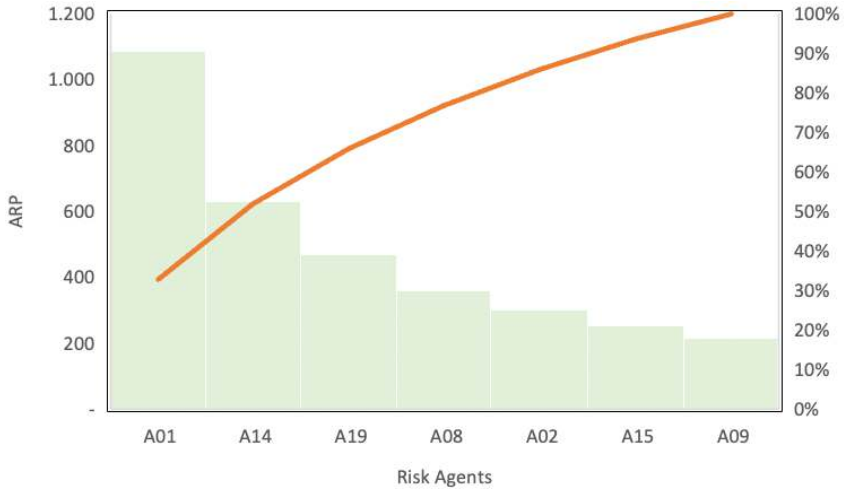


Figure 3. Diagram Pareto for Risk Agent Priority

Furthermore, after the selection of risk agents is the identification of preventive actions that are carried out to minimize the potential impact of risk agents. From the results of discussions with management, it was identified that there were 13 preventive actions obtained by reviewing several written procedure documents related to forecasting planning, supplier performance, order policies and other related documents

Table 2 Correlation between Preventive Action (PA) and Risk Agent (RA)

		Stategi Penanggulangan (Preventive Action) PA*i*													**ARP**
		PA1	PA2	PA3	PA4	PA5	PA6	PA7	PA8	PA9	PA10	PA11	PA12	PA13	
Pemicu Resiko (Risk Agent)	A01	9	9	9	3				1	1	3				1.086
	A14				3	9	9	9			3				630
	A19								3	3		3	3	3	468
	A02	9	3	3	3						3				300
	A15					3	3	9		1	3				252
	A09			9	1						3				216
	A08								9	3	3	3	3	1	360
	TEk	12.474	10.674	12.618	6.264	6.426	6.426	7.938	5.730	3.822	8.532	2.484	2.484	1.764	
	Dk	3	4	3	3	4	4	4	3	3	3	5	3	3	
	ETDk	4.158	2.669	4.206	2.088	1.607	1.607	1.985	1.910	1.274	2.844	497	828	588	
	Rk	2	4	1	5	8	8	6	7	10	3	13	11	12	

The following diagram is used to analyze the correlation between risk agents and preventive action.

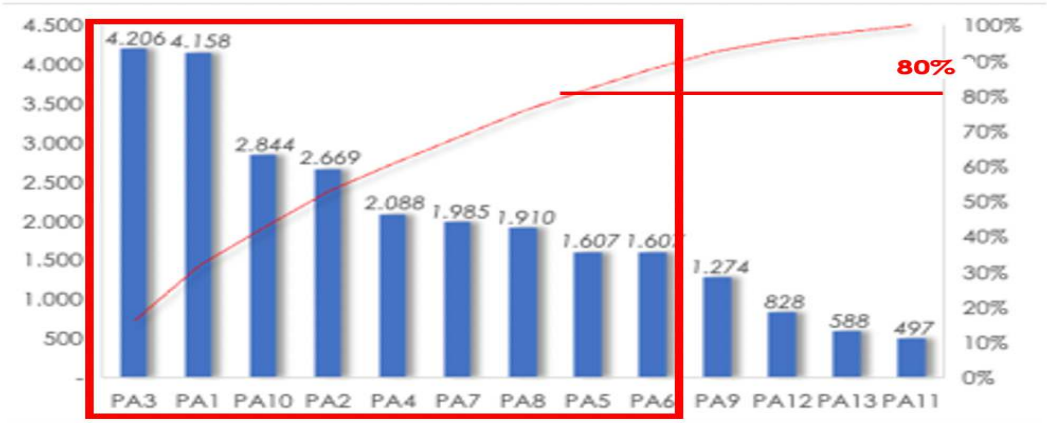


Figure 4 Pareto Diagram Preventive Action

Based on diagram above, this study limits the ETDk value above 80% as a priority for preventive action or mitigation strategies. From these results, the company will prioritize the prevention strategies, as many as 8 preventive actions are attached to the following table of preventive action priorities so that it can determine which precautions must be taken immediately to reduce the risk. Because not all preventive actions must be carried out by considering the effectiveness and existing resources in the company as well as the level of difficulty of the prevention that will be carried out.

Table 3. Preventive Action (PA) Priority 80%

Rk	Risks Agent	Description	ARP	cum %	
1	A01	Unclear/changes in forecasting (forecasting)	1.086	27,7%	
2	A14	Lack of supplier performance control	630	43,8%	
3	A19	Management, Control & Planning Customer Delivery that doesn't working	468	55,7%	
5	A02	Sudden requests / urgent requests from customers	360	64,9%	
6	A15	Unclear order policy to suppliers	300	72,6%	
7	A09	Lack of investigation of supplier's ability to forecast	252	79,0%	
4	A08	Supplier Delivery Monitoring not working properly	216	84,5%	80% Coverage
8	A16	Production control that doesn't work	168	88,8%	
9	A17	Setting the production schedule is not good	108	91,6%	
10	A20	Control & Management on receiving that doesn't work	90	93,9%	
11	A05	New Man Power (skill to understand system/operation is not optimal)	42	94,9%	
12	A18	Insufficient returnable box/packaging control	36	95,8%	
12	A06	Unclear requirements and schedule when ordering	30	96,6%	
14	A04	The condition of the BOM/ Product Structure master data at CIGMA is no	36	97,5%	
15	A11	Disconnected internal/external communication	18	98,0%	
15	A12	Supplier payment control that doesn't work	18	98,4%	
15	A21	NG items were found (no good) so further evaluation is needed	18	98,9%	
18	A10	Lack of understanding of the system and operations	16	99,3%	
19	A13	There are trouble settings in System Maintenance/Closing by IT and Finan	10	99,6%	
20	A03	System Maintenance/ Closing by IT and Finance	9	99,8%	
21	A07	Inaccurate comparison of goods and materials prices	8	100,0%	

6. CONCLUSIONS

The conclusions from the research conducted at PT X as an automotive manufacturing company for procurement related to the supply chain of goods and materials are:

- Supply chain risk management of goods & materials at PT X use the House of Risk (HOR) method as the right solution to carry out risk mitigation strategies that will occur.
- The results of the identification of risk events in the business process using SCOR method obtained 59 risk events covering several business unit areas from suppliers, delivery of goods, until inventory at PT X.
- Risk agent identification with discussions and interviews have results of HOR 1 analysis are 21 risk agents and after processing with Pareto diagrams, 7 Risk Agents are selected as priorities.
- HOR 2 analysis obtained 8 preventive actions that have been prioritized using Pareto analysis to minimize the emergence of risk agents.
- Managerial implication of risk mitigation strategy involving several activities related departments requires good coordination and have support system to support the implementation of these activities.

REFERENCES

ISO 31000. 20011. "Risk Management - Principles and Guidelines." Switzerland. https://doi.org/ISBN 978-1-86975-127-2.

Pujawan, I. Nyoman, and Laudine H. Geraldin. 2009. "House of Risk: A Model for Proactive Supply Chain Risk Management." Business Process Management. Journal 15 (6): 953–67. https://doi.org/10.1108/14637150911003801.

Pujawan, I. N., & Mahendrawati. (2010). Supply Chain Management, Edisi Kedua. (I.K. Gunarta, Ed.). Surabaya.

Geraldin, L. H. (2007). Risk Management and Mitigation Actions to Create Robust Supply Chain. Surabaya: Jurusan Teknik Industri: Institut Teknologi Sepuluh Nopember.

Aleksic, A., Jeremic, B., Stefanovic, M., & Dapan, M. (2009). Risk management processes in s supply chains. International journal for quality research, 1-6.

Erkoyuncu, J. A., Apa, M., & Roy, R. (2015). Quantifying risk mitigation strategies for manufacturing and service delivery. Procedia cirp, 179-184.

Normain, A., & Jansson, U. (2004). Ericsson's proactive supply chain risk management approach after a serious sub-supplier accident. International journal of physical distribution & logistics management, 434-456.

Thun, J. H., & Hoenig, D. (2011). An empirical analysis of supply chain risk management in the german automotive industry. 242-249.

Heizer, J., dan B. Render. 2014. Manajemen Operasi. Salemba Empat. Jakarta.

Besterfield, Dale H. 2009. Quality Control. 8th edition. New Jersey: Pearson Prentice Hall.

THE EFFECT OF SOCIAL MEDIA INFLUENCER CHARACTERISTICS ON LOYALTY TO INFLUENCER, PRODUCT ATTITUDE, AND PURCHASE INTENTION

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ABSTRACT

The term influencer is growing rapidly along with the development of social media such as Instagram and Tiktok which are homes for influencers. Many previous researchers have discussed how influencer characteristics influence purchase intention, but it is still very rare to discuss how influencer characteristics influence purchase intention, especially on Instagram and Tiktok. So it is important for marketers and brands to be able to find out what characteristics of influencers can influence loyalty to influencer, product attitude, and purchase intention on these two social media platforms. In general, the characteristics of influencers are divided into 2 models, namely The Source Credibility Model and The Source Attractiveness Model which can affect consumer confidence which in turn can affect loyalty to influencer, product attitude, and purchase intention. An online survey was conducted on 450 users of Instagram and Tiktok who follow influencer accounts on these social media platforms. The results of this study indicate that both on Instagram and Tiktok, Authenticity is the characteristic of influencers that most influences consumer trust in influencers, while physical attractiveness does not have a significant influence on influencing trust in influencers on these two social media.

Keywords: Characteristics of Influencer, Instagram, Tiktok, Loyalty to Influencer, Product Attitude, Purchase Intention

1. INTRODUCTION

The term of social media influencer is growing rapidly along with the development of social media Instagram and Tiktok which are home to the influencers. The difference between Instagram and Tiktok requires brands to be able to choose the right marketing strategy to be placed on Instagram and Tiktok to influence the target consumer so that the marketing message that the brand wants to deliver can be conveyed to the target consumer. Instagram is a social media platform that focuses on sharing images, basically showing Instagram users' content to their followers. Contents are usually accompanied by a series of text and hashtags and in its development, Instagram released the stories feature which is a content format that can be in the form of images, text, or short videos of 15-60 seconds in length where the stories feature only last for 24 hours. In addition, there is also IGTV which has a video duration of 15-60 minutes. While Tiktok focuses on short videos (15-60 seconds) accompanied by sound snippets, songs, or dialogues from a TV show, as well as a sound produced and uploaded by other Tiktok users, so that the content on Tiktok is intertwined based on the type of sound used so that the Tiktok content

usually follows the current trend where Tiktok content consists of displaying user content that is followed by other users and "For You" content which is the content that is displayed because it is most likely to be enjoyed by Tiktok users (Haenlein et al., 2020). Tiktok is a creative media platform compared to just social media, where Tiktok frees the younger generation to play without the limitations of visual styles, certain narratives, or past online culture. The features presented by Tiktok are also very interesting because they can attract Tiktok users to perform a duet with the influencers they want, and the user is able to do lip-synching where users can recreate video or sound on Tiktok content (Katie Elson Anderson, 2020).

The effect of communication that exists between an influencer and his followers depends on the characteristics of the influencer and the intent of the message. Because Influencers are the spokespersons for brands in the context of social media, the characteristics of Influencers can produce branding that can be utilized by brands (Li & Peng, 2021) and the characteristics of influencers serve as sources to form consumer trust (Y. Do Kim & Kim, 2021). Trust is important in marketing using social media because there is no face-to-face communication and content created by social media users that cannot be controlled by brands. The relationship of trust between target consumers and influencers mediates loyalty to influencers, product attitudes, and purchase intentions. Loyalty to influencers occurs because of continuous communication between influencers and their followers where trust in influencers has more impact on the relationship between influencers and followers on social media, while trust also mediates influencer relationships on consumer attitudes towards brands, and purchase intentions. Trust depends on the integrity of feelings, trust, and mutual understanding so that consumers feel more trust in influencers because they think influencers have something in common with consumers and are easier to trust (Schouten et al., 2020)

The selection of influencers is something that must be considered by companies, so that the characteristics of these influencers can increase positive associations with brands and create consumer confidence in the brand which is then expected to provide the results desired by the brand, so that the selection of the right influencer must also be adjusted to the social media platform that is appropriate. Based on the background that has been explained, the formulation of the problem in this study is what are the characteristics of influencers that affect consumer confidence in influencers on the Instagram and Tiktok social media platforms? How can trust in influencers on social media platforms such as Instagram and Tiktok affect consumer loyalty to influencers, product attitudes, and purchase intentions? Is there a difference between the characteristics of influencers on social media platforms Instagram and Tiktok on consumer loyalty to influencers, product attitudes, and consumer purchase intentions mediated by trust in influencers?

2. LITERATURE REVIEW

2.1 Social Media Influencer (SMI)

The significant development of social media led to the development of influencer marketing(Y. Do Kim & Kim, 2021). Social media influencers (SMI) refers to people who have built a large social community of followers on one or more social media platforms (Pick, 2021). Others have defined social media influencers as a type of micro- celebrity, who practices self-presentation on social media, accomplished through the creation of an online image and the use of that image to attract and engage with a large number of followers (Dhanesh & Duthler, 2019). SMIs promote themselves by engaging in self-branding, always looking to attract new followers, maintaining relationships with existing followers, and ultimately increasing social capital through a distinct and visible identity (Lee & Eastin, 2020).

Influencers can influence the decision-making process because influencers can become "trusted tastemakers" who present interesting content and credible words on their social media platforms (Lee et al., 2021). The reputation of influencers depends on the content and activities they upload on their social media accounts, and usually also collaborate with their followers (Hu et al., 2020). Because influencers are more focused on audience segments that have similar interests, so they have a close relationship with their followers, influencers are easier to trust than conventional celebrities (Yuan & Lou, 2020).

2.2 Source Credibility Model: Expertise & Authenticity

Source credibility is expressed as the expertise of a speaker which can affect the trust of the recipient of the message (Ismagilova et al., 2020). Source credibility is one of the factors that can be used by followers to consider the decision-making process if they consider their influencer to be credible. There are two dimensions of source credibility, namely: Expertise and Authenticity influencers(Y. Do Kim & Kim, 2021). Expertise is defined as the extent to which the source is considered capable of providing correct and relevant information, knowledge or experience to target consumers. An influencer's expertise can be judged based on the number of reviews posted, the content posted, and the length of time the reviewer has been a member on the platform (Li & Peng, 2021). Expertise depends on how influencers can provide knowledge and have experiences that can be shared with target consumers. In previous research, it was stated that the influence of expertise in forming trust in influencers is very significant if there is a strong relationship between influencers and followers, where the deeper and more frequent communication occurs between influencers and followers, the followers will realize the expertise of the influencer and become dependent on the influencer (Y. Do Kim & Kim, 2021). Influencers with high skills are easier to influence than those with less expertise (Li & Peng, 2021). Expertise is an important characteristic of influencers, because it can increase followers' trust in these influencers. Trust in influencers can occur because influencers are considered to be able to provide information and share their experiences that can be a reference for their followers, especially when the influencer explains in detail a product that adds information to his followers on social media.

H1: The expertise of an influencer positively influences trust in the influencer.

Authenticity is described as an inherent attribute where the attribute is not a clone or a copy because the attribute is unique. Influencer authenticity is an important attribute, where authenticity can increase message acceptance, increase perceived quality, and increase purchase intention (Audrezet et al., 2020). Social media users are now starting to become aware of the presence of sponsorship, causing doubts about the products recommended by influencers on social media where the need for authenticity is to influence followers to believe that the content that influencers post is based on honest and sincere personal opinions. Creative and authentic content can be seen as a way for influencers to blend in with their followers (Y. Do Kim & Kim, 2021). The content that recommends a product on social media is very much and tends to be almost the same, so influencers need to provide authentic and based content with honest personal opinions in order to attract the attention and trust of their followers.

H2: The authenticity of an influencer positively influences trust in the influencer.

2.3 Source Attractiveness Model : Physical Attractiveness & Homophily

Source attractiveness states that the attractiveness of the endorser increases the effectiveness of advertising because consumers form positive stereotypes of attractive people who are then associated with the advertised product or brand (Frank & Mitsumoto, 2021). An attractive source will influence the recipient of the message so that they are willing to like and receive messages from the source, where in the context of influencer marketing, the attraction referred to here is physical attraction and homophily (Y. Do Kim & Kim, 2021). Physical attractiveness refers

to the extent to which influencers can visually attract consumers (Pick, 2021). Physical attractiveness is considered to be attractive to individuals which is often associated with good, attractive, sociable, strong, simple, and responsive (Y. Do Kim & Kim, 2021). Attractive speakers will influence the recipient of the message through the identification process, where the recipient of the message will feel similar or want to be similar to the speaker and create a positive relationship with him where currently many millennials want to resemble attractive celebrities and even use some aspects of the personality and lifestyle of the celebrities to look like the celebrities they like (Sokolova & Kefi, 2020). The appearance of an influencer that is physically attractive will result in a positive view of the influencer, where followers will make themselves look like the influencer. A positive view of influencers will generate follower confidence in the content shared by the influencer that the content can provide the information needed by followers.

H3: The attractiveness of an influencer positively influences trust in the influencer.

Homophily is defined as the extent to which influencers are similar to consumers such as age, gender, education, lifestyle, and interests (Li & Peng, 2021) Homophily can affect a person's willingness to seek opinions and connect with others through social networks, besides Homophili can encourage followers to build interpersonal relationships with influencers and share information (Bu et al., 2022). Homophily can be perceived as the similarity or similarity of values between influencers and followers, where Homopili can be interpreted that consumers find recommendations given by sources that have similarities to consumers are more influential because these sources are considered suitable for interests, attitudes, and choices (Ismagilova et al., 2020). When consumers judge themselves to be the same as influencers, consumers will interact with the influencer and assume that the information provided by the influencer is reliable information.

H4: Homophily to an influencer positively influences trust in the influencer.

2.4 Trust in The Social Media Influencer

Trust is defined as a belief held by one party about the characteristics of the other party that can increase the willingness to take risks and ultimately can help to solve social dilemmas. Trust is also a number of beliefs about other people (Ferrin et al., 2007). People tend to refuse to believe direct advertising messages about brands, but are inclined to believe influencers because they think that direct advertising's goal is merely to sell products, while influencers do not have such an objective (Pick, 2021). When followers feel that the content uploaded by the influencer is trustworthy and credible, the follower is willing to interact continuously with the influencer which causes loyalty to the influencer. Followers will be more willing to connect with influencers when they have an emotional attachment to the influencers they follow on social media (Jun & Yi, 2020).Influencer characteristics that match the type of product advertised by the influencer will increase consumer attitudes towards the brand (Lee & Eastin, 2020). Influencers can produce more positive consumer attitudes towards brands, this happens because consumers often associate influencers' personal characteristics with the product being advertised by the influencer (Nafees et al., 2021). When consumers believe in influencers, consumers have a positive attitude towards products and brands, where consumers will assume that the information provided by the influencer is correct so that it will shape consumer attitudes towards the product. Purchase intention indicates that consumers will plan and have a desire to buy a product in the future. In the context of social media, purchase intention is the possibility and desire of social media users to make a purchase of recommended products on social media platforms. When consumers want to buy a product, consumers are accustomed to looking for relevant information based on their own experiences and the external environment, where after collecting data about the product they want to buy,

consumers will begin to evaluate, consider, and compare which of these processes will end with purchase behavior (Choedon et al., 2020). So that if consumers have a positive assessment of influencers, it will generate purchase intentions for brands advertised by influencers (Li & Peng, 2021). Trust can reduce the complexity that consumers feel when they make a purchase and reduce the risk that consumers feel in making purchasing decisions and increase the certainty of the expected results, so that trust will affect consumers' purchase intentions. Trust in influencers results in trust related to information and product recommendations provided by the influencer, which will affect consumers' purchase intentions for the products recommended by the influencer where consumers believe that the influencer recommends products that are true and honest.

H5: Trust positively influences loyalty to the influencer.

H6: Trust positively influences product attitude.

H7: Trust positively influences purchase intention.

Based on the purpose of this study is to find out whether there is a difference in the mediating effect of trust in the influencer on the relationship between the characteristics of the influencer and the loyalty of the influencer, product attitude, and purchase intention in social media. Trust can reduce the complexity and risk perceived by consumers, so trust plays an important role in predicting a consumer's outcome in terms of purchasing a product (Li & Peng, 2021). Comparing the two social media Instagram and Tiktok is considered important because basically, these two social media are different. Initially, Instagram was a social media whose content format was in the form of photos, while Tiktok appeared with a content format in the form of short videos. It is important to know what kind of social media you want to use to engage consumers because the content is not easily transferred from social media Tiktok to Instagram and vice versa so each platform requires new resources and expertise (Heanlein et al, 2020). The difference between the Instagram and Tiktok social media platforms, both in terms of content formats, social media users, and social media influencers, causes you to be able to choose the right influencers to be placed on social media so that the marketing goals you want to achieve can be achieved. So that obtained the following hypothesis:

H8: There is a difference in the mediating effect of trust in influencers on the relationship between influencer characteristics and loyalty to influencers, product attitudes, and purchase intentions of Instagram and Tiktok users

3. METHODS

This study will use quantitative research methods with cross-sectional methods to be able to describe the relationship between the variables studied. and data collection will be carried out using an online survey method, where this study refers to previous research by (Y. Do Kim & Kim, 2021). The measurement items for each construct in the hypothesized model were adopted and modified from the preexisting measurements that were validated in the previous studies and scales for each of the following constructs were measured on a 5-point Likert rating scale (1 = Strongly Disagree, 5 = Strongly Agree) and physical atrractiveness were measured through 5-pointsemantic differential scale.

4. RESULTS

4.1 Sample

The data was taken from respondents aged between 18-34 years old users of the Instagram and Tiktok applications in Indonesia, the reason for selecting respondent aged 18-34 because they are active users of social media and already able to make a purchase decision. Obtained 450 valid samples with 57% respondents are Instagram users dan 43% respondents are Tiktok users. The

number of female respondents was more than male respondents, namely 69% with a total of 312 respondents, while male respondents were 31% with a total of 138 respondents. The distribution of respondents' occupation is divided into private employees by 43% with a total of 194 respondents, 31% by students with a total of 141 respondents, Civil Servants (PNS) by 6% with a total of 26 respondents, Entrepreneurs by 6% with a total of 26 respondents, and Housewives by 5% with a total of 25 respondents, BUMN/BUMD employees by 5% with a total of 21 respondents, and others each accounted for 4% with a total of 17 respondents. More respondents domiciled in Greater Jakarta, namely 62% with a total of 279, while respondents who live outside Jabodetabek are 23% with a total of 104 respondents and respondents who live outside Java Island are 15% with a total of 67 respondents. Products that are recommended by Influencers that are remembered by respondents are divided into 38% of Cosmetic products, 25% of Food/Beverage products, 16% of Fashion products, 4% of Technology products, and 17% of Other products.

4.2 Measurement Model

The Measurement model was tested using SPSS and SmartPLS software. The reliability of each construct was assessed Cronbach's alpha and convergent and discriminant validity were examined by average variance extracted (AVE), composite reliability (CR), and correlation coefficients among the variables. Then, the result found that the construct was valid and reliable

Table 1. Measurement validity & reability

VARIABEL	ITEMS	FACTOR LOADING	CRONBACH ALPHA	COMPOSITE REABILITY	AVE
EXPERTISE	a. Expertise in product recommendation	0,82	0,89	0,91	0,69
	b. Experienced in product recommendation	0,86			
	c. Knowledgeable in product recommendation	0,85			
	d. Qualified to make product recommendations	0,84			
	e. Skilled in product recommendation	0,78			
AUTHENTICITY	a. I think this person is Genuine	0,78	0,85	0,9	0,69
	b. I think this person is Honest	0,89			
	c. I think this person is Sincere	0,87			
	d. Because they are open with their followers	0,76			
PHYSICAL ATTRACVINESS	a. Attractive	0,76	0,73	0,82	0,54
	b. Beautiful	0,83			
	c. Sexy	0,62			
	d. Elegan	0,72			
HOMOPHYLI	a. This YouTuber and I have a lot in common	0,85	0,87	0,91	0,71
	b. This YouTuber and I are a lot alike	0,83			
	c. This YouTuber thinks like me	0,87			
	d. This YouTuber shares my values	0,82			
TRUST	a. The influencer can be relied upon on his/her content	0,84	0,9	0,93	0,77
	b. I believe what this influencer says and that he/she would not try to take advantage of the followers	0,9			
	c. The influencer is straightforward and honest even though his/her self-interests are involved	0,9			
	d. The influencer would not tell a lie even if he/she could gain by it	0,87			
LOYALTY TO INFLUENCER	a. I would recommend this influencer to someone who seeks my advice.	0,76	0,87	0,91	0,72
	b. I say positive things about this influencer.	0,87			
	c. I intend to continue following this influencer.	0,88			
	d. I will continue to watch the posting of this influencer.	0,87			
PRODUCT ATTITUDE	a. The influencer would not tell a lie even if he/she could gain by it	0,86	0,9	0,92	0,71
	b. I Think the sponsored Instagram post and the product endorsed by the influencer is good	0,89			
	c. I Think the sponsored Instagram post and the product endorsed by the influencer is pleasant	0,86			
	d. I Think the sponsored Instagram post and the product endorsed by the influencer is favorable	0,72			
	e. I Think the sponsored Instagram post and the product endorsed by the influencer is likeable	0,87			
PURCHASE INTENTION	a. The probability that I would buy the beauty products suggested by this Instagram account is high.	0,89	0,9	0,93	0,78
	b. I will try to buy the beauty products suggested by this Instagram account within the next 12 months.	0,89			
	c. I plan to purchase the beauty products suggested by this Instagram account within the next year.	0,89			
	d. If I were going to buy beauty products, I would	0,85			

Table 2. Discriminant & convergent validity of constructs

	A	E	H	LI	P	PA	PI	T
Authenticity	0,83							
Expertise	0,54	0,83						
Homophily	0,45	0,36	0,84					
Loyalty to Influencer	0,65	0,54	0,51	0,85				

	A	E	H	LI	P	PA	PI	T
Physical Attractiveness	0,36	0,33	0,24	0,35	0,73			
Product Attitude	0,48	0,58	0,44	0,64	0,33	0,84		
Purchase Intention	0,36	0,52	0,53	0,57	0,23	0,71	0,88	
Trust	0,66	0,56	0,58	0,78	0,31	0,65	0,58	0,88

4.3 Hypothesis Testing

Based on the measurement results using SEM in Table 3, it is known that the characteristics of influencers that affect trust in influencers directly and positively and significantly are the characteristics of Expertise, Authenticity, and Homophily both on Instagram or Tiktok so H1 is accepted, H2 is accepted, and H4 is accepted. The measurement results show that the characteristics in the form of Physical Attractiveness on influencers do not directly affect trust in influencers, both influencers on Instagram or Tiktok social media because they provide a p-value greater (>) 0.05 on each social media. So it can be concluded that H3 is rejected because there is no significant relationship between the characteristics of influencers in the form of Physical Attractiveness and trust in influencers both on Instagram and Tiktok. The trust in influencers has a positive and significant direct influence on influencer loyalty, product attitudes, and purchase intentions which gives a t-value greater (>) 1.96 and a p-value smaller (<) 0.05, so it can be said that H5 is accepted, H6 is accepted, and H7 is accepted. The results of this measurement also support previous research by Kim & Kim (2020) which said that the characteristics of influencers in the form of physical attractiveness did not affect trust in influencers (not differentiated between the characteristics of influencers on different social media). In Table 1 it is known that the characteristics of influencers that most influence trust in influencers on Instagram and Tiktok are generated by the Authenticity variable.

Table 3. Path Analysis

	Path Coefficients	t-Value	p-Value
Authenticity -> Trust	0,383	8,715	**0,000**
Expertise -> Trust	0,232	5,894	**0,000**
Homophily -> Trust	0,318	7,911	**0,000**
Physical Attractiveness -> Trust	0,019	0,570	**0,569**
Trust -> Loyalty to Influencer	0,775	36,028	**0,000**
Trust -> Product Attitude	0,654	18,432	**0,000**
Trust -> Purchase Intention	0,579	15,901	**0,000**

The next test is to find out whether there are differences in the influence of trust mediation on influencers on the relationship between influencer characteristics and loyalty to influencers, product attitudes, and purchase intentions in groups of Instagram and Tiktok social media users using Multi-Group Analysis.

Table 4. Measurement Results of the Effect of Influencer Characteristics on Loyalty to Influencer, Product Attitude, and Purchase Intention Mediated by Trust on Instagram and Tiktok

	Path Coefficients		t-Value		p-Value	
	IG	Tiktok	IG	Tiktok	IG	Tiktok
Expertise -> Trust -> Loyalty to Influencer	0,171	0,193	4,150	3,698	**0,000**	**0,000**
Expertise -> Trust -> Product Attitude	0,130	0,182	3,550	3,600	**0,000**	**0,000**
Expertise -> Trust -> Purchase Intention	0,107	0,165	3,279	3,572	**0,001**	**0,000**
Authenticity -> Trust -> Loyalty to Influencer	0,291	0,310	6,360	6,031	**0,000**	**0,000**
Authenticity -> Trust -> Product Attitude	0,221	0,292	5,687	6,083	**0,000**	**0,000**
Authenticity -> Trust -> Purchase Intention	0,181	0,265	5,274	6,014	**0,000**	**0,000**

	Path Coefficients		t-Value		p-Value	
Physical Attractiveness -> Trust -> Loyalty to Influencer	0,029	0,036	0,842	0,906	**0,400**	**0,366**
Physical Attractiveness -> Trust -> Product Attitude	0,022	0,034	0,827	0,914	**0,409**	**0,361**
Physical Attractiveness -> Trust -> Purchase Intention	0,018	0,030	0,822	0,917	**0,412**	**0,360**
Homophily -> Trust -> Purchase Intention	0,123	0,229	4,703	5,179	**0,000**	**0,000**
Homophily -> Trust -> Loyalty to Influencer	0,197	0,268	4,901	5,801	**0,000**	**0,000**
Homophily -> Trust -> Product Attitude	0,150	0,252	5,056	5,372	**0,000**	**0,000**

Based on Table 4 it is known that for both Instagram and Tiktok users, trust in influencers does not have a significant influence on mediating trust in influencers on the relationship between influencer characteristics in the form of physical attractiveness and loyalty to influencers, product attitude, and purchase intention because it produces the t-value is smaller than (<) 1.96 and the p-value is greater than (>) 0.05. While the characteristics of influencers, namely authenticity, expertise, and homophily, show a positive and significant relationship with loyalty to influencers, product attitudes, and purchase intentions mediated by trust in influencers (trust) because they provide a t-value greater than (>) 1, 96 and the p-value is less than (<) 0.05. So it can be concluded that H8 is rejected because in general there is no difference between the mediating effect of trust on influencers (trust) on the relationship between influencer characteristics in the form of expertise, authenticity, homophily, and physical attractiveness with loyalty to influencers, product attitude, and purchase intention both at groups of Instagram and Tiktok social media users.

6. CONCLUSIONS

Characteristics of influencers that positively and significantly affect trust in Instagram and Tiktok social media are Expertise, Authenticity, and Homophily. While physical attractiveness does not significantly affect trust in influencers, both Instagram and Tiktok users. In the Instagram and Tiktok user groups, the influencer characteristic that has the strongest influence in influencing trust in influencers (trust) is Authenticity. Honesty is an important factor for respondents in shaping the characteristics of influencer authenticity. Influencers who are honest in their uploads on social media can increase their followers' trust in these influencers, currently, social media users are getting familiar with endorsements or sponsorship content uploaded by influencers on social media, which causes doubts among social media users about the content of influencer whether based on personal opinion or because the influencer has been endorsed by a brand. The influencers that have the same positive view as the respondent is an important factor in shaping the characteristics of Homophily influencers. When social media users find similarities to the influencers they follow on social media, followers of the influencer will consider the influencer to be suitable for their interests, attitudes, and choices. resulting in consumers will support the opinions of these sources and assuming that information provided by these influencers on the social media they use is reliable information (Kim & Kim, 2021; E. Ismagilova et al, 2020).

Expertise is an important characteristic of influencers on social media because it can increase follower confidence in these influencers because influencers are considered to be able to provide information and share their experiences that can be a reference for their followers on social media.

Trust in Influencers (trust) has a positive and significant influence on loyalty to influencers, product attitudes, and purchase intentions in groups of Instagram and Tiktok users. In general, in the Instagram and Tiktok user groups, the variable trust in influencers has the strongest influence on loyalty to influencers, and trust in influencers has the weakest influence on purchase intention for both Instagram and Tiktok users. The trust in influencers can be formed by content that uploading by the influencers is honest and trustworthy. This can happen because social media users, especially Instagram and Tiktok have been exposed to various products and brands recommended by influencers where one influencer can recommend the same product with a

different brand or one influencer can recommend a variety of different products and brands, so it is important for consumers to first build trust in influencers on social media where this trust is the belief of social media users that the influencers they follow on Instagram or Tiktok can influence positively and the content on social media is honest and reliable. When trust in this influencer has been formed, social media users will be willing to follow the influencer or even become loyal followers, form attitudes towards products recommended by influencers, and even form social media users' purchase intentions for products recommended by the influencers they follow.

There is no difference in the mediating effect of trust on influencers on the relationship between influencer characteristics and loyalty to influencers, product attitudes, and purchase intentions for both Instagram and Tiktok so it is important for marketers to be able to take advantage of both social media. This shows that in the Instagram user group, influencers who are sincere and honest with the content uploaded on the Instagram social media platform will form Instagram users' trust in the influencer so that it will give Instagram social media users the desire to follow or stay connected with the influencer on Instagram so the influencer's content can continue to be seen on the follower's homepage where the uploads displayed by Instagram are only accounts followed by Instagram users. Whereas for Tiktok users, influencers who are honest and sincere with the content uploaded on Tiktok will form trust in the influencer so that the image of the influencer on Tiktok seems to give an honest opinion on a product or information without going through excessive editing process that uploaded in the form of a short video will shape the attitude of the product recommended by the influencer.

Limitations and further research

The following are the limitations of the study encountered by the researchers because there are very few studies that discuss the differences between Instagram and Tiktok social media, so in this study, the dimensions used to examine the characteristics of influencers still use general characteristics derived from research using M-Truck social media, respondents in this study only came from Indonesia, so research results may differ in certain countries or regions, this research does not specifically discuss a type of product (Cosmetics, Technology, Fashion, Food, etc.) recommended by influencers, so the results of this research are still general, research respondents were not differentiated between those who had purchased Influencer-recommended products and those who had never purchased Influencer-recommended products, and this research does not take into account the entertainment elements of each social media platform such as Instagram or Tiktok. Further research development can examine the effect of influencer characteristics on trust in influencers as mediators which in turn affect purchase intentions mediated by loyalty to influencers and product attitudes, further research also can divide influencers into their areas of expertise so as to get a more in-depth analysis of the influence of influencer characteristics on the content produced and the products recommended by the influencer and can use the type of influencer (Nano influencer, Micro Influencer, etc.) as a moderator in further research.

REFERENCES

Audrezet, A., de Kerviler, G., & Guidry Moulard, J. (2020). Authenticity under threat: When social media influencers need to go beyond self-presentation. Journal of Business Research, 117(November 2017), 557–569. https://doi.org/10.1016/j.jbusres.2018.07.008

Bu, Y., Parkinson, J., & Thaichon, P. (2022). Influencer marketing: Homophily, customer value co-creation behaviour and purchase intention. Journal of Retailing and Consumer Services, 66(January). https://doi.org/10.1016/j.jretconser.2021.102904

Choedon, T., Business, I., Course, C., & Lee, Y. (2020). The Effect of Social Media Marketing Activities on Purchase Intention with Brand Equity and Social Brand Engagement: Empirical Evidence from Korean Cosmetic Firms. 지식경영연구, 21(3), 141–160.

Dhanesh, G. S., & Duthler, G. (2019). Relationship management through social media influencers: Effects of followers' awareness of paid endorsement. Public Relations Review, 45(3), 1–13. https://doi.org/10.1016/j.pubrev.2019.03.002

Ferrin, D. L., Bligh, M. C., & Kohles, J. C. (2007). Can i trust you to trust me?: A theory of trust, monitoring, and cooperation in interpersonal and intergroup relationships. Group and Organization Management, 32(4), 465–499. https://doi.org/10.1177/1059601106293960

Frank, B., & Mitsumoto, S. (2021). An extended source attractiveness model: the advertising effectiveness of distinct athlete endorser attractiveness types and its contextual variation. European Sport Management Quarterly, 0(0), 1–24. https://doi.org/10.1080/16184742.2021.1963302

Haenlein, M., Anadol, E., Farnsworth, T., Hugo, H., Hunichen, J., & Welte, D. (2020). Navigating the New Era of Influencer Marketing: How to be Successful on Instagram, TikTok, & Co. California Management Review, 63(1), 5–25. https://doi.org/10.1177/0008125620958166

Hu, L., Min, Q., Han, S., & Liu, Z. (2020). Understanding followers' stickiness to digital influencers: The effect of psychological responses. International Journal of Information Management, 54(May 2019). https://doi.org/10.1016/j.ijinfomgt.2020.102169

Ismagilova, E., Slade, E., Rana, N. P., & Dwivedi, Y. K. (2020). The effect of characteristics of source credibility on consumer behaviour: A meta-analysis. Journal of Retailing and Consumer Services, 53(February 2019), 101736. https://doi.org/10.1016/j.jretconser.2019.01.005

Jun, S., & Yi, J. (2020). What makes followers loyal? The role of influencer interactivity in building influencer brand equity. Journal of Product and Brand Management, 29(6), 803–814. https://doi.org/10.1108/JPBM-02-2019-2280

Katie Elson Anderson. (2020). Getting acquainted with social networks and apps: it is time to talk about TikTok. Library Hi Tech News, 37(4), 7–12. https://doi.org/10.1108/LHTN-01-2020-0001

Kim, D. Y., & Kim, H. Y. (2021). Influencer advertising on social media: The multiple inference model on influencer-product congruence and sponsorship disclosure. Journal of Business Research, 130(November 2018), 405–415. https://doi.org/10.1016/j.jbusres.2020.02.020

Kim, Y. Do, & Kim, H.-Y. (2021). Trust me, trust me not: A nuanced view of influencer marketing on social media. Journal of Business Research, 134(November 2019), 223–232. https://doi.org/10.1016/j.jbusres.2021.05.024

Kim, J., & Kim, M. (2022). Rise of Social Media Influencers as a New Marketing Channel : Focusing on the Roles of Psychological Well-Being and Perceived Social Responsibility among Consumers.

Lee, J. A., & Eastin, M. S. (2020). I Like What She's #Endorsing: The Impact of Female Social Media Influencers' Perceived Sincerity, Consumer Envy, and Product Type. Journal of Interactive Advertising, 20(1), 76–91. https://doi.org/10.1080/15252019.2020.1737849

Lee, J. A., Sudarshan, S., Sussman, K. L., Bright, L. F., & Eastin, M. S. (2021). Why are consumers following social media influencers on Instagram? Exploration of consumers' motives for following influencers and the role of materialism. International Journal of Advertising, 0(0), 1–23. https://doi.org/10.1080/02650487.2021.1964226

Li, Y., & Peng, Y. (2021). Influencer marketing: purchase intention and its antecedents. Marketing Intelligence and Planning, 39(7), 960–978. https://doi.org/10.1108/MIP-04-2021-0104

Masuda, H., Han, S. H., & Lee, J. (2022). Impacts of influencer attributes on purchase intentions in social media influencer marketing: Mediating roles of characterizations. Technological Forecasting and Social Change, 174(September 2021), 121246. https://doi.org/10.1016/j.techfore.2021.121246

Nafees, L., Cook, C. M., Nikolov, A. N., & Stoddard, J. E. (2021). Can social media influencer (SMI) power influence consumer brand attitudes? The mediating role of perceived SMI credibility. Digital Business, 1(2), 100008. https://doi.org/10.1016/j.digbus.2021.100008

Pick, M. (2021). Psychological ownership in social media influencer marketing. European Business Review, 33(1), 9–30. https://doi.org/10.1108/EBR-08-2019-0165

Schouten, A. P., Janssen, L., & Verspaget, M. (2020). Celebrity vs. Influencer endorsements in advertising: the role of identification, credibility, and Product-Endorser fit. International Journal of Advertising, 39(2), 258–281. https://doi.org/10.1080/02650487.2019.1634898

Sokolova, K., & Kefi, H. (2020). Instagram and YouTube bloggers promote it, why should I buy? How credibility and parasocial interaction influence purchase intentions. Journal of Retailing and Consumer Services, 53(September 2018), 101742. https://doi.org/10.1016/j.jretconser.2019.01.011

Yuan, S., & Lou, C. (2020). How Social Media Influencers Foster Relationships with Followers: The Roles of Source Credibility and Fairness in Parasocial Relationship and Product Interest. Journal of Interactive Advertising, 20(2), 133–147. https://doi.org/10.1080/15252019.2020.1769514

CHANNEL DEVELOPMENT:
BUSINESS-COACHING CASE STUDY OF PT SAMPURNA RONA SELARAS

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ABSTRACT

As the largest contributors to employment in Indonesia MSMEs have significant role in Indonesian economy, the category absorbs around 97% of the national workforce. And from many types of MSMEs that exist, those in the construction sector such as suppliers of building material have an additional significancy due construction sector contribution to Indonesia's GDP, around 10.7% in 2020. The consumer were the owners, architects, and contractors. With this market, the improvement should have a benefit in overall situation of construction sector. A study with a business coaching approach was carried out on one of the MSMEs in this category. Qualitative research using business model canvas as tools was held to find discrepancy in existing business model. Follow the finding we formulated business model improvements to trigger an intervention in the form of a business model innovation. In this research we find Channel development has a role to improve the company performance. but it was necessary to propose a new business model including Channels and Customer Relations which will affect their Key resources and Key activities. because business models were an activity system, which has interactions and interdependencies between building components.

Keywords: MSMEs, B2B, Business Coaching, Business model canvas, Channel.

1. INTRODUCTION

The Micro, small, and medium enterprises or abbreviated as MSMEs acknowledged for their role in national economies worldwide. For Indonesia, MSMEs are the largest contributors to employment in Indonesia. Based on information from the Indonesian Ministry of Cooperatives and MSMEs, the category absorbs around 97% of the national workforce. Meanwhile, large enterprises only absorb about 3% of the total national workforce. In addition, MSMEs in material building suppliers have a role due to the construction sector as based on BPS (2021) contributed 10.7% in 2020 to gross domestic product (GDP) and in the first quarter of 2021, it was already 10.8%.

The customers for MSMEs in material building suppliers are the owners, architects, and contractors. The customer in this type of product calmly and carefully integrates as much information as possible with what they already know about a product, painstakingly weighs the pluses and minuses of each alternative, and arrives at a satisfactory decision (Solomon, 2017). We found companies in this category choose a business to business (B2B) approach that involve more

complex products, more extensive purchasing processes, different selling skills, and more collaborative management processes(Cravens & Piercy, 2009). Face-to-face selling is still considered to be the dominant form of communication for B2B organizations, although only a fraction of the communication happens in person (Järvinen, J., Töllinen, A., Karjaluoto, H. & Jayawardhena, 2013).

The study involves PT Sampurna Rona Selaras with their product SampurnaMix as one of the local building materials MSMEs that use business to business (B2B). Business coaching was carried out to find nonconformity in their existing business model, and then we propose the best approach based on the Business Model Canvas (BMC) tools from Osterwalder & Pigneur. This study aims to explore how to improve the existing business model using business model innovation as case study. And then help business owners solve problems that have been identified to achieve business performance targets that have been set at the beginning.

2. LITERATURE REVIEW

2.1 Business Model

Business models have been conceptualized as activity systems, whose interactions and interdependencies can be used to create, capture and deliver value(Zott et al., 2011). The business model also can act as an abstract representation of an organization's architecture and this interpretation of the organization can assist it in realizing its strategic goals(Teece, 2010). Other researchers conceptualize business models through their defining components which are representations and descriptions of how organizations operate (Massa et al., 2017). Lanzolla & Markides (2021) argue that by starting strategy development with interdependencies among activities, we can: (1) develop new insights on how to build superior strategies; and (2) explain company performance variance especially when heterogeneity in resources and capabilities is not strong and barriers to imitation are weak. Within the MSMEs context, it could be argued that practical component-based business model tools can help MSMEs to visualize and develop structure and design within their business model.

One of the most popular BM representation frameworks is the Business Model Canvas by (Osterwalder & Pigneur, 2010). They state that a business model describes the rationale of how an organization creates, delivers, and captures value. Furthermore, the framework consists of nine interrelated components, namely Consumer Segment, Value Proposition, Channels, Consumer Relationship, Revenue Streams, Key Resources, Key Activities, Key Partnership, and Cost Structure. These nine components have an important role that can explain a company's business model and from here we can also see if some linkages and synergies will help in the analysis.

2.2 Channels & Digital Platform

Osterwalder & Pigneur (2010) describes Channels as to how a company communicates with and reaches its Customer Segments to deliver a Value Proposition. Communication, distribution, and sales Channels comprise a company's interface with customers. To maintain what Viki et al., (2017) call a growth engine, the Channel holds an important role in avoiding the risk to use the same Channels and sales methods they have always used. The company must develop the capacity and knowledge to manage this new growth engine. Unfortunately, face-to-face selling is still considered to be the dominant form of communication for B2B organizations, although only a fraction of the communication happens in person.

A website is a place where a company can operate so that its consumers can collect information related to products or services provided by the company and have the potential to make purchases (Mcpheat, 2011) furthermore website is a form of online marketing, where if the company's website design is arranged properly, the company's website will be easily found on search engines such as Google and will be accessible to consumers who have potential purchases.

In the emergence of digitalization B2B organizations view social media as a supportive tool to enhance customer relationships. In B2B organizations, social media is used to enhance SEO (Search Engine Optimisation) driving traffic to home and/or landing pages, thus resulting in customer engagement, customer service, and lead generation (Itani et al., 2017). SM possesses immense potential for gathering customer data and assisting B2B marketers (Tiwary et al., 2021) B2B sales professionals use social media marketing for prospecting, handling objections, and after-sale follow up (Bastos & Moore, 2021).

3. RESEARCH METHODS

Business coaching is done by first analysing the business environment and the owner's concern for his business. Based on the results of observations and dialogue with the owner, the researcher identifies research problems and research questions which will be solved using the business model with reference to the canvas business model which consists of nine components. Based on the results of the evaluation of the current business model, researchers can assist business owners to carry out the process of changing the business model, as an instrument in solving problems. There are a number of alternative business models that can be designed. What matters is the research problem and the research question to be solved.

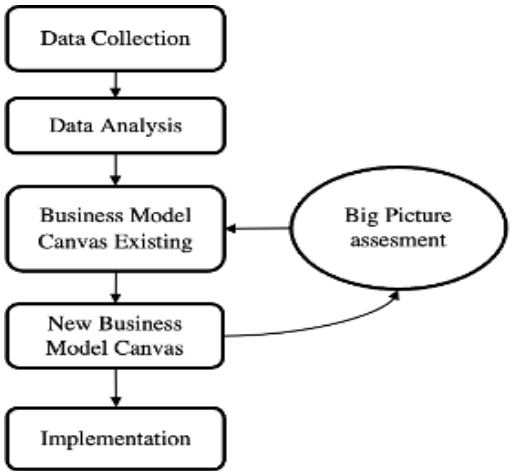


Figure 1. Research implementation flow

The data collection stage techniques include qualitative interviews and observation(Patton, 2002) stated, “there are three basic approaches to collecting qualitative data through open-ended interviews which includes informal conversational interviews, standardized open-ended interviews, and the general interview guide approach. An interview guide using business model canvas as framework is prepared for the face-to-face interview. These interviews involve open-ended questions intended to elicit views and opinions from the participants (Creswell & Creswell,

2018). And for the observation, takes field notes on the behaviour and activities of individuals at the research site. These observations are open-ended with general questions to the participants, allowing the participants to freely provide their views.

MSMEs naturally only have a few people and each person has a different information due their job and responsibilities. To acquire a pattern based on the interview result in this situation was not precise. Therefore, to get a more reliable and definite picture, respondents' reliability was categorized based on the information and position they have in the company. Conducting interviews with customer as respondents would not achieve the study objectives. Because what we want to investigate, whether the business model conducted daily was suficient to achieve the expected target. We need to explore each activity in nine component based on BMC, the connectivity and overall impact.

Participants were interviewed in two separate interview sessions. The objective of the first interview was completion of the interview guide while the second for clarification and follow-up questions. Interviewing more than once provides an opportunity to reflect upon the first interview and to "build upon and explore the participants' responses" in the second interview, thereby providing richer and thicker descriptions. All the activity was carried out to create the current business model canvas accurately.

Existing business model canvas was assessed by looking the interrelationships and how each activity relates to each other, we look for areas for incremental business model improvements, and to trigger a serious intervention in the form of a business model innovation initiative (Osterwalder & Pigneur, 2010). Move further in analysing we conduct SWOT Analysis by using questions for each of the nine BMC elements. All assessment done thoroughly to find the company situation problem statement and then resolve by new business model canvas or business model innovation. In this research more than one proposed business model was discussed with the owner. From the problems we identified, we were looking for the most crucial and visible to solved based on the problem and available resources of the MSMEs.

4. RESULTS

4.1 Analysis and Discussion

Based on the interview and discussion we found the problem was the low growth of PT. Sampurna Rona Selaras customers. This situation occurred because of their inadequacy in utilizing their Channel as we could see in the existing business model canvas (**Figure** 2). Resulting in the number of new customers yearly average is less than ten. In the business model canvas, Channels were described as how a company communicates with and reaches its customer segments to deliver a value proposition (Osterwalder & Pigneur, 2010). Meanwhile PT. Sampurna Rona Selaras in their Channel relies on the owner as a seller and sales partner. Secondly, they did not have communication media to send value propositions other than traditional media and mouth to mouth communication from their existing customer.

Table 1. Existing customer growth

	2017	2018	2019	2020	2021
NUMBER OF PROJECT/ CUSTOMER	72	77	83	52	24
GROWTH IN PERCENTAGE		7%	8%	-37%	-54%

SWOT analysis was performed using questions for each of the nine BMC component. The results show the nonconformity from Channels of at least two points. First, Channels were not yet integrated, has a low reach and did not reach potential customers widely. On the other hand, there was an opportunity to increase efficiency or effectiveness by integrating and finding new Channels. Second, customer relationships only rely on traditional media during the digitalization trend. Meanwhile based on Arora et al. (2022) the increment of Channels used by B2B Customers in affecting their decision-making journey in purchase were increased from average 5 in 2016 to 10 Channels in 2021.

Table 2. Business Model Canvas SWOT Analysis Result

Components	Strength	Weakness	Threat	Opportunity
Value Proposition	60	0	30	60
Revenue Stream	35	20	60	40
Cost Structure	65	10	30	40
Key Resources	67	13	50	30
Key Activities	40	30	60	60
Key Partnership	30	20	73	36
Customer Segmentation	33	47	55	53
Channels	9	80	40	96
Customer Relationship	25	30	80	50

This shows that increasing the Channel is the right approach if we want to increase the customer growth. But to increase the customer growth at PT. Sampurna Rona Selaras MSMEs by fixing the Channel won't solve the problem. Because business models were an activity system, which has interactions and interdependencies between building components. It was necessary to propose a new business model including Channels and Customer Relations which will affect their Key resources and Key activities.

<table>
<tr>
<td rowspan="2">Key Partner

• Raw Material Supplier
• Sales (Partner)</td>
<td>Key Activities

• Direct Selling
• Production
• Delivery
• After Sales Service</td>
<td rowspan="2">Value Proposition
• Local products with competitive prices.
• Ease, better quality compared to cement mortar, sand on site (job site mix)</td>
<td>Customer Relationship
• Personal assistance
• WA, email, telephone
• WoM/ Reference
• After Sales Service
• Website (in active)</td>
<td rowspan="2">Customer Segment

Organizational Characteristics:
• Small to medium contractor.

Geographical
Primary
• Jakarta, Bekasi, Tangerang, Bogor, Depok and Cikarang
Secondary
• Kalimantan, Palembang</td>
</tr>
<tr>
<td>Key Resource
• Asset (tools, building, vehicle, computer)
• Product formula</td>
<td>Channels
• Salesman (partner)
• Owner UMKM</td>
</tr>
</table>

Cost Structure	Revenue Stream
• *Fixed cost:* Salary, tax, electricity, water • *Variable cost:* raw material, transportation maintenance, incentive	• Product Sales

Figure 2. Business Model Canvas Existing - Big Picture Assessment

Sales Forces Development - Channels

Channels are customer touch points that play an important role in the customer experience. Channels serve several functions, including raising awareness among customers about a company's products and services, helping customers evaluate a company's value proposition, allowing customers to purchase specific products and services, delivering a value proposition to customers, and providing post-purchase customer support. In the B2B model, direct approach was used by PT. Sampurna Rona Selaras. Sales forces become a crucial part because all the functions are majorly delivered by the salesperson.

The lack of sales personnel either in terms of quantity or quality will affect the most revenue in the end. Instead of relying solely on the owner as a salesperson and one external salesperson in the existing situation, we suggest developing a sales force internally. By adding salesperson PT. Sampurna Rona Selaras will acquires additional sales point or increase direct selling reach.

Digital Media Development – Channels, Customer Relationship

The Customer Relationships describes the types of relationships a company establishes with specific Customer Segments. They should clarify the type of relationship it wants to establish with their Customer Segment. Customer relationships may be driven by the following motivations: Customer acquisition, Customer retention, and Boosting sales (upselling). For PT. Sampurna Rona Selaras the relation should be driven by customer acquisition.

Using traditional media and relying on existing customer Mouth to Mouth (MOM) makes the reach of these MSMEs limited. There are several digital approaches in digital marketing ecosystem that we could utilize. In this study we propose websites and social media as initial stage. There are some recommended actions to be applied to enhance the website. First, implemented search-enhancing keywords for search engine optimization (SEO). Here we choose some keywords that will be entered on the website to make it easier for the website to be on the first page of Google search. In addition to SEO, we also feel the need to install google ads so that the website is optimized not only organically, but also with paid advertising. In the website interface, we put a link into a WhatsApp number. Whit this we integrated the Channel and website as communication tools.

The next was social media, we proposed to have LinkedIn business account and Instagram. Social media has function for retargeting, and many media Channels will increase the reach of communication.

<table>
<tr>
<td rowspan="2">Key Partner

• Raw Material Supplier
• Partner Sales
• Digital Marketing Partner</td>
<td>Key Activities

• Digital Media Promotion
• Direct Selling
• Production
• Delivery
• After Sales Service</td>
<td rowspan="2">Value Proposition

• Local products with competitive prices.
• Ease, better quality compared to cement mortar, sand on site (job site mix)</td>
<td>Customer Relationship

• Personal assistance
• WA, email, telephone
• WoM/ Reference
• After Sales Service
• Customer acquisition by new Website
• Retargeting social media</td>
<td rowspan="2">Customer Segment

Organizational Characteristics:
• Small to medium contractor.

Geographical
Primary
• Jakarta, Bekasi, Tangerang, Bogor, Depok and Cikarang
Secondary
• Kalimantan, Palembang</td>
</tr>
<tr>
<td>Key Resource

• Asset (tools, building, vehicle, computer)
• Product formula
• Internal Sales
• Domain Website, Social media account</td>
<td>Channels

• Direct selling,
• Salesman(partner)
• Salesman (Internal)
• Web Sales</td>
</tr>
<tr>
<td colspan="3">Cost Structure
• Fixed cost: Salary, tax, electricity, water, website, and social media activation cost
• Variable cost: raw material, transportation maintenance, incentive, digital marketing partner retainer cost</td>
<td colspan="2">Revenue Stream
• Product Sales</td>
</tr>
</table>

Figure 3. New Business Model Canvas

4.2 Implementation

Developing sales force - internal sales has three challenges in this research for implementation. First sales will increase operational costs but potentially do not have satisfying revenue. Second, how to find salespeople who are qualified because this product requires knowledge of products and general construction knowledge. And the third one is how to monitor or make sure the new addition sales force work properly

Answering those questions, the following actions was done. For the first challenge we are making a cost and benefit analysis. With this the owner can have a full picture of the benefits he potentially will acquire every time he adds a salesperson. And gets an idea of the costs that will be issued generally and can make decisions objectively based on the calculations carried.

Second, new sales training needs was held. The training must be short, simple, and measurable. So, a fast-track sales training was proposed with a three-month evaluation specially designed to improve sales skills. The training majorly consists of three parts. Product knowledge training to impart necessary information of the product, which is held in the office, second part is shadowing where after the product knowledge training, the new salesperson directly goes to the customer to do presentation but accompanied by the experienced salesperson. Third part was on the job training, for 2-3 month with initial targets and KPIs. Every end of sequence an evaluation needs to be carried out. Third one to make sure the new sales activity run properly, a simple flow chart for sales was create. Due the nature of MSMEs, the flow chart consists of a simple explanation and can be improved over time according to the needs of the organization

First action in developing digital media was to find a third party for digital marketing services. Finding the right partner is the key to the next activity because we want to make sure our target will be delivered by them. After that all the action start from creating website, SEO and google ads. For social media we decide to be carried in the second stage, because we want to see the impact of the website first. Digital development was never a consideration by the owner before, so it was important to see the initial result.

Implementing new business model canvas has a time constraint, we predicted to at least three months to get the results. But regardless of the situation, we have some preliminary results to lay the groundwork for further development. From the evaluation of the first month of internal sales, 14 potential customers were obtained. This were more we if compared to PT. Sampurna Rona Selaras customers growth per year, with average of 5,5 account between 2017-2019. The next result was the digital marketing development. From the SEO some of the selected keywords make the website on the first page of a google search. And there were two requests via WhatsApp message link connected to the website.

5. CONCLUSIONS

The problems faced by PT. Sampurna Rona Selaras was the low growth of customer due inadequacy in utilizing their Channel in their existing business model. Channels were not integrated and have a low reach. The solutions to these problems are a new business model with improvement in Channel and Customer Relations that also affect Key Activities, Key Resources, and Key Partners. After all the implementation we also can conclude that by adding internal sales, increases the reach of Channels that increase the company's ability to deliver its value proposition. Digital Marketing is a means of relationship with customers and is a part of additional Channel.

We suggest for the company to keep developing the Channel by adding internal sales or in other words B2B point of sale as well as develop social media further as an addition to the digital marketing ecosystem.

REFERENCES

Arora, A., Harrison, L., Plotkin, C. L., Magni, M., & Stanley, J. (2022). *The new B2B growth equation*.

Bastos, W., & Moore, S. G. (2021). Making word-of-mouth impactful: Why consumers react more to WOM about experiential than material purchases. *Journal of Business Research*, *130*(December 2019), 110–123. https://doi.org/10.1016/j.jbusres.2021.03.022

BPS. (2021). Pertumbuhan Ekonomi Indonesia Triwulan IV-2020. *Www.Bps.Go.Id*, *13*, 12. https://www.bps.go.id/pressrelease/2021/02/05/1811/ekonomi-indonesia-2020-turun-sebesar-2-07-persen--c-to-c-.html

Cravens, D. W., & Piercy, N. F. (2009). *Strategic Marketing Ninth Edition*.

Creswell, W. J., & Creswell, J. D. (2018). Research Design: Qualitative, Quantitative adn Mixed Methods Approaches. In *Journal of Chemical Information and Modeling* (Vol. 53, Issue 9). file:///C:/Users/Harrison/Downloads/John W. Creswell & J. David Creswell - Research Design_ Qualitative, Quantitative, and Mixed Methods Approaches (2018).pdf%0Afile:///C:/Users/Harrison/AppData/Local/Mendeley Ltd./Mendeley Desktop/Downloaded/Creswell, Cr

Itani, O. S., Agnihotri, R., & Dingus, R. (2017). Social media use in B2b sales and its impact on competitive intelligence collection and adaptive selling: Examining the role of learning orientation as an enabler. *Industrial Marketing Management*, *66*(May), 64–79. https://doi.org/10.1016/j.indmarman.2017.06.012

Lanzolla, G., & Markides, C. (2021). A Business Model View of Strategy. *Journal of Management Studies*, *58*(2), 540–553. https://doi.org/10.1111/joms.12580

Massa, L., Tucci, C., & Afuah, A. (2017). A Critical Assessment of Business Model Research. *Academy of Management Annals*, *11*, 73–104. https://doi.org/10.5465/annals.2014.0072

Mcpheat, S. (2011). *Developing an Internet Marketing The Internet Marketing Academy Developing an Internet Marketing Strategy*. web: www.internetmarketingacademy.com

Osterwalder, A., & Pigneur, Y. (2010). *Business Model Generation* (T. Clark, Ed.). John Wiley & Sons, Inc.

Patton, M. Q. (2002). Two Decades of Developments in Qualitative Inquiry: A Personal, Experiential Perspective. *Qualitative Social Work*, *1*(3), 261–283. https://doi.org/10.1177/1473325002001003636

Solomon, M. R. (2017). Consumer Behavior: Buying, Having, and Being. In *Essex: Pearson*. http://www.pearsonmylabandmastering.com

Teece, D. J. (2010). Business models, business strategy and innovation. *Long Range Planning*, *43*(2–3), 172–194. https://doi.org/10.1016/j.lrp.2009.07.003

Tiwary, N. K., Kumar, R. K., Sarraf, S., Kumar, P., & Rana, N. P. (2021). Impact assessment of social media usage in B2B marketing: A review of the literature and a way forward. *Journal of Business Research*, *131*, 121–139. https://doi.org/10.1016/j.jbusres.2021.03.028

Viki, T., Toma, D., Gons, E., Faulkner, R., Toma, D., & Gons, E. (2017). *The corporate startup : how established companies can develop successful innovation ecosystems / Tendayi Viki, Dan Toma, Esther Gons.* https://encore.exeter.ac.uk/iii/encore/record/C__Rb4274702?lang=eng

Zott, C., Amit, R., & Massa, L. (2011). The Business Model: Recent Developments and Future Research. *Journal of Management*, *37*(4), 1019–1042. https://doi.org/10.1177/0149206311406265

SOCIAL MEDIA STRATEGY IMPLEMENTATION TO REACH CUSTOMER SEGMENTATION AND CUSTOMER RELATIONSHIP AT CULINARY MSMES (BUSINESS COACHING CASE)

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ABSTRACT

The number of MSMEs has growing significantly in more than a decade. MSMEs became the largest contributor to GDP in Indonesia both before and after the Covid-19 pandemic hit. Moreover, the competition whether from another MSMEs or large companies that have the same target market are also a threat. In pandemic situation, there are restrictions on activities in public areas which make people must reduce their activities. Competitors can adapt to the situation by utilizing technology. Therefore MSMEs must also find ways to develop and maintain their business. The purpose of this Business Coaching is to help one of the micro scale MSMEs in the culinary industry called BSI Meatballs (Super Ribs Meatballs) to implement communication channels using social media strategy in their business. Data retrieved using qualitative methods in the form of in-depth-interviews and observations to describe the current situation in this MSMEs that then are mapped into the Business Model Canvas and analyzed by the SWOT assessments to find out the root cause of the problems that occur. The solutions offered are then mapped into the Business Model Innovation. This research is expected to reach customer segmentation relationship of BSI Meatballs by implementing social media strategy using Instagram.

Keywords: micro small and medium enterprises, business model innovation, business channel, business coaching, digital marketing, customer relationship.

1. INTRODUCTION

Micro, small, and medium enterprises (MSMEs) are the major players in Indonesia's domestic economy. The number of MSMEs constantly growth since 1998, according to Statistical Bureau of Indonesia (BPS) there were around 36,8 million units MSMEs in Indonesia. It is continuously growing in a decade, in 2018 there are around 64,2 million units of MSMEs in Indonesia. In 2019, just before the pandemic the total number of MSMEs in Indonesia reach 65,5 million units. The numbers of MSMEs equal to 99,9 % of total numbers of business units in Indonesia. These MSMEs contribute around 60,51 % to Indonesia's Gross Domestic Product (GDP). Based on Katadata (2021) There are around 119,6 million of people work for MSMEs in Indonesia. Cited from nasional.kontan.co.id (2024) MSMEs has become the largest contributor to Gross Domestic Product both before and after the Covid-19 pandemic hit. In 2020, MSMEs contribute around 61.07% of National GDP. Meanwhile, in 2021 MSMEs are targeted to contribute around 62.36% to GDP and increase more in 2024. MSMEs need to get more attention

and support because of their contribution to not only 60.4% of total investment but also absorbing 97% of the total workforce in Indonesia. One of the biggest challenges that MSMEs faces today is the Covid-19 pandemic, which has impacted all areas of the economy, including the Creative Industry. However, the coordinator minister for Economic Affairs Airlangga Hartarto said that based on observations from various indicators, the recovery was starting to be seen from the consumption side (Bisnis.com, 2021).

Apart from the Covid-19 pandemic, competitors are still a threat to MSMEs. Not only do they compete with other MSMEs, but also with large companies. Moreover, competitors can adapt to the situation by utilizing technology. MSMEs must find ways to develop and maintain their business. Agostini et al. (2014) describe Besides Covid and other competitors, MSMEs are facing the limitation of resource and money constraints and need more effort to conduct their branding activities. According to research of Sidi & Yogatama (2017), digital media marketing can minimize the impact of Covid-19 by increasing marketing efficiency. Batra & Keller (2016) defined that Digital marketing is a marketing strategy using digital channels to promote products and services. One of the Digital Marketing techniques that can be applied to MSMEs is social media marketing. Kaplan & Haenlein (2010) describe that social media is a platform that allows people to build their networks and exchange knowledge with others if there is an internet network. Khajuria & Rachna (2017) indicates by using social media, companies can increase brand awareness, association, and brand quality, affecting brand equity.

During the Covid-19 pandemic just like other business units, MSMEs also have to adapt to various existing conditions. The increasing number of MSMEs shows that small businesses can survive and even continue to grow. The ability to adapt to the business environment and technology during a pandemic is the key. Unfortunately, the business has not applied "social-media" strategy to reach its customers and develop relationship. Therefore, this study aims to propose Social Media strategy properly to develop small and medium sized of MSMEs culinary industry. The purpose of this case study with Business Coaching Approach is to propose innovation solutions (innovative business model) to manager or owner of BSI Meatballs (Super Ribs Meatballs) within the framework that the manager or owner of the business can solve his own business problems for better business performance. We apply Business Coaching approach and business model innovation as foundation of analysis in facilitating business' manager or owner to define and develop his new business model.

2. LITERATURE REVIEW

We apply business model, innovation, and strategic entrepreneurship framework. According to, Business Model Canvas (BMC) is a tool used to describe how an organization creates, delivers, and captures value. BMC consists of nine blocks namely Customer Segments, Value Proposition, Channel, Customer Relationships, Revenue Streams, Key Resources, Key Activities, Key Partners, and Cost Structure. The focus of the block in this paper is channels and customer relationship. According to Osterwalder (2010) Channels is a way of how a company delivers the value proposition to customers through communication, distribution, and sales channels (Osterwalder, 2010). According to (Merrilees, 2016), brand awareness can be built by social media brand communication that allows business to post interesting information about their product and services to attract their consumers. Osterwalder (2010) has stated Customer relationship is a tool to that describe the type of relationship a company builds with its customers. There are three types of customer relationship motivation according to Osterwalder (2010), namely acquisition, retention, and upselling.

According to Schneider (2013) the innovation business model describes how an innovation is conducted. BMI can lead us to create new value in reaction to environmental changes. Schneider (2013) has stated there are four business model approaches, the first approach is applied in this paper, namely the organizational aspect. The other three dimensions of business model innovation approach are value proposition innovation, environmental approach, product & service, and perspective approach.

3. METHODS

Data and information needed are collected by business coaching approach. We analyze data and information by referring to the concept of business model innovation, business model canvas, and both concepts are within the framework of business coaching approach.

Data required in this research was collected using primary data. Data collection will be conducted using qualitative approach. Cooper & Schindler (2019) define that Qualitative approach is techniques that aim to describe, solve problems, and to understand phenomena in the social world. This technique is considered appropriate to find out the problems that exist in MSMEs. The qualitative method used focuses on the business itself, focusing on the internal and external problems of MSMEs. Primary data retrieval conducted using qualitative methods that was collected by interviewing the owner and customers. Cooper & Schindler (2019) explain Interviews are conducted when the interviewer can ask questions so that the object under study can provide information to be explored in depth and quality data is obtained. Semi Structured type of interview that involved twenty respondents used in this study conducted face to face to ask specific questions using business model canvas framework as guidance and then follow every individual's thought. Besides interviews, data collection is also done by direct observations to the field to see consumer interactions, MSMEs locations, atmosphere, and services at BSI Meatballs.

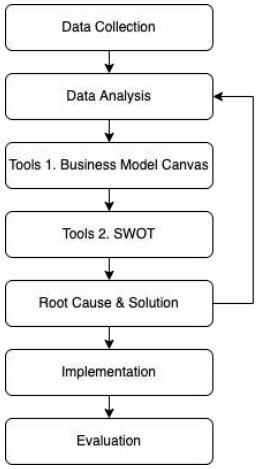


Figure 1. Research Methods

The data collected will be processed using further analysis by mapping nine building blocks in business model canvas framework to define the current situation of how the company delivers value and money (Osterwalder & Pigneur, 2010). Each block is then analyzed by using SWOT (Strength, Weakness, Opportunity, Threat) framework to define focus areas where improvements are needed. The analysis is expected to provide knowledge regarding the most crucial problems or

improvements that must be raised in this business coaching followed by implementation and evaluation.

4. RESULTS

Based on the results of observations and interviews with the owner, the owner already has knowledge of BMC and has implemented it well. However, there are components that have not been found and or need to be added from the existing business model. In Customer Relationships, relationships with customers are only done by buy one get one promotion when the outlet was opened for the first time. On the other blocks, they are also communicate their value to their segmented customers once when the outlet just opened for the first time by giving brochure to passersby.

BSI Meatballs, especially the Kedoya branch, is a newly opened business, so it requires efforts to introduce even greater products to customers. Utilization of social media is one way that can be done to introduce products with a wider and more precise target. In addition, efforts are also needed to attract customers to come to the outlet by giving discounts. Currently BSI Meatballs branch only accepts direct purchases at outlets, even though the pandemic situation will affect Government Regulations by limiting community activities in public places. In Customer Segments, segmentation is limited to individuals. BSI Meatballs is a large business with adequate factories and number of outlets to increase corporate segmentation. In the Cost Structure, there are no costs incurred for land rental costs. Even though the land lease is provided free of charge by partners, the cost of rent must still be included in the expenses. This is necessary to know more about the real financial condition of BSI Meatballs.

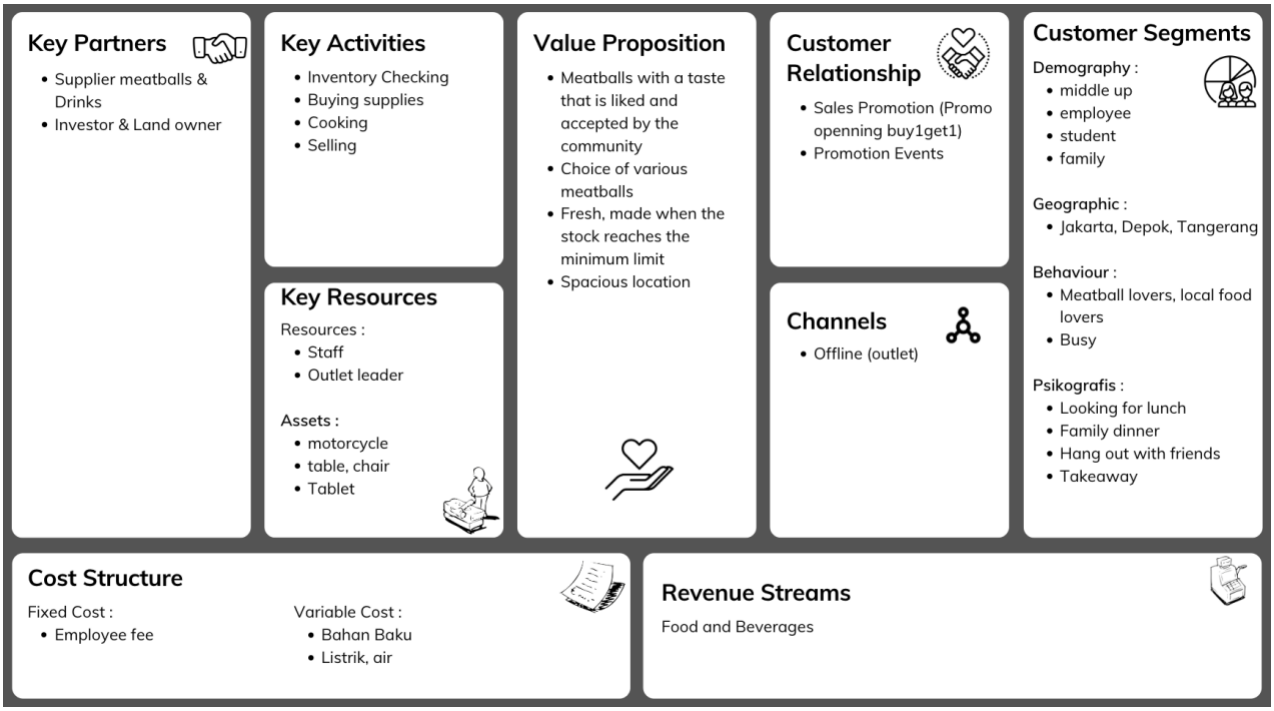


Figure 2. BSI Meatballs Business Model Canvas Existing

Based on the SWOT (Strength, Weaknesses, Opportunity, and Threat) assessment in each Business Model Canvas building block (Table 1), there are two blocks that still have shortcomings and need to be improved. These blocks are Customer relationship and Channels. Customer Relationship is a relationship that exists between MSMEs and their customers. MSMEs still have weak relationships because their relationship is not suitable with customer segmentation. Moreover, MSMEs do not have the right channels to communicate their value proposition to their customers.

Table 1. SWOT Analysis Based on BMC

Blocks	Strength	Weakness	Threat	Opportunity	Average
Channels		62,86	100	92,00	**84,95**
Customer Relationship		75,00	80,00	76,67	**77,22**
Value Proposition	75,00		60,00	64,00	66,33
Key Partnership	60,00		73,33	64,00	65,78
Revenue Stream	17,50		66,67	68,00	50,72
Customer Segmentation	26,67		70,00	53,33	50,00
Key Resources	13,33		70,00	55,00	46,11
Key Activities		5,00	60,00	60,00	41,67
Cost Structures	35,00		40,00	40,00	38,33

BSI Meatball MSMEs needs to develop channels that can reach new customers. This channel will also improve relationships with customers and create loyalty to BSI Meatballs. Keplan & Haenlein (2010) explain that social media is a platform that allows people to build their networks and exchange knowledge with others if there is an internet network**.** In Indonesia, the use of social media has been huge and is still growing. According to We Are Social (2021) Instagram is the most popular social media in Indonesia. Moreover, Instagram as a social media is a channel that has a low cost to implement. It is considered suitable for micro scale business. In this research, Instagram is used as a social media platform to communicate the value of MSMEs.

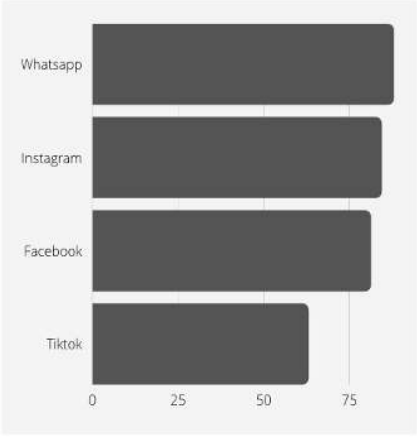


Figure 3. The Most Used Social Media in Indonesia

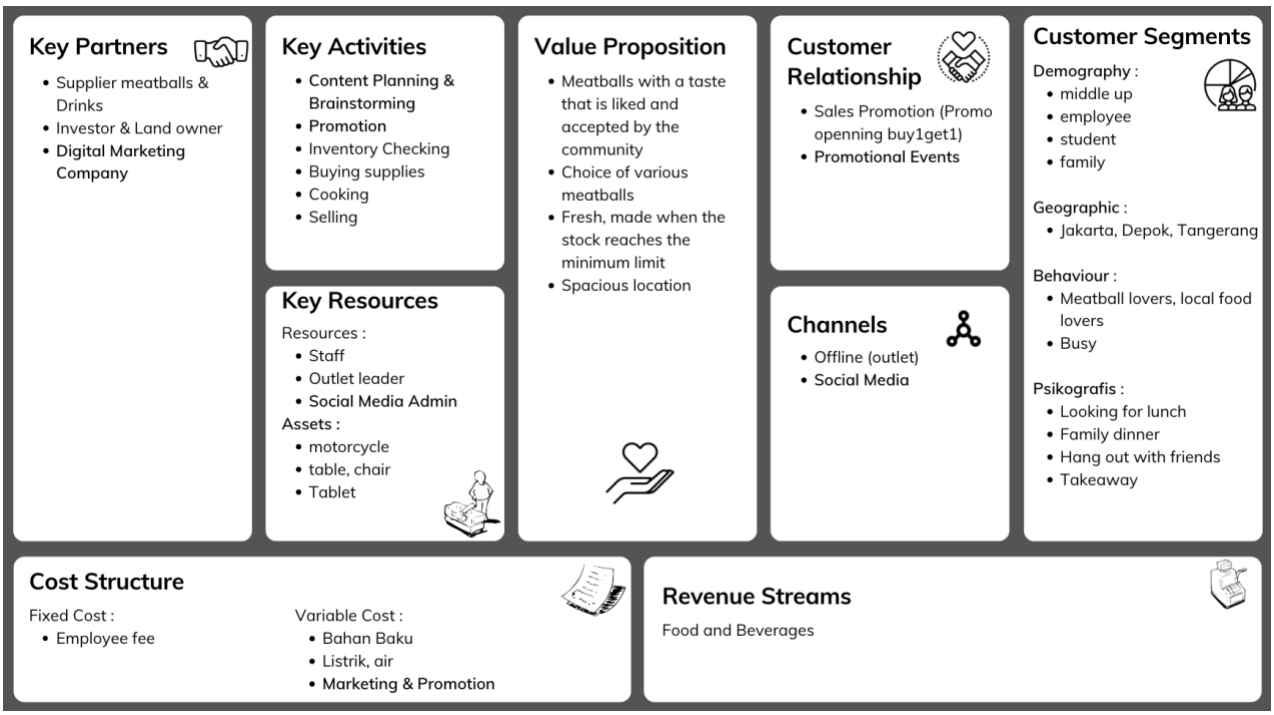


Figure 4. BSI Meatballs Business Model Canvas Existing

Social media implementations have been done in BSI meatballs included logo, slogans, captions, Linktree, product photos, and content in the form of Instagram feeds and reels within two months. The results shows that the attempt to create a communication channel using Instagram has shown promising results, proven by positive engagement on the MSMEs Instagram Insights (Figure 2).

Table 2. MSMEs Instagram Insights

Date	Post	Profile Visit	Reach	Impression	Interaction	Followers
25 Apr - 6 May	10	201	702	1,835	85	351
7 May - 23 May	10	157	1,315	2,723	236	407
25 Apr - 23 May	20	358 (-21,89%)	2,017 (+87,32%)	4,558 (+48,29%)	318 (+177,54%)	407 (+2,29%)

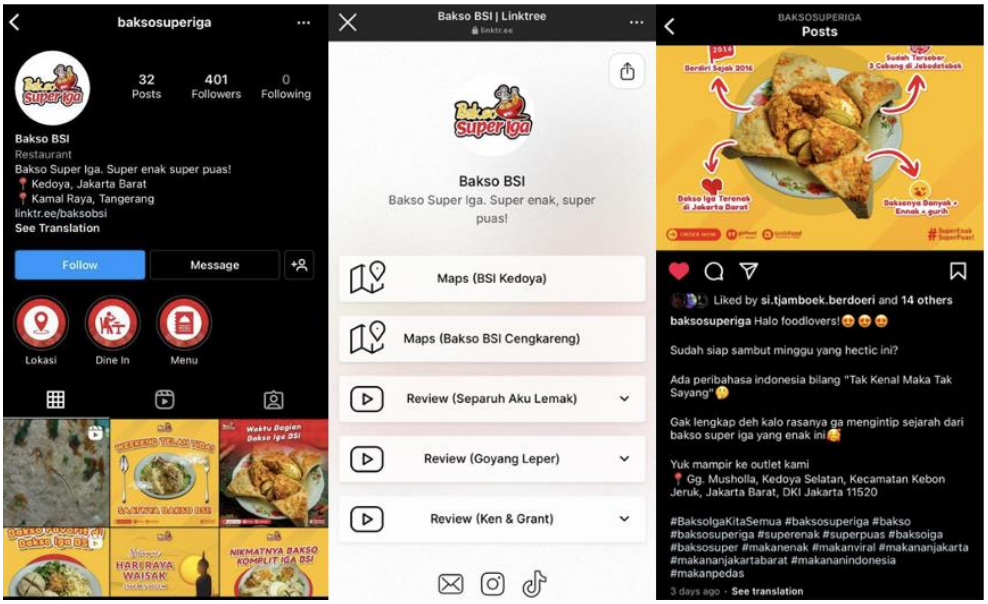


Figure 5. MSMEs Instagram Profile

6. CONCLUSIONS

BSI Meatballs MSMEs must implement the right strategy to survive among competitors in pandemic situations. The result of the study shows that the efforts to create communication channels using Instagram that included logo, slogans, campaign, captions, Linktree, product photos, location tag, and content in the form of Instagram feeds and reels within two months has shown promising results in terms of raising awareness to BSI Meatballs MSMEs, proved by the positive engagement on MSMEs' Instagram insights.

Although the increase in profit is not yet shown significantly because Instagram has only been built in limited times, social media tools must remain active to retain, maintain, and convert followers into buyers. Future implementation of business model and its marketing strategy must collaborate with Key Opinion Leaders (KOL) or influencers to encourage purchases.

The study has covered one unit of business that needs marketing development to grow.

REFERENCES

Batra, R., & Keller, K. L. (2016). Integrating Marketing Communications: New Findings, New Lessons, and New Ideas. *Journal of Marketing*, *80*(6), 122–145. https://doi.org/10.1509/jm.15.0419

Belch, G. E., & Belch, M. A. (2018). *Advertising and Promotion: An Integrated Marketing Communications Perspective*. (11th ed.) McGraw Hill Education.

Chaffey, D., & Ellis-Chadwick, F. (2019). *Digital Marketing* (7th ed.). Pearson (Intl).

Cobb-Walgren, C. J., Ruble, C. A., & Donthu, N. (1995). Brand Equity, Brand Preference, and Purchase Intent. *Journal of Advertising*, *24*(3), 25–40. https://doi.org/10.1080/00913367.1995.10673481

Farjam, S., & Hongyi, X. (2015). Reviewing the Concept of Brand Equity and Evaluating Consumer-Based Brand Equity (CBBE) Models. *The International Journal of Management Science and Business Administration*, *1*(8), 14–29. https://doi.org/10.18775/ijmsba.1849-5664-5419.2014.18.1002

Instagram. *Hitting 500,000 advertisers | Instagram Business blog | Instagram for Business*. (2016). Instagram Business Team. https://business.instagram.com/blog/500000-advertisers

Kaplan, A. M., & Haenlein, M. (2010). Users of the World, Unite! The Challenges and Opportunities of Social Media. *Business Horizons*, *53*(1), 59–68. https://doi.org/10.1016/j.bushor.2009.09.003

Keller, K. L. (2009). Building Strong Brands in a Modern Marketing Communications Environment. *Journal of Marketing Communications*, *15*(2–3), 139–155. https://doi.org/10.1080/13527260902757530

Iesha Khajuria, & Rachna (2017). IMPACT OF SOCIAL MEDIA BRAND COMMUNICATIONS ON CONSUMER-BASED BRAND EQUITY. *Indian Journal of Commerce & Management Studies*, *VIII*(3), 124–131. https://doi.org/10.18843/ijcms/v8i3/14

Malesev, S., & Cherry, M. (2021). Digital and Social Media Marketing-Growing Market Share for Construction SMEs. *Construction Economics and Building*, *21*(1), 65–82. https://doi.org/10.5130/AJCEB.v21i1.7521

Merrilees, B. (2016). Interactive Brand Experience Pathways to Customer-Brand Engagement and Value Co-Creation. *Journal of Product and Brand Management*, *25*(5), 402–408. https://doi.org/10.1108/JPBM-04-2016-1151

Osterwalder, A., & Pigneur, Y. (2010). *Business Model Generation*. Wiley.

Rana, N. P., Barnard, D. J., Abdullah, A. M. A., Rees, D., & Roderick, S. (2019). Exploring Barriers of M-Commerce Adoption in SMEs in the UK: Developing a Framework Using ISM. *International Journal of Information Management*, *44*, 141–153. https://doi.org/10.1016/j.ijinfomgt.2018.10.009

Verbeke, W., Sioen, I., Brunsø, K., Henauw, S., & Camp, J. (2007). Consumer Perception versus Scientific Evidence of Farmed and Wild Fish: Exploratory Insights from Belgium. *Aquaculture International*, *15*(2), 121–136. https://doi.org/10.1007/s10499-007-9072-7

We Are Social, & Hootsuite. (2022, February). *Digital 2022: Another Year of Bumper Growth*. We Are Social.

COAL GASIFICATION FURNACE (CGF) PERFORMANCE EVALUATION USING INTEGRATED RCA-MLR (ROOT CAUSE ANALYSIS-MULTIPLE LINEAR REGRESSION) TOWARD SUSTAINABILITY PRODUCTION OF SYNGAS

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ABSTRACT

The development of Coal Downstream Industry has a big challenge in creating clean coal technology, especially Coal Gasification. The Smelter Grade Alumina (PSGA) company has technology of gasification, but there are problems like low heating value < 5550 kJ/m3, Contribution of CO_2 ± 354,956.85 tpy, Furnace Downtime for 3-4 weeks due to slagging, and ash handling problems. That problems effected to performance of Coal Gasification Furnace (CGF). This study aims to identify factors that cause decline CGF performance, Optimize production process indicators to increase CGF performance, and give recommendations. The method use integration of RCA-MLR (Root Cause Analysis-Multiple Linear Regression) approach. The research result found root cause of problem, namely the absence of an optimal CGF temperature regulation mechanism. It was found that the variable steam, gasification wind, fluidization wind, and type of furnace had an effect on increasing the CGF temperature through the MLR approach. Through the multiple linear regression model, the results obtained are high quality Coal Gas products with a Heating Value Coal Gas value of 5595 kJ/m3 and there is no downtime for CGF due to slagging problems. The application of the multiple linear regression model can save costs of Rp. 2,607,942,761,-/month.

Keywords: Coal Gasification Furnace, Root Cause Analysis, Multiple Linear Regression

1. INTRODUCTION

The development of the Coal Downstream Project is one of the strategic projects of the Indonesian state to realize its commitment to the development of Renewable Energy, particularly the development of coal gasification technology. According to the Director General of Mineral and Coal at the Ministry of Energy and Mineral Resources, Indonesia's coal reserves to date have reached 38.84 billion tons. With an average coal production of 600 million tons per year. Under these conditions, the coal downstream project has great potential to be developed. The Smelter Grade Alumina (PSGA) company is one of the smelter companies that pioneered the development of coal gasification technology. The biggest challenge going forward is to create environmentally

friendly coal gasification technology in order to realize the SDG's (Sustainable Development Goals) by 2030.

Coal gasification is the process of convert coal into gaseous products that can be used for fuel (syngas) or chemical industry raw materials through the combustion process. Syngas is a mixture of CO, CO_2, H_2, CH_4, etc obtained from the gasification reaction of coal at high temperatures. According to Maitlo G. et.al (2022), the application of syngas in the industrial world is quite broad, including in gas turbines, combustion engines, biocatalytic, and catalytic for the synthesis of alcohol, hydrocarbons, and other esters. So that syngas becomes one of the most competitive and sustainable renewable energy options.

Smelter Grade Alumina (PSGA) company as an Alumina smelter company, its production activities are strongly supported by the Coal Gasification Plant to produce coal gas as fuel in the calcination process. Coal Gasification Technology is expected to become an environmentally friendly technology in the future. However, in practice several problems were found, such as low product quality with a Heating Value Coal Gas value of < 5550 kJ/m3, the effect of GHG (Greenhouse gas) with a CO2 contribution of ± 354,956.85 tons/year, slagging problems that impacted Furnace Downtime during ± 3-4 weeks, and ash handling problems in Fly Ash as a result of Coal Gasification activities amounting to ± 62,000 tons/year. These four problems have an impact on the performance of the Coal Gasification Furnace (CGF).

This study aims to identify the indicators that have the most influence on CGF performance, optimize the production process to improve CGF performance, and provide recommendations for improvements to CGF to realize sustainable syngas production. The method used in this research is the integration of the RCA-MLR (Root Cause Analysis – Multiple Linear Regression) method. The RCA method is used to describe and get the root cause of the decline in CGF performance. Then from the root of the problem selected, the production process indicators were optimized by looking at the relationship between the dependent variable and the independent variable through multiple linear regression (MLR) models.

2. LITERATURE REVIEW

2.1 Coal Gasification Technology

Coal gasification is the process of synthesizing coal gas where there is a thermochemical process of converting solid fuel into gas. The gaseous products consist of carbon monoxide (CO), carbon dioxide (CO_2), hydrogen (H_2), methane (CH_4), slightly higher chain hydrocarbons (ethene, ethane), water vapor (H2O), nitrogen (if using air as an oxidant) , and various contaminants such as charcoal particles, dust, tar, high chain hydrocarbons, alkalis, ammonia, acids, and similar compounds. This is achieved by reacting the material at high temperatures (>700°C), with incomplete combustion reactions (non-stoichiometric), with controlled or limited amounts of oxygen and/or water vapor (Nugroho, 2020).

According to Antonio et al (2016), in the Coal Gasification Furnace, there are several reactions to convert coal into coal gas (Coal Gas), including:

(a) Oxidation Process (exothermic stage)

This oxidation process is needed to obtain the heat energy needed in the endothermic process, as well as to maintain the operating temperature of the furnace at a certain value. This oxidation process is carried out under conditions of lack of oxygen according to the stoichiometric ratio, so that only part of the fuel is oxidized. Although the partial oxidation involves all carbon compounds (including tar), it can be simplified because only the char and hydrogen contained in the syngas occur during the partial oxidation process.

(b) Drying Process (endothermic stage)

Drying consists of evaporation of water vapor contained in the raw material. The amount of heat required in this stage is proportional to the moisture content of the raw material. In general, the heat required comes from other stages of the process. Drying can be said to be complete when the temperature of the coal raw material reaches 150 °C.

(c) Pyrolysis Process (endothermic stage)

This phase consists of the thermochemical decomposition of the carbon-containing material, in particular for the cracking of chemical bonds to occur with the formation of molecules with lower molecular weight values. At this pyrolysis stage, it is possible to obtain different phases in the coal gas content, such as solid fraction, liquid fraction, and gas fraction.

The solid fraction contained in coal gas ranges from 5-10% by weight for this type of fluidized bed gasifier. Meanwhile, for the fixed bed gasifier, the solid fraction content ranges from 20-25% by weight, has a high carbon content, and is characterized by a high heating value characteristic. This fraction includes the inert material contained in coal gas in the form of ash (ash) and a high carbon content fraction commonly called char (charcoal).

The liquid fraction contained in coal gas is commonly referred to as tar. This varies greatly depending on the type of gasifier used. For the downdraft gasifier type, it contains a liquid fraction of less than 1% by weight, while the bubbling bed gasifier contains a liquid fraction in the range of 1% - 5% by weight, and for the updraft gasifier it is in the range of 10% - 20% by weight formed by complex organic substances condensed at relatively low temperature.

The gas fraction generally ranges from 70-90% by weight of coal raw materials consisting of a mixture of gases that cannot be condensed (incondensable) at ambient temperature (ambient). This gas product is commonly called pyrolysis gas which consists of several compounds including Hydrogen (H), Carbon monoxide (CO), Carbon dioxide (CO_2), light hydrocarbons such as Methane (CH_4), and CnHm content (C2 or C3) hydrocarbons as well as a small amount of acid or inert gas (Nitrogen). This pyrolysis reaction occurs at temperatures ranging from 250-700 °C. The reaction is endothermic. As in the drying process, the heat required comes from the Oxidation Process stage.

(d) Reduction Process or Gasification (endothermic stage)

This reduction or gasification process involves all the products formed in the previous process. In this phase, a mixture of gas and charcoal reacts with each other to produce the final product, namely syngas. At this stage the majority of reactions are reversible.

2.2 *Coal Gasification Furnace* (CGF) Performance

According to Ting Wang & Gary Stiegel (2017), the characteristics of the gasification results depend on the type of gasifier used. In general, three types of gasifiers can be classified as follows:

(a) Fixed bed gasifier: This type of gasification is mostly operated at low temperatures, requires little oxygen, coal residence time in the furnace is long, requires a lot of steam, and achieves low carbon conversion efficiency.

(b) Fluidized bed gasifier: This type of gasification is operated at moderate temperature, the residence time of coal in the furnace is relatively moderate, suitable for coal with high ash fusion temperature, and achieves moderate carbon conversion efficiency.

(c) Entrained Flow Gasifier: This type of gasification is operated at high temperature (>1220 ^{o}C or 2230 ^{o}F) with high reaction rate, produces molten slag, high oxygen demand for coal ratio (such as stoichiometric ratio), requires less steam, the residence time of coal in the furnace is relatively short in a few seconds, and achieves high carbon conversion efficiency.

According to Najwa et al (2019), the performance of coal gasification furnaces can be evaluated through four parameters including: (a) syngas yield, (b) calorific value of syngas (HHV or LHV), (c) efficiency cold/hot gasification, (d) conversion carbon (CCE/CCR). Of the four parameters can represent the performance of the Coal Gasification Furnace (CGF).

2.3 *Root Cause Analysis (RCA) Approach*

Root cause analysis (RCA) is a problem solving process to conduct an investigation into a problem, concern or discrepancy found. RCA requires investigators to find solutions to pressing problems and understand the fundamental or underlying causes of a situation and treat the problem appropriately, thereby preventing the recurrence of the same problem. It may therefore involve identifying and managing processes, procedures, activities, activities, behaviors or conditions (British Retail Consortium, 2018).

The steps taken before starting the Root Cause Analysis (RCA) method include:

(a) Define the problem (Define the non-conformity). At this stage, what must be known and clearly defined is what problem is currently happening, then explains the specific symptoms that indicate the occurrence of a problem.

(b) To investigate the root cause of the problem (investigate the root cause). This stage is the most important stage in RCA because when it is wrong to find the root cause of the problem, the action plan taken will not be able to solve the problem properly so it cannot avoid the same problem from happening again. At this stage, tools or methods will be used to explore the root cause of the problem.

(c) Proposing an action plan (create a proposed action plan). At this stage, a solution will be offered in the form of an action plan to prevent the problem from reappearing.

(d) Implement the action plan (implement the proposed action). At this stage it will be determined who is responsible for implementing the action plan, how to make the action plan run, then who the most important thing is to determine time scales, namely the time schedule and target for this implementation to be carried out.

(e) Monitoring (verification & monitoring of effectiveness). This action is very necessary to ensure that the changes or new activities implemented have actually been carried out in accordance with the proposed action plan. then this stage also helps provide confidence whether the corrective steps taken are appropriate to manage the root cause of the problem or even cause additional problems. Examples of activities that include monitoring and verification are internal audits which include newly implemented processes, making a checklist marking the completion of work for each modified process, checking at start-up, and others.

2.4 Multiple Linear Regression (MLR) *Approach*

Regression analysis is a method about the relationship of one dependent variable with one or more independent variables with the aim of estimating and/or predicting (on average) the dependent variable population from a known value or a fixed value of the independent variable (in repeated sampling) (Gujarati, 2004:19).

3. METHODS

3.1 Research Method

Research methodology is a way to obtain data with a specific purpose and use. In this study, the method that will be used by researchers is the RCA (Root Cause Analysis) method to select the root cause that affects the performance of the Coal Gasification Furnace. Then it will be continued with the MLR (Multiple Linear Regression) method to optimize the performance of the Coal Gasification Furnace from the model generated through the relationship of the independent variable with the dependent variable. These two methods will assist researchers in determining the priority of completion and optimization of the process so that gas products with high Caloric Value and environmentally friendly will be obtained with reduced production costs (cost). These two aspects are a strategy in realizing sustainable syngas production in the Coal Gasification Plant area.

3.2 Types and Sources of Data

3.2.1 Type of Data

The types of data needed in the preparation of this thesis are primary data and secondary data. Primary data can be obtained from:

a. The results of the Focus Group Discussion (FGD) directly with the Section Head and Engineer from the Smelter Grade Alumina (PSGA) Company regarding the problem of decreasing the performance of the Coal Gasification Furnace (CGF).
b. Field Observation

Meanwhile, secondary data can be obtained from:

a. Production report data of the Gas Plant Division
b. Process parameter data from the Distributed Control Room (DCS) in real time. (The predictor data used include Furnace Pressure (P), Slag Output Frequency (F), Gasification Wind Flowrate, Fluidization Wind Flowrate, and Steam Flowrate (S))

3.2.2 Source of Data

In conducting a Focus Group Discussion (FGD), the researcher held discussions with employees of the Smelter Grade Alumina (PSGA) Company who had 7 years of experience in strategic positions (experts).

4. RESULTS

In this chapter, the researcher will discuss, describe and analyze the priority of selecting process indicators that have the most significant influence on the Coal Gasification Furnace (CGF) with the RCA (Root Cause Analysis) approach. After obtaining the most dominant root cause and becoming a priority for process improvement or optimization, the next step is to look at the relationship between the dependent and independent variables using the MLR (Multiple Linear Regression) approach. From the integration of these two methods, a linear regression equation will be obtained that can be used to optimize the indicators of the production process.

4.1 *Root Cause Analysis (RCA) Approach*

Root Cause Analysis (RCA) is an in-depth process or technique to find the main factors underlying a problem. This method is used to fix or eliminate the cause and prevent the problem from recurring. The steps that can be taken in the application of the RCA method include Defining Problems (Define), Collecting Data (Measures), Identifying and analyzing possible causes (Analyze), Identifying Root Problems and Implementing Solutions (Improvement), and Supervising the Solutions. offered so that the problem does not recur (Control). Conceptually, this

step is the same as the implementation of Lean Six Sigma with the DMAIC concept which focuses on reducing the variance of defects that occur.

In this case, there is a decrease in the performance of the CGF (Coal Gasification Furnace) in the Coal Gasification Plant area at the Smelter Grade Alumina (PSGA) Company. This decrease will have an impact on the quality of SGA (Smelter Grade Alumina) during the calcination process for problems of low caloric value of coal gasification and environmental issues. This is evidenced by the application of gasification technology that has been applied to PSGA which is still less than the standard (Brenchmarking) that has been set, namely the Heating Value above 5550 Kj/m3. In addition, the Coal Gasification Plant also has a large contribution to the effect of GHG (Greenhouse Gas), namely by producing CO_2 of 354,956.85 tons per year or contributing to CO_2 emissions of 32.2% (second rank after Power Plant in PSGA). The fly ash produced from the processing of the Coal Gasification Plant is ± 42,000 tons/year, most of which is dumped into the reservoir (redmud). The performance parameters of the Coal Gasification Furnace (CGF) can be measured quantitatively through 4 parameters, including Yield Gas, Heating Value, Cold Gas Efficiency, and Carbon Conversion Efficiency.

From the description described above, the following are the results of the FGD (Focus Discussion Group) with the related team regarding the decline in the performance of the Coal Gasification Furnace (CGF) consisting of experts in the field of Coal Gasification which are displayed in the form of a Fishbone Diagram. The following is Figure 4.1 which displays the Fishbone Diagram of the problem of decreasing the performance of the Coal Gasification Furnace (CGF)

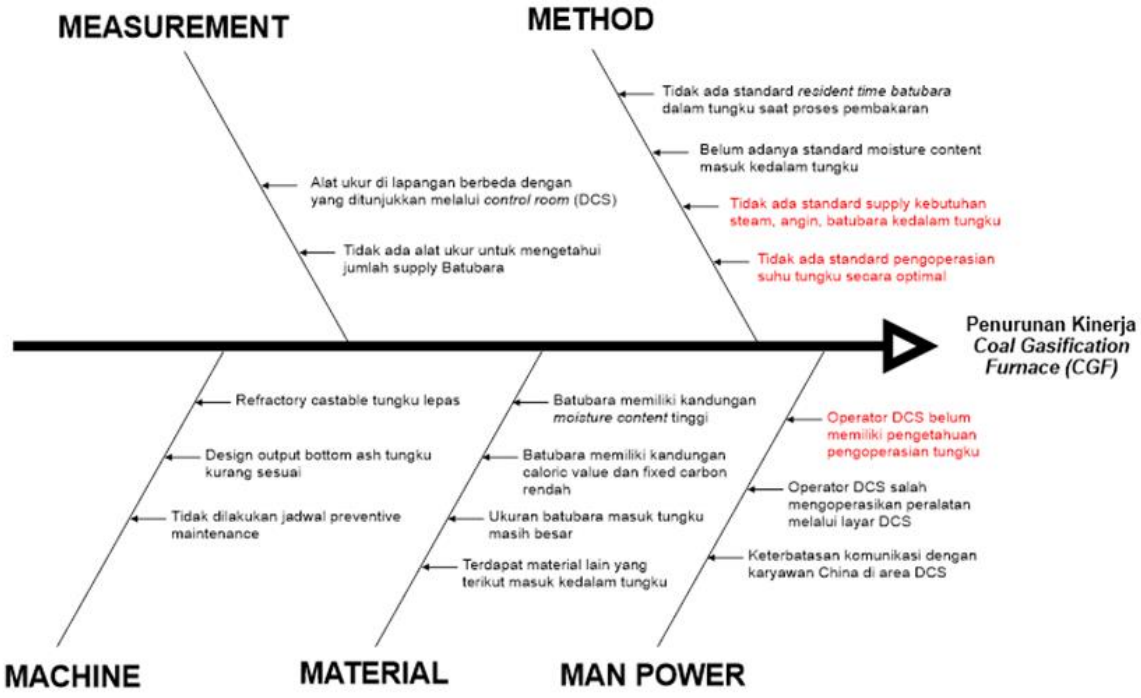


Figure 4.1 Fishbone diagram of Coal Gasification Furnace (CGF) Decline Performance

4.2 Multiple Linier Regression (MLR) Approach

From the results obtained through the Root Cause Analysis (RCA) method with fishbone diagram tools, the dominant root cause and priority for improving the performance of the Coal Gas Furnace (CGF) is by optimizing the production process indicators (in this case the operating

temperature of the furnace or Coal Gas Furnace). Then, multiple linear regression equation will be obtained by looking at the relationship between the dependent variable and the independent variable that affects the temperature of the Coal Gasification Furnace (CGF) using the MLR (Multiple Linear Regression) method. From the integration of the two methods, the most dominant root cause will be obtained which will be optimized for the production process indicators. The following is a schematic (Block Diagram) of the conversion process of coal into coal gas through the Gasification process:

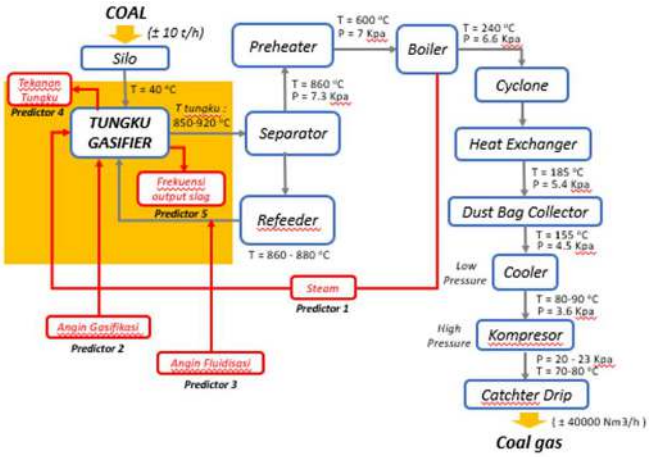


Figure 4.2 Block Diagram Coal Gasification Process

From Figure 4.2, it can be seen that the reaction temperature is one of the important factors in increasing the heating value of coal gas. Optimizing the temperature of the CGF (Coal Gasification Furnace) reaction is obtained through the identification of the dependent & independent variables that have an effect on increasing the temperature of the CGF (Coal Gasification Furnace) reaction. The dependent variable in this case is the CGF furnace temperature data (oC), while the independent variables in this case are steam data (kg/h), gasification wind (Nm3/h), fluidization wind (Nm3/h), pressure (Kpa) , slag output frequency (A), and furnace type.

The following shows the research model and hypothesis used in the Multiple Linear Regression (MLR) method to see the effect of the predictor variable (independent variable) on the response variable (dependent variable).

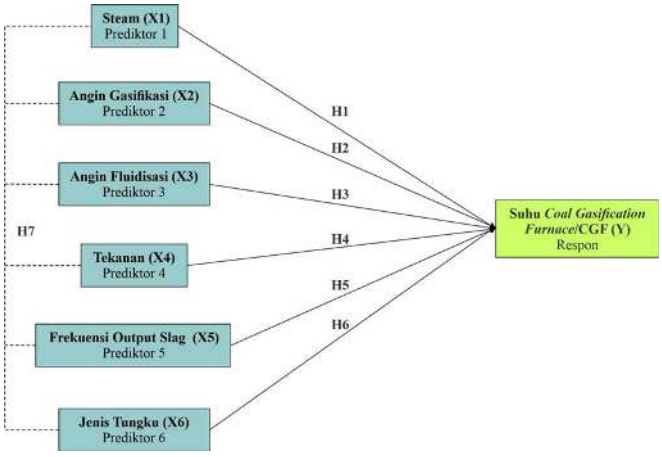


Figure 4.3 Hypothesis Model

From Figure 4.3, it is found that there are seven hypotheses for the effect of predictor variables (Steam, Gasification Wind, Fluidization Wind, Pressure, Slag Output Frequency, and Furnace Type) on the response variable (Coal Gasification Furnace Temperature).

From seven hypotheses that have been described, each hypothesis will be tested using the ANOVA test. The effect of each predictor variable (independent variable) on the response variable (dependent variable) will be seen for its effect, so that it can be concluded which predictor variables have a significant effect on the response variable or in this case an increase in the temperature of the Coal Gasification Furnace (CGF). From these results, multiple linear regression equations will be obtained that can be used to estimate the need for each predictor variable in order to achieve the response variable in an optimal state. In the MLR (Multiple Linear Regression) method, there are several stages carried out including the Instrument Test Phase, the Classical Assumption Test Phase, and the Data Analysis Phase.

5. CONCLUSIONS

Based on the discussion regarding Coal Gasification Problem effected to Coal Gasification Performance use integration RCA-MLR *(Root Cause Analysis – Multiple Linear Regression)* approach that has been carried out, The following conclusions are obtained : (a) Through RCA (Root Cause Analysis) approach, the root cause of decrease Coal Gasification Furnace (CGF) Performance is obtained, there is no mechanism/standard that regulates the operation of the CGF temperature for estimating steam, gasification wind, fluidization wind. (b) Through MLR (Multiple Linear Regression) approach, there are four hypotheses partially significantly affect to increase Coal Gasification Furnace (CGF) temperature with independent variable like steam, gasification wind, fluidization wind, and type of furnace. There are MLR equation based on type of furnace $Y_1 = 458 + 0.03178\ X_1 + 0.1877\ X_2 + 0.147\ X_3$ (equation 1) and $Y2 = 454.3 + 0.03178\ X_1 + 0.1877\ X_2 + 0.147\ X_3$. (c) Through integration RCA-MLR can solve some problem in Coal Gasification Plant. It was found that the heating value of Coal Gas increased to 5595 kJ/m3, the frequency of CGF downtime was reduced from 5 times to 1 time in one year, reducing the contribution of CO_2 and handling fly ash problems by create close loop system and use ESP (Electrostatic Precipitator) as filter system to reduce amount of emissions that contribute to GHG (Greenhouse gas). From this model, the optimal operating point for CGF is 920 ^oC to obtain the best conditions for increasing CGF performance. From the economic aspect, this multiple linear regression model can save costs of ± Rp. 2,607,942,761,-/month.

REFERENCES

Drapper, N. N., dan Smith, H. (2014). Applied Regression Analysis Third Edition. Canada: John Wiley & Sons.

Durdan, Milan et. al. (2021). *Regression Models Utilization to the Underground Temperature Determination at Coal Energy Conversion.* Slovakia: Institute of Control and Informatization of Production Processes, Faculty of Mining, Ecology, Process Control and Geotechnologies.

Ghozali, I. (2017). Aplikasi Analisis Multivariate dengan Program SPSS. Semarang: Universitas Diponegoro

Halim, Najwa H.A, Suriyati Saleh, Noor A.F (2019). *Effect of Gasification Temperature on Synthesis Gas Production and Gasification Performance for Raw & Torrefied Palm Mesocarp Fibre.* Malaysia:Universiti Malaysia Pahang

Li, Guang et, al. (2018). *Application of general regression neural network to model a novel integrated fluidized bed gasifier.* China : University of Chinese Academy of Sciences, Beijing

Nafaji, Mehdi et al. (2015). *Prediction of cavity growth rate during underground coal gasification using multiple regression analysis.* Iran : Yazd University, Department of Mining and Metallurgical Engineering

Qiang, F. dan Yinhe Liu (2021). *Effect of coal particle size on gasification performance of two-stage entrained-flow coal gasifier*. China

Shahabuddin, M. dan Sankar B. (2021). *Effect of reactant types (steam, CO2 and steam + CO2) on the gasification performance of coal using entrained flowgasifier*. Australia : Monash University

Sugiyono. (2021). Metode Penelitian Pendidikan Pendekatan. kuantitatif, Kualitatif, dan R&D. Bandung: Alfabeta.

Sugiarto, D. S. (2016). Metode Statistika. Jakarta: PT. Gramedia.

Suharyadi dan Purwanto. (2019). Statistika untuk Ekonomi dan Keuangan Modern. Jakarta: Salemba Empat.

Suryadi, K., & Ramdani, M. A. (1998). Sistem Pendukung Keputusan. Bandung: Rosdakarya.

Thomson, Richard et. al. (2020). *Clean syngas from small commercial biomass gasifiers; a review of gasifier development, recent advances and performance evaluation.* Australia: School of Chemical Engineering and Advanced Materials, The University of Adelaide

Turban, & Efraim. (2015). Decision Support System and Intelligent system . New Jersey: Pearson Education.

Veeso, M dan Masroor A. (2021). *Investigating the Effects of Different Operating Parameters on the Performance of Biomass Gasification Mixed with Coal in Multi-Opposite Burner (MOB) Gasifier.* Mehran : Mehran University

Wang, Ting, Gary Stiegel (2017). Integrated Gasification Combined Cycle (IGCC) Technologies. United State : Woodhead

Xiaofang, W. dan Zhiping (2019). *Experimental study of pilot-scale CFB gasification: Effect of gasifying agent and coal feeding modes on the gasification performance.* China : University of Chinese Academy of Science.

Zaman, Sk Arafat; Dibyendu Roy, Sudip Ghosh (2020). *Process modeling and optimization for biomass steam-gasification employing response surface methodology.* India : Department of Mechanical Engineering, Indian Institute of Engineering Science and Technology, Shibpur

Zhang, Xiao-Pei et. al. (2018). *Effects of hydrothermal upgrading on the physicochemical structure and gasification characteristics of Zhundong coal.* China : Huazhong University of Science and Technology, Wuhan

THE IMPACT OF INCOME DIVERSIFICATION ON PROFIT AND RISK IN THE BANKING INDUSTRY (ANALYSIS OF BANKING IN EAST & SOUTH EAST ASIA)

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ABSTRACT

Commercial banks basically rely on interest income, so that when an economic crisis occurs, such as a pandemic, banks are at risk of being affected by bad loans or non-performing loans (NPL). This apparently did not happen in Indonesia alone, but in other countries, many banks felt economic changes that led to an increase in NPLs. At a time when the economic crisis was getting worse, some banks even suggested reducing lending, especially to industries in sectors that were most affected by the pandemic. Therefore, it is necessary for banks to diversify income to look for alternative income other than credit income. This study will look at the profits and risks arising from income diversification activities through non-interest income in banking. Research data obtained from Thomson Reuters and obtained 205 banks as samples, the dependent variable in this study is net non-interest income, while the control variables are size, equity, debt, asset growth, and equity, to analyze profit using ROAA and ROAE variables for analyze profit and SD ROA and SD ROE to analyze risk. The variables were then regressed using panel data regression with previously performed Chow test, Hausman test, and Lagrange Multiplier test to get the best regression method. The results show that income diversification activities have a significant negative effect on risk and do not have a significant effect on profits both during the pandemic and outside the pandemic, so income diversification activities can be carried out to minimize risks that may occur due to being too dependent on interest income.

Key Words: Bank, Non Interest Income, Profit, Risk, Asia

1. INTRODUCTION

The main income in the banking sector comes from interest income. In Indonesia, based on data from the Indonesian Banking Statistics (SPI), 2020, the average income of the banking sector in the 2016-2020 period (last 5 years), in the form of 68% interest income (interest income) and 32% non interest income (non-interest income). When there is an economic downturn such as the economic crisis and the current Covid-19 Pandemic, the movement of the credit sector is limited due to the high risk of Non Performing Loans (NPL). Gross NPL in June 2020 rose from 3.11% to 3.22% and is predicted to worsen if there is no relaxation or credit restructuring. When the economy improves, other factors such as competition in lending from non-bank lenders such as financial institutions, Fintech, leasing, and others will also affect bank loan interest income.

Banking in East Asia experienced a considerable impact due to being the first area where COVID-19 was discovered and arguably included in the area affected by the pandemic effect for quite a long time. In China, the non performing loan ratio has increased by 1% in the last 3 months since June 2021, outstanding NPLs, especially for the consumptive sector such as property loans, have increased 2 times from 2.5% in mid-2021 to 5.5% at the end of 2021. (Yan, et al., 2021)
Large banks in Japan also experienced an increase in NPL at the end of 2021, such as Sumitomo Mitsui Financial Group Inc, which experienced an increase from 1.04% to 1.22% at the end of 2021, other things were also experienced by large banks in Japan. Mizuho Financial Group Inc. which increased to 1.36% after the previous quarter was only 1.02%. (Ahmad, 2022) The pandemic is quite influential in Japan, because Japan has managed to keep its NPL ratio below 1.3% since 2017, but must increase in 2021.

In 2020, several countries in Southeast Asia such as the Philippines, Thailand, Indonesia, Cambodia, and Malaysia are ranked in the top 20 countries in Asia with the highest NPL levels. In 2021, Asian countries and Japan are also ranked in the top 10 countries in Asia with the highest loan ratings. (Weng, 2022). When a crisis occurs in a country, for example during the Pandemic, banks begin to restrict lending, therefore banks begin to focus more on diversifying income through non-interest income activities. Income diversification activity, is an activity to seek income from other products. This activity is carried out by the Bank to obtain income from other products in the non-credit sector. In the banking industry, the term Fee Based Income (FBI) is known, namely, non-interest income as a reward or commission for financial services provided to customers. In the midst of uncertainty in lending and increasingly fierce competition with similar businesses, the current direction of the banking industry is more focused on increasing Fee Based Income (FBI). In addition to minimal risk, the FBI can also improve the quality of service to customers by increasing the alternative service solutions offered.

Diversification of income will certainly increase the profitability of a bank. However, the increase in profit is not necessarily inversely proportional to the risks that may arise. Previous research conducted by (Ferreira, et al., 2019); (Stiroh, 2006); (Stiroh, 2004) shows that diversification activities through non-interest income have a positive impact on returns, with the dependent variable being Return on Assets (ROA). Meanwhile, based on research conducted by (Tamba, 2015) income diversification has a positive influence on insolvency risk, or the risk that occurs due to a decrease in asset value, so that the bank's capital position will decrease and the debt position will increase (Siamat, 2005).

This study will discuss more deeply the impact of income diversification carried out by banks, especially banks in Southeast Asia and East Asia. The reasons for selecting the sample are first, because the countries in the area initially had the biggest impact of the Asian Crisis compared to other countries in the Asian Region so that the banks also carried out major reforms to the direction of their business movements, second, research on the region, especially in

Southeast Asia. still little done compared to other countries in the Asian Region, third, based on data obtained from the Global Economy, many banks in the East and Southeast Asia Region have a ratio of non-interest income to total income above 20% compared to other Asian regions (data for 2020), and lastly, banking in Indonesia itself often uses the East and Southeast Asia Region as a benchmark country for exchanging knowledge in an effort to improve the quality of banking in Indonesia.

2. LITERATURE REVIEW

Bank is a business entity whose main task is as financial intermediaries that channel funds from parties with excess funds (surplus side) to parties in need or lack of funds (deficit side). The income earned by the Bank is divided into two, namely, interest income and non-interest income. Interest income is income obtained in the form of interest as a result of banking intermediation activities in the form of lending to debtors, both individuals and business entities, as well as interest obtained from placing bank funds in other banks (bank call money). The examples of interest income are loan from both productive loans (working capital and investment) and consumer loans (House Ownership Credit, Vehicle Ownership Credit, Credit Cards, Unsecured Loans) and savings interest generated by placing funds in other banks.

Non Interest Income is income earned by banks outside of intermediation activities, for example fee based income obtained from fees and commissions on sales of bank products or transactions for other services in banking. In contrast to interest income which depends on the central interest rate, non-interest income does not depend on the reference interest rate. Factors that affect non-interest income are the products and services that can be provided by the bank, supported by technological capabilities to produce more appropriate technology to answer customer needs and product variations according to customer needs in the banking sector.

Non Interest Income are divided into three parts mainly:

1. Execution/Processing
2. Principal Transaction
3. Advisory

The ability of a bank to rely on non-interest income for its business operations is often associated with the asset quality and NPL conditions of the bank itself. Based on Bank Indonesia Regulation No.6/10/PBI/2004 concerning the Rating System for Commercial Banks, asset quality is a component used to assess the condition of Bank assets, including anticipation of the risk of non-payment of financing (credit risk) that will arise. A study conducted in India by Ahamed (2017), shows that income diversification carried out by banks with low Asset Quality, this is shown for banks with high NPL levels, will provide higher benefits to profits compared to banks with high levels of NPL. already have good asset quality.

Several studies on income diversification to increase profits have been carried out previously on national and international banks. Research conducted by Adiyatna (2000) regarding the development of the FBI in overcoming the decline in revenue at PT Bank Rakyat Indonesia, stated that an approach through the FBI needed to be taken to overcome interest losses that occurred during the economic crisis. In addition, as an income portfolio outside of interest income, more emphasis should be placed on Strategic Business Units (SBUs) that have business strengths and attractive markets, namely SBU Micro Banking and SBU Retail banking.

Another study conducted by (Massie, 2014) states that Fee Based Income and Intellectual Capital (Value added Capital employed, value added human capital, structural capital value added) will have a simultaneous influence on the profitability of the banking industry on the Indonesia Stock Exchange.

Research (Bernadien, 2014), states that one of the income diversification carried out by banks such as trading income or transactions on foreign exchange and selling securities will increase bank risk due to its fluctuating nature, it will increase income volatility. Another study by (Zhou, 2014) states, an increase in the proportion of Non Interest Income will be directly proportional to volatility, so the risk posed will be higher.

3. METHODS

The research sample used the purposive sampling method, with the following criteria:

1. The sample bank tested must have published financial statements (especially recorded on Thomson reuters) and must have a detailed explanation of financial transactions, for the period 2017-2021
2. Banks have income other than credit income (non-interest income) which is clearly recorded
3. The samples used are countries in East Asia and Southeast Asia that have active non-interest income activities, as evidenced by the ratio of non-interest income to total income above 20% in each country.

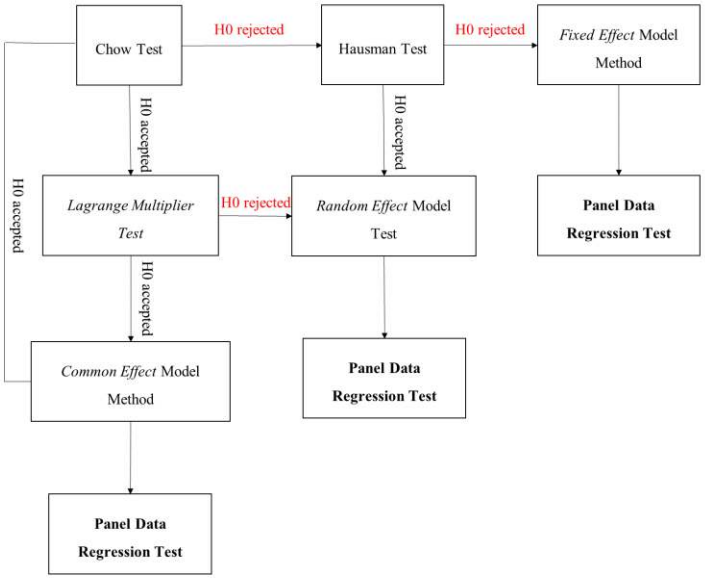
Research variable consist as:

Table 1. Variable

Independent Variable
Net Non Interest Income
Control Variable
Equity
Size
GrowthTA
Growth TE
Loans
Dependent Variable
Risk Measurement
Standard Deviation ROA
Standard Deviation ROE
Profit Measurement
Return on Average Asset (ROAA)
Return on Average Equity (ROAE)

Panel data regression test was carried out on these variables by previously testing panel data such as the following flowchart:

Figure 1. Panel Data Regression Flowchart



4. RESULTS

Table 2. Panel Data Regression Result on Profit

	South-East Asia & East Asia			
	ROAA	**ROAE**	**ROAA Covid**	**ROAE Covid**
NNII	negative non significant	negative non significant	**negative significant**	negative non significant
SIZE	negative non significant	negative non significant	**positive significant**	**positive significant**
EQUITY	positive non significant	negative non significant	**positive significant**	negative non significant
LOANS	**positive significant**	positive non significant	**positive significant**	negative non significant
GROWTH_TA	**positive significant**	**positive significant**	**positive significant**	**positive significant**
GROWTH_TE	negative non significant	positive non significant	**negative significant**	positive non significant
	East Asia			
	ROAA	**ROAE**	**ROAA Covid**	**ROAE Covid**
NNII	positive non significant	negative non significant	**negative significant**	**negative significant**
SIZE	**positive significant**	**positive significant**	**positive significant**	**positive significant**
EQUITY	**positive significant**	**positive significant**	**positive significant**	**positive significant**
LOANS	-	-	**negative significant**	**negative significant**
GROWTH_TA	positive non significant	positive non significant	**positive significant**	**positive significant**
GROWTH_TE	**positive significant**	**positive significant**	positive non significant	**positive significant**
	South-East Asia			
	ROAA	**ROAE**	**ROAA Covid**	**ROAE Covid**
NNII	negative non significant	**negative significant**	negative non significant	negative non significant
SIZE	negative non significant	positive non significant	**positive significant**	**positive significant**
EQUITY	positive non significant	negative non significant	**positive significant**	negative non significant
LOANS	**positive significant**	**positive significant**	**negative significant**	negative non significant
GROWTH_TA	positive non significant	positive non significant	**positive significant**	**positive significant**
GROWTH_TE	negative non significant	positive non significant	**negative significant**	negative non significant

The regression results show that NNII has a negative effect on profits for banks in East Asia and Southeast Asia, both during pandemics and non-pandemic, this indicates that an increase in NNII will result in a decrease in profits. Based on (Lee, et al., 2014) stated that NII will reduce banking profits, especially for banks whose main business is saving banks, this is because banks will tend to reduce costs (which are a source of income from NII) to increase the number of customers who save (creditors). Meanwhile, NII may be directly proportional to the increase in banking profits for banks whose main business is investment banking.

According to (Lee, et al., 2014), 65% of countries in East Asia and Southeast Asia are commercial banks, while 25% are investment banks, and 1.76% are saving banks. The majority of commercial banks in East Asia and Southeast Asia still depend on interest income income (an average of 60%), so that non-interest income continues to be suppressed, such as fees and commissions to benefit from lending. As for investment banking, commissions and fees are the main income.
The size or size of a bank is an indicator to assess the strength of the bank. Table 19. shows that size has a significant positive effect on profits, especially in pandemic conditions, because the greater the strength of a company, the more stable the company will be and not easily shaken, this will have an impact that is directly proportional to the increase in profit. (Salike, et al., 2018). Likewise with total asset growth, an increase in assets will increase the strength of the company, so that the company will not be easily shaken in pandemic or non-pandemic conditions, so that it will be in line with the increase in profit.
Equity, the increase in equity has a significant positive relationship to profit both during the pandemic and non-pandemic. Banks that have strong capital will face a lower cost of going bankcrouptcy, and have the strength to face crises such as a pandemic, this will have a positive impact on profits. (Sufian, 2009)

Table 3. Panel Data Regression Result on Risk

	RISK			
	South-East Asia & East Asia			
	STDEV ROA	**STDEV ROE**	**STDEV ROA Covid**	**STDEV ROE Covid**
NNII	**negative significant**	**negative significant**	**negative significant**	**negative significant**
SIZE	**negative significant**	**negative significant**	**positive significant**	negative non significant
EQUITY	**positive significant**	**negative significant**	**positive significant**	**negative significant**
LOANS	negative non significant	positive non significant	**negative significant**	**positive significant**
GROWTH_TA	**negative significant**	**negative significant**	**positive significant**	negative non significant
GROWTH_TE	negative non significant	negative non significant	positive non significant	**positive significant**
	East Asia			
	STDEV ROA	**STDEV ROE**	**STDEV ROA Covid**	**STDEV ROE Covid**
NNII	**negative significant**	**negative significant**	positive non significant	**negative significant**
SIZE	negative non significant	negative non significant	**negative significant**	negative non significant
EQUITY	**positive significant**	negative non significant	**positive significant**	**positive significant**
LOANS	-	-	positive non significant	positive non significant
GROWTH_TA	**negative significant**	**negative significant**	positive non significant	negative non significant
GROWTH_TE	**negative significant**	**negative significant**	**negative significant**	negative non significant
	South-East Asia			
	STDEV ROA	**STDEV ROE**	**STDEV ROA Covid**	**STDEV ROE Covid**
NNII	**negative significant**	**negative significant**	**negative significant**	**negative significant**
SIZE	negative non significant	**negative significant**	**positive significant**	negative non significant
EQUITY	**positive significant**	**negative significant**	**positive significant**	**negative significant**
LOANS	**negative significant**	**positive significant**	**negative significant**	**positive significant**
GROWTH_TA	positive non significant	negative non significant	**positive significant**	negative non significant
GROWTH_TE	positive non significant	**positive significant**	positive non significant	**positive significant**

The results of the analysis of income diversification on risk show that NNII has a significant negative effect on risk, meaning that the higher the income diversification carried out by a bank, the smaller the impact on risk. This is also in line with previous research which states that income diversification tends to reduce risk for commercial banks (Lee, et al., 2014), this is appropriate because 65% of banks in East Asia and Southeast Asia are commercial banks. The majority of commercial banks' income still comes from interest income, this indicates that income diversification will reduce the dependence of a bank on interest income. So that in pandemic conditions that are vulnerable to the risk of bank defaults, they can still survive by diversifying their income.

The size of the bank has an average negative significant effect on risk, meaning that the stronger the bank, the less risk it may pose. This is because the larger the size of a company, the company will be stronger and not easily shaken.

Equity or capitalization will affect the strength of banks to support banks when facing a storm of risk. The higher the equity, the more stable banks will be, and will affect the dependence of banks on depositors (customers who save in the bank). Equity is inversely proportional to loans, the higher the value of loans, indicating that depositors are in a bank. This will affect banking liquidity, because banks become dependent on depositors, if large depositors withdraw their funds, banking liquidity will be disrupted. Disrupted liquidity will then affect bank lending, so that income through interest will also decrease.

The size of total assets, asset growth will result in the company becoming stable and stronger against risk, during a pandemic, asset growth provides a significant positive for risk. This can happen because asset growth will result in a too big to fail effect, meaning that the greater the influence of a company, the greater the impact of the company.

6. CONCLUSIONS

Effect of Income Diversification Activities through NII and Control Variables on Profit

The results of this research show that income diversification through Non Interest Income has no significant effect on profits for banks in East Asia and both (East Asia and Southeast Asia combined), but has a significant positive effect on profit growth in Southeast Asia. in non-pandemic conditions. Meanwhile, during the pandemic, income diversification activities through the NII did not have a significant effect on profits.

The control variables that have a significant positive effect on profits include the Equity variable for banks in East Asia and Loans for banks in Southeast Asia in both pandemic and non-pandemic conditions.

Effect of Income Diversification Activities through NII and Control Variables on Risk

In all research objects, Income diversification activities through NII have a significant negative relationship to risk, so it is best done to minimize risk, both in pandemic and non-pandemic conditions.

Control variables such as equity, asset growth, equity growth have a significant effect, where equity ratios, asset growth, and equity growth have a negative effect on risk in banking in East Asia. Similar to banks in Southeast Asia, the ratio of equity to total assets has a significant negative effect on risk, while the risk assessed through the standard deviation of ROA, EQUITY has a significant positive effect on risk, both in pandemic and non-pandemic conditions.

Based on the research, it can be concluded that income diversification activities can minimize banking risk even though the results do not have a significant positive effect on profits.

REFERENCES

(OJK) Otoritas Jasa Keuangan Penerapan Manajemen Risiko bagi Bank Umum [Journal]. - Jakarta : POJK , 2016. - Vol. Nomor 18/POJK.03/2016.

(OJK) Otoritas Jasa Keuangan Statistik Perbankan Indonesia [Online] // ojk.go.id. - Agustus 2021. - https://www.ojk.go.id/id/kanal/perbankan/data-dan-statistik/statistik-perbankan-indonesia/Pages/Statistik-Perbankan-Indonesia---April-2021.aspx.

Acharya V. [et al.] Measuring Systemic Risk [Book]. - New York : Stern School of Business, 2010.

Acharya Viral, Engle, Robert, Richardson, Matthew Capital Shortfall: a New approach to ranking and regulating systemic risks [Journal] // American Economic Review 102. - 2012. - pp. 59-94.

Adrian T. and Burnnermeier Covar [Book]. - Princeton : Department of Economics, Bendheim Center for Finance , 2009.

Ahamed M. Mostak Asset Quality, non-interest income, and bank profitability: Evidence from Indian Banks [Journal] // Economic Modelling 63. - 2017. - pp. 1-14.

Ahmad Yuzi Yamaguchi & Rehan S&P Global [Online] // spglobal.com. - 02 09, 2022. - 02 09, 2022. - https://www.spglobal.com/marketintelligence/en/news-insights/latest-news-headlines/japanese-megabanks-see-bad-loan-ratios-rising-as-pandemic-lingers-68809411.

Antao Sherika and Karnik Ajit Bank Performance and Noninterest Income: Evidence from Countries in the Asian Region [Journal]. - Dubai : Asia-Pacific Financial Markets, 2021.

Baek Lee, K. Lee and S. Mohanty Diversifcation in Korean banking business: Is noninterest income a fnancial saviour? [Journal]. - [s.l.] : Journal of Emerging Market Finance, 2018. - 3S(299S-326S) : Vol. 17.

Bandt O. De and Hartmann P. Systemic Risk: A Survey [Journal]. - [s.l.] : CEPR Discussion Paper Series, 2000. - Vol. No. 2634.

Basyaib Fachmi Manajemen Risiko [Book]. - Jakarta : PT. Grasindo , 2007.

Bernadien Yuki Masiliana Pengaruh Diversifikasi Pendapatan terhadap Risiko Bank Umum pada Periode Krisis dan di luar Krisis [Book]. - Jakarta : Universitas Indonesia, 2014.

Bollerslev Tim Generalized Autoregressive Conditional Heteroskedasticity [Journal] // Journal of Econometrics . - 1986. - pp. 307-327.

Brownlees C. and Engle R. Volatility, Correlation, and Tails for Systemic Risk Measurement [Book]. - New York University : Working Paper Series, Deparment of Finance, 2010.

Brunnermeier Markus, Dong Gang and Palia Darius Banks Non Interest Income and Systemic Risk [Journal] // AFA Chicago Meetings Paper. - 2012.

Corporate Finance Institute CFI [Online] // corporatefinanceinstitute.com. - 2021. - April 7, 2022. - https://corporatefinanceinstitute.com/resources/careers/companies/top-10-banks-hong-kong/.

Dielman Terry E. Applied Regression Analysis for Business and Economics [Book]. - KENT : PWS-KENT Publishing Company, 1961.

Dowd Kevin Introduction to Market Risk Measurment [Book]. - Chichester : John Wiley & Son Ltd, 2002a.

Dowd Kevin Introduction to Market Risk Measurment [Book]. - Chichester : John Wiley & Son Ltd, 2002b.

Engle Robert F. Autoregressive Conditional Heteroscedasticity with Estimates of the Variance of United Kingdom Inflation [Journal] // Econometrica . - 1982. - pp. 987-1007.

Ferreira Jorhge H.L., Zanini Fransisco A. M. and Alves Tiago W. Bank revenue diversification: its impact on risk and return in Brazilian Banks [Journal] // R. Cont. Fin. - 2019. - pp. 91-106.

Ghozali Imam Aplikasi Analisis Multivariate dengan Program IBM SPSS [Book]. - Semarang : Badan Penerbit Universitas Diponegoro, 2018.

Hawkins J. Restructuring Banking Systems [Book]. - Boston, MA : Springer, 2000.

Hikmah Mutiara Analisis Risiko Sistemik dengan Menggunakan Metode Marginal Expected Shortfall (MES) pada Bank yang terdaftar di Bursa Efek Indonesia periode 2009-2013 [Book]. - Depok : Universitas Indonesia, 2016.

Hsiao Analysis of Panel Data [Book]. - Cambridge : University Press, 2003.

Jiang Guorong [et al.] The Profitability of the Banking Sector in Hong Kong [Report]. - Hong kong : HONG KONG MONETARY AUTHORITY QUARTERLY BULLETIN, 2003.
Kasmir Bank dan Lembaga Keuangan lainnya [Book]. - Jakarta : PT Rajagrafindo Persada, 2002.
Keuangan Otoritas Jasa [Journal].
Lee C. and C. Yang S. & Chang Non-interest income, proftability and risk in banking industry: A cross-country Analysis [Journal]. - [s.l.] : North American Journal of Economics and Finance , 2014. - 48-67 : Vol. 27.
Lee Chien Chiang, Yang Shin Jui and Chang Chi Hung Non-interest income, profitability, and risk in Banking Industry: A cross-country Analysis [Journal]. - Taiwan : North American Journal of Economics and Finance, 2014. - 48-67 : Vol. 27.
Lim Ching Mun and Sek Siok Kun Comparing the Performances of GARCH-type Models in Capturing the Stock Market Volatility in Malaysia [Journal] // Proceddia Economics and Finance 5. - 2013. - pp. 478-487.
Massie Gracious Madamba Pengaruh Fee Based Income dan Intellectual Capital terhadap Profitablitas pada Industri Perbankan di Bursa Efek Indonesia [Journal]. - [s.l.] : e-journal Katalogis, 2014. - Vols. 2 (7) : 13 - 22.
Parzen Emanuel On Estimation of a Probability Density Function and the Mode [Journal] // The Annals of Mathematical Statistics 33. - 1962. - pp. 1065-1076.
Pranesh S. and R. Prem Kumar The Impact of Asian Financial Crisis on the Four Asian Dragons [Journal]. - Karnataka : International Journal of Advance Research and Development, 2018. - 1 : Vol. 3.
Salike N. and Ao B. Determinants of bank's proftability: Role of poor asset quality in Asia [Journal]. - [s.l.] : China Finance Review International, 2018. - 2 : Vol. 8.
Saunders A. and Cornett M. M. Financial Institutions Management: A Risk Management Approach [Book]. - New York : McGraw Hill, 2006.
Setiawan I Gusti Agung Ngurah Alit Pramana and Mahardika Dewa Putra Krishna Market to Book Value, Firm Size, dan Profitabilitas terhadap Pengambilan Keputusan Lindung Nilai [Journal]. - Bandung : Jurnal Ilmiah Akutansi, 2019. - No. 1 Hal:124-140 : Vol. 4.
Siamat Dahlan Manajemen Lembaga Keuangan [Book]. - Depok : Fakultas Ekonomi Universitas Indonesia, 2005.
Silverman B.W. Density Estimation for Statistics and Data Analysis [Book]. - London : Chapman and Hall , 1986.
Stiroh K. J. Diversification in Banking: Is Noniterest Income the Answer? [Journal] // Journal of Money, Credit, and Banking 36. - 2004. - pp. 853-882.
Stiroh K.J. A Portfolio View of Banking with Interest and Non Interest Activities [Journal] // Journal of Money, credit, and Banking 38. - 2006. - pp. 1351-1361.
Sufian Fadzlan Determinants of Bank Efficiency during Unstable Macroeconomic Environment: Empirical evidence from Malaysia [Journal]. - [s.l.] : Research in International Business and Finance , 2009. - 54-77 : Vol. 23.
Tamba Deta Basa Nia Octavia Pengaruh Diversifikasi Pendapatan terhadap Profitabilitas dan Risiko Bank Umum Konvensional di Indonesia Periode 2006-2012 [Book]. - Depok : Universitas Indonesia, 2015.
Weng Wendy [Online] // theasianbanker.com . - June 07, 2022. - July 14, 2022. - https://www.theasianbanker.com/updates-and-articles/5-out-of-10-banks-with-the-highest-npl-ratio-in-asia-pacific-are-indian-banks.
Widarjono Agus Ekonometrika Teori dan Aplikasi [Book]. - Yogyakarta : Ekonisia FE UII, 2007.

Williams Barry The Impact of Non-Interest Income on Bank Risk In Australia [Journal] // Journal of Banking and Finance 73. - 2016. - pp. 16-37.
Yan Zhang and Woo Ryan Reuters.com [Online]. - December 15, 2021. - July 09, 2022. - https://www.reuters.com/markets/rates-bonds/chinese-banks-see-doubling-bad-property-loan-ratio-warns-sp-2021-12-15/.
Zhou Kaiguo The Effect of Income Diversifiation on Bank Risk: Evidence fro China [Book]. - Guangzhou : Lingnan College, Sun Yat-sen University, 2014.

COMPARISON OF PREDICTIVE MAINTENANCE MODEL BY USING MACHINE LEARNING APPROACH ON CEMENT PLANT OPERATIONAL DATA (CASE STUDY OF PT XYZ)

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ABSTRACT

Good equipment reliability is achieved through a good maintenance strategy. PdM is a maintenance strategy where maintenance activities are carried out by evaluating and analyzing the actual condition of the equipment so that the optimal time for maintenance activities can be predicted before equipment failure occurs. Currently, predictive maintenance activities at PT XYZ are carried out by analyzing real-time plant operation data integrated into the Technical Information System (TIS) in conventional way. Several main equipment operational parameter data such as data feed rate, speed of revolution per minute (rpm), temperature, air pressure, and load current were downloaded form TIS. The raw data is then pre-processed to produce data that is ready to be partitioned and modeled into Random Forest, Gradient Boosting, and XGBoosting algorithms, then tested and evaluated to obtain the most accurate algorithm model. The results of the model evaluation show that the Random Forest model gave the best results among other models with R2 83.1%, MSE 47.4, RMSE 6.89, MAE 3.55, and MAPE 3.55%. The most influential operating parameters are actual feed rate fine coal, outlet gas temperature CT, actual rate coal weigh feeder, and shut off flap bypass raw mill gas duct.

Keywords: Reliability, TIS, Machine Learning, Predictive Maintenance.

1. INTRODUCTION

The success of production processes depends on reliable equipment performance. Failures in components or sub-systems can cause the entire production process to stop, or production stops, where the costs of losses that occur include but are not limited to production loss, maintenance costs, and the waste product during the start-up process to achieve stable operation, and equipment damage (Aurelian Froger, 2016).

Equipment reliability is obtained through a good maintenance strategy. In general, maintenance strategies can be categorized into three (Weiting Zhang, 2019), namely Corrective Maintenance (CM), Preventive Maintenance (PM), and Predictive Maintenance (PdM). CM or often called Reactive Maintenance, is a maintenance strategy where maintenance or repair activities will only be carried out in the event of equipment failure. PM is a maintenance strategy where routine maintenance activities are carried out based on scheduled time intervals (Tomasz Nowakowski, 2018). Although PM aims to maintain the system or equipment before failure occurs, this strategy does not consider the actual condition of the equipment. PdM is a maintenance strategy where maintenance activities are carried out by evaluating and analyzing the actual condition of the

equipment so that the optimal time for maintenance activities can be predicted before equipment failure occurs (AndreasTheissler, 2017). If failures in components or sub-systems can be predicted early and resolved without causing the production process to stop, the resulting cost savings are very significant (Yu, 2019).

The development of Industry 4.0 and Digital Manufacturing encourages industry players to rely on a predictive approach in maintenance activities, where the development of Cloud Computing and Big Data allows the collection and processing of various tool maintenance data from different sources and in large amounts (Ioannis T. Christou, 2020). In addition, artificial intelligence applications that can utilize data collected through IoT devices will be very helpful in Predictive Maintenance activities (Ameeth Kanawaday, 2017). Therefore, the role of PdM is currently increasing in the industry in terms of increasing tool utilization, reducing downtime, maintaining unnecessary Maintenance, and estimating the remaining life of the tool (Veronica Jaramillo Jimenez, 2020).

Predictive Maintenance activities at PT XYZ are still carried out in a conventional way where data that is integrated into the Technical Information System (TIS) has not been analyzed by machine learning. In this study, raw data related to plant operations, such as feed rate, current load, temperature, pressure, engine speed, vibration, and material level, is detected by sensors and transferred through a data cable to be collected on the TIS server. The objectives of this study are to build and compare several Predictive Maintenance algorithm models that can produce predictions of potential failures on the production process line using Machine Learning; where to obtain the most suitable modeling to solve this problem, several algorithms, including Random Forest, XGBoost, and Gradient Boosting are reviewed in detail and compared with actual operating data.

2. LITERATURE REVIEW

A PdM system on a weight feeder with an IoT approach and real-time data was developed in the personal care manufacturing industry (Serkan Ayvaz, 2021). The results of the research show that the PdM system that was built succeeded in identifying the factors causing machine failure so that unplanned stoppages on the production line can be evaluated. Comparative evaluation of Machine Learning algorithm modeling shows that Random Forest and XGBoosting modeling are the most superior compared to other models.

A Random Forest modeling was developed to predict failure with a classification approach and remaining life with a regression approach (Rodney Kizito, 2018). The evaluation results show that the level of accuracy in Random Forest modeling is very good, with an accuracy of 1.0 for each bearing, while for regression, Random Forest shows better results in the larger data set (C1B1 and C1B3) compared to the smaller data set (C1B1 and C1B3). C1B2).

A statistical study of PdM was conducted in the heavy vehicle industry (Reza Khoshkangini, 2020). This study aims to create an early detection model for product quality problems with a machine learning approach to predict the failure of certain components in a population of heavy vehicles. The ML method used is Linear Regression and Gradient Boosting. The results of this study indicate that the approach finds better results if large data are available. Meanwhile, regression modeling shows better predictive performance on smaller amounts of data (Reza Khoshkangini, 2020).

The failure of the compressed air system on SCANIA trucks was predicted using Random Forest modeling (Christopher Gondek, 2016). They use the median to replace the missing values , and the data is not normalized. Then the new feature is calculated as the distance to other distributions, the distribution of positive mean values, negative mean distributions, normal

distributions with mean = 5 and standard deviation = 1.5, mirror normal distribution. In order to overcome the class imbalance problem, the threshold value was modified, and the most suitable 95% value was found. They were able to obtain an average cost of 0.6, which was calculated as the total cost of Maintenance divided by the total number of trucks.

3. METHODS

The data used are the operating parameters related to cement plant operation, which are feed rate, speed of revolution per minute (rpm), temperature, air pressure, load current, and pollutants content in the flue gas. In this study, the operation parameters, which are taken as predictors variables, were taken from several main equipments, as seen in figure.1, which relate to bag filter performance like coal mill, raw mill, kiln, pre-heater, fan, and gas conditioning tower. Meanwhile, dust emission was set as the target variable which good or bad bag filter performance could observe from dust emission on air quality that comes out from the stack.

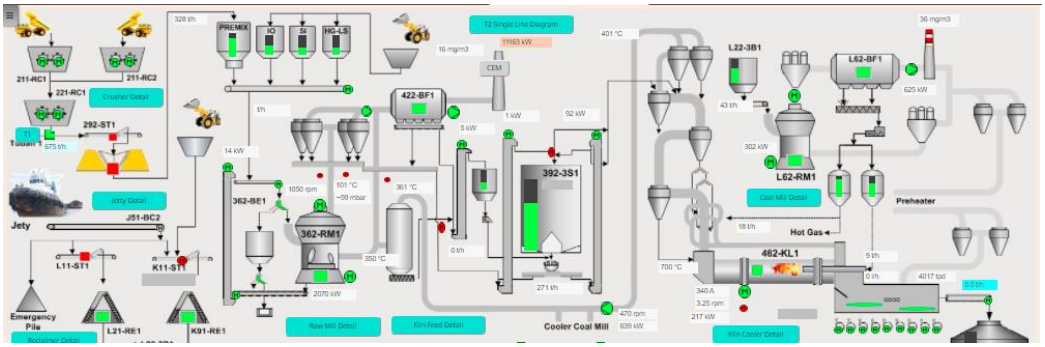


Figure 1 Mimic diagram of cement processing

The data is obtained from sensor readings that are installed on the production line, which were recorded and stored on Technical Information System (TIS) from January 2019 up to May 2022. The sensor readings are calculated in hour units. TIS's server was connected to Microsoft Excel through the Add-Ins feature, which allows the respective user to download the plant operation data. The data used in this study consisted of 65 columns, 27.000 rows, and 3.1% missing data. The hardware which was used in this study is Processor 11th Gen Intel (R) Core (TM) i7-1165G7 @ 2.80Ghz (8 CPUs) RAM 8GB with Operating System Windows 10 Pro 64-bit. Data processing is supported by Orange Data Mining software version 3.31.1.

Data Pre-Processing

The data downloaded from the technical information system (TIS) is raw data. It needs to go through several processes until the data is ready for use. The following is the initial data processing which is divided into several parts:

- Data Cleaning

  During operation, the equipment's sensor several times errors where the data reading was far from the average value. That data is still recorded in the plant information system, so the downloaded raw data needs to be cleaned of outlier data or another kind of error.

- The Missing Value

  As with outlier data and error data, several times, the sensor is disturbed so that it cannot read and record data. Therefore, the value of the empty data needs to be filled with the values in the feature or treated with some imputation methods. A model-based imputer constructs a model to predict the missing value based on the values of other attributes, and a separate model is constructed for each attribute. It is used to find a predictive model for each target variable in the data set that contains missing values. The model is compatible with the observed data and afterward used to generate imputations for the missing values.

- Correlation analysis and feature selection

  The next step is correlation analysis, which in this study is a case of regression on plant operating data. Correlation analysis was carried out by testing the correlation of emission operating parameters as target variables with other plant operating parameters as predictor variables. Furthermore, the predictor with a correlation greater than 0.300 is selected to proceed to the model development stage, where the widget used is selected columns. A total of 25 predictors were selected. Figure 2 shows the selected features to be continued into the model development.

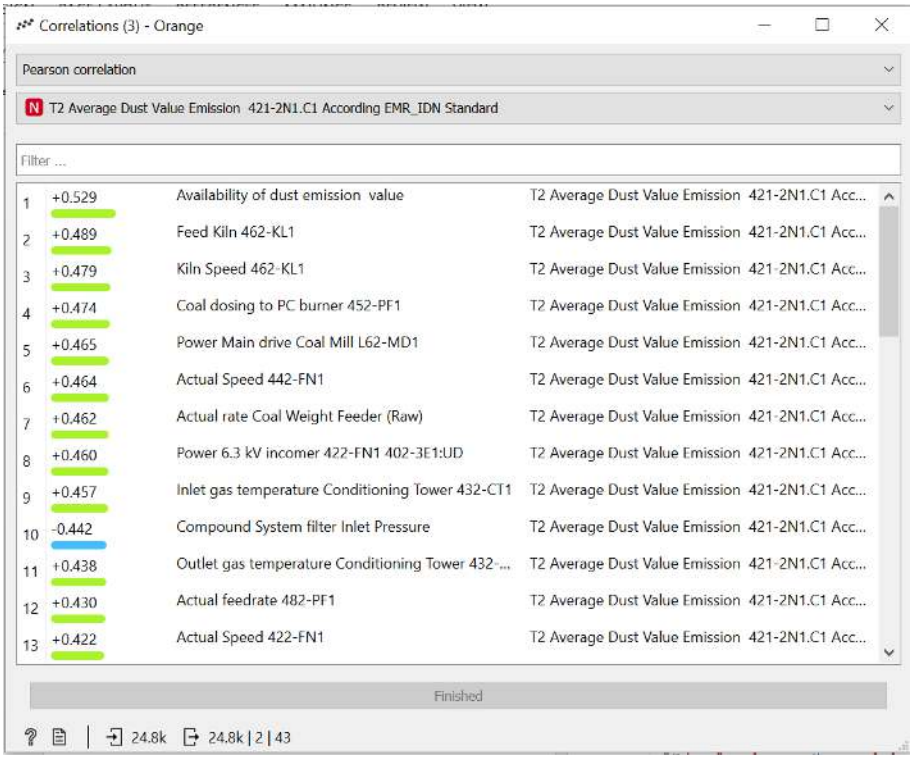


Figure 2 Correlation among the features

Algorithm model development.

Raw data that has been pre-processed is ready to be processed for algorithm model development. The data is divided into two parts, where 80% of the data set is used as learning data, and the remaining 20% is used as test data. The modeling algorithms used in the development of this model are Random Forest, Linear Regression, XGradient Boosting, and Adaboost.

- Random Forest

Random Forest is an ensemble learning method that can be used for cases related to classification, regression, and others. This method (Breiman, 2001)was first proposed by Tin Kam Ho and further developed by Leo Breiman and Adele Cutler. The process of Random Forest begins by building a set of decision trees where each tree is developed from a bootstrap sample from the training data. When developing an individual tree, a subset of attributes that vary randomly, then the best attribute is selected to be separated. After that, the final model is based on the main sound of the individually developed trees in the forest. Following are the steps in Random Forest modeling and the estimated failure rate (Xiaohua Luo, 2021).

- Gradient Boosting

Gradient Boosting is a method of machine learning introduced in 2001 by Friedman, which can solve regression and classification problems (Friedman, 2001). The principle of the method, which is also known as Gradient Boosting Regression Tree (GBRT) and Gradient Boosting Machine (GBM), is to add several weak trees together from the previous tree through the gradient descent method and form a strong learner with the smallest possible objective function to optimize the predictive performance of the model (Minxing Si, 2020) (Shaowei Pan, 2021)

- XGBoosting

XGBoost, or the so-called Extreme Gradient Boosting Decision Tree, is an ensemble tree model that can be used to solve classification and regression problems. This model was first released in 2014 (Labram, 2019). This model is quite popular; where in 2015, 17 of the 29 winners in the Kaggle machine learning competition used the XGBoost algorithm (Nielsen, 2016). This model is easier to interpret compared to algorithms based on ANN, quite easy in initial data processing, and has few hyperparameters to adjust (Minxing Si, 2020). This model works based on the gradient lifting decision tree algorithm, although when compared to it, this model has better prediction accuracy and stronger generalization performance.

Interpretation of results and selection of the best modeling algorithm

The results of the modeling algorithm are then evaluated, and the results are compared with each other. The parameters considered are R-squared, MAE (Mean Absolute Error), MSE (Mean Square Error), and RMSE (Root Mean Squared Error). R2 indicates the fit of the model to the overall data, where the larger R2, the better the model. MAE is the absolute value of the average difference between the prediction and the actual. The lower the MAE value, the better the prediction of the algorithm for potential failure. RMSE is another parameter commonly used to measure the standard deviation of the prediction error.

4. RESULTS

The iteration result showed that the optimum hyperparameter setting of the Random Forest model was achieved by the number of trees was 25 and the number of attributes considered at each split as 25. Meanwhile, the optimum result of the Gradient Boosting model was achieved by setting the number of trees as 300, learning rate 0.300, growth control 1, and subsampling 1. Then the optimum result of the XGBoosting model was achieved by the number of trees as 300, a learning rate of 0.300, regularization was set 10 for lamda, limit the depth of individual trees as 20, and

fraction on subsampling was 1.

In this phase, the data was split into 80% data training and 20% data testing. Then test/train was repeated by five times. Model evaluation results, as shown in Table 1, show that Random Forest has the best accuracy, which R2 being 83.1%, MSE 47.425, RMSE 6.887, MAE 3.552, and MAPE 3.55%. Figures 3, 4, and 5 are shown the comparison of the predicted value with the actual value of emissions. Random Forest and XGBoosting have shown the best curve with R 0.91.

Table 1 Model evaluation result

No	Model	MAPE	MSE	RMSE	MAE	R2
1	Random Forest	3.55%	47.425	6.887	3.552	0.831
2	XGBoosting	16.80%	50.307	7.093	3.675	0.821
3	Gradient Boosting	18.71%	84.349	9.184	5.663	0.7

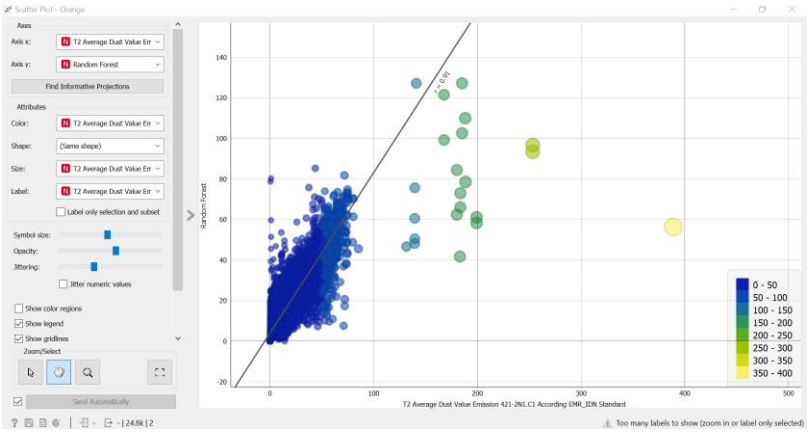


Figure 3 Comparison of the predicted results of the Random Forest model with the actual value of emissions

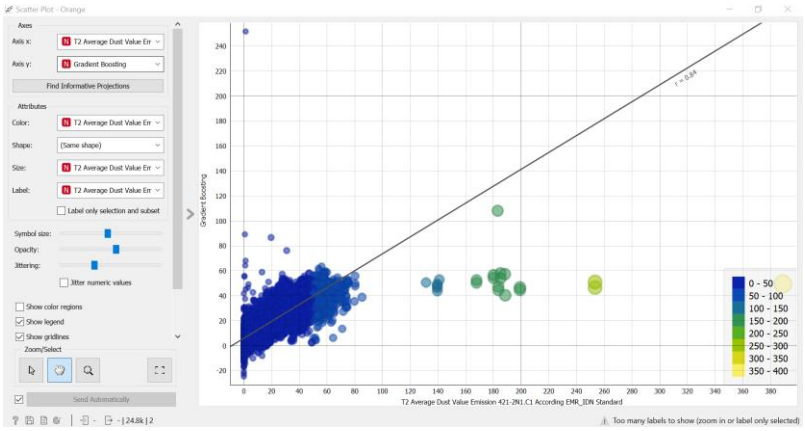


Figure 4 Comparison of the predicted results of the Gradient Boosting model with the actual value of emissions

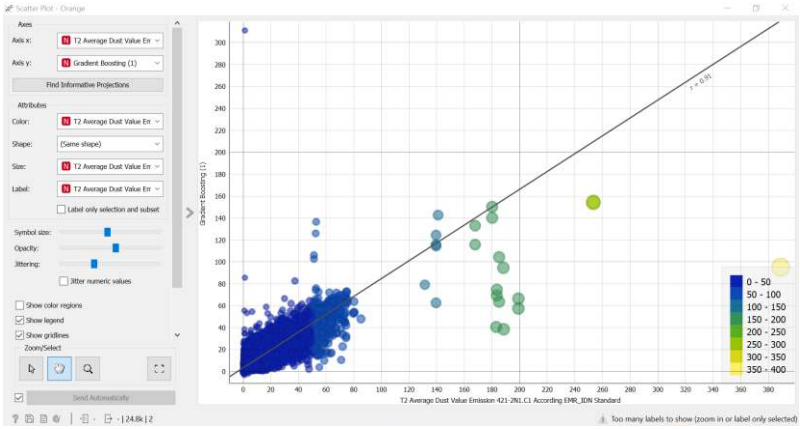


Figure 5 Comparison of the predicted results of the XGBoosting model with the actual value of emissions.

Then from the results of the Rank widget, the factors or operating parameters that have the most influence on the model are obtained, as can be seen in Figure 6 below.

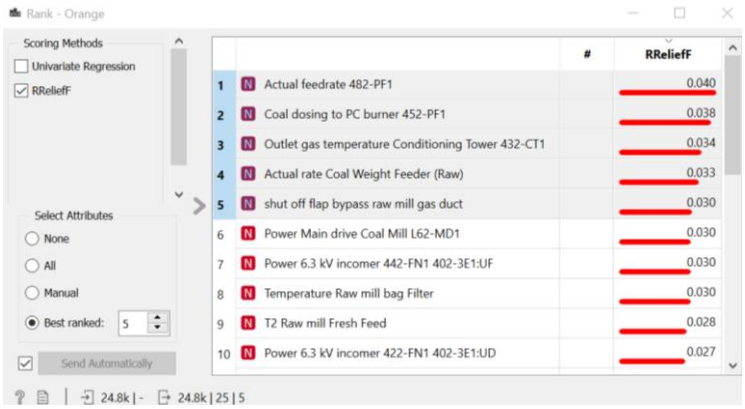


Figure 6 The most influencing features of the model

6. CONCLUSIONS

Predictive Maintenance or also known as Condition Based Maintenance (CBM), is a strategy where maintenance activities are carried out based on actual conditions and the results of data analysis of key parameters of an equipment system. This is intended so that maintenance activities can be carried out before the equipment system malfunctions and is reached at the optimum point, where premature and high-cost maintenance actions can be avoided. The series of operations in the cement industry involve quite complex processes from raw material extraction, raw meal preparation, clinker production, up to finish mill and dispatch. The right maintenance strategy will keep the main equipment's performance protected from equipment failure or unplanned stops.

In this study, the operating data of several pieces of equipment related to the bag filter is modeled by using machine learning in which the variable target is dust emission. The reliability of a good bag filter will make dust emissions in the flue gas better controlled. The evaluation results show that the Random Forest model has the best accuracy. From the model, it can be known the top five operating parameters that affect the performance of the bag filter.

The first parameter is the actual feed rate 482-PF1. This operating parameter indicates the volume rate of fuel in the kiln burner. The second parameter is coal dosing to PC burner 452-PF1. This operating parameter indicates the rate of fuel volume in the calciner. These two parameters are correlated to the kiln feed, where the increase in the kiln feed, the greater the fuel consumption. This

shows that the operating conditions in the kiln have an influence on dust emissions in the exhaust gas. The third parameter is the outlet gas temperature Conditioning Tower 432-CT1. This shows the temperature of the air coming out of the Conditioning Tower (CT). CT is a tool that works when the Raw Mill stops and serves to reduce the temperature of the hot air before it enters the filter bag so that the operation in the bag filter remains safe. This operating parameter is also related to raw mill operation, where good raw mill operation will make the hot gas flow load to the filter bag more stable. On the other hand, when the raw mill stops, a load of gas and material flow into the filter bag will be higher. This stability will make the bag filter performance good because the hot gas temperature is stable. The fourth parameter is the actual rate of coal weight feeder. These parameters indicate the stability of the coal mill operation; if the coal mill operation is not stable, then the load flow rate of hot gas to the bag filter will increase. At the same time, the last parameter is shut off flap bypass raw mill gas duct. This parameter indicates the flapper opening of the hot air duct entering the raw mill. Similar to the third parameter, the fifth parameter is also related to the operation of the raw mill, where the stability of the raw mill operation can be seen from the three parameters. Stable raw mill operation will make the filter bag flow load more controlled and make the bag lifetime better. If the raw mill stops, the bag filter load will be heavier because the flow of hot gas material that enters the bag filter increases with the flow of material from the gas conditioning tower. In general, the machine learning method can be used by management as a reference in making decisions regarding the management of plant operations and plant equipment maintenance strategies.

REFERENCES

Ameeth Kanawaday, A. S. (2017). Machine learning for predictive maintenance of industrial machines using IoT sensor data. *2017 8th IEEE International Conference on Software Engineering and Service Science (ICSESS)* (pp. 87-90). Beijing: IEEE.

AndreasTheissler. (2017). Detecting known and unknown faults in automotive systems using ensemble-based anomaly detection. *Knowledge-Based Systems, 123*(1 May 2017), 163-173.

Aurelian Froger, M. G.-M. (2016). Maintenance scheduling in the electricity industry: A literature review. *European Journal of Operational Research*, 695-706.

Breiman, L. (2001). Random Forest. In *In Machine Learning* (pp. 5-32). Netherland: Kluwer Academic Publishers.

Christopher Gondek, D. H. (2016). Prediction of Failures in the Air Pressure System of Scania Trucks Using a Random Forest and Feature Engineering. *The Fifteenth International Symposium on Intelligent Data Analysis.* Stockholm, Sweden: ResearchGate.

Friedman, J. H. (2001). Greedy Function Approximation: A Gradient Boosting Machine. *The Annals of Statistics Vol 29 No 5*, 1189-1232.

Ioannis T. Christou, N. K. (2020). End-to-End Industrial IoT Platform for Actionable Predictive Maintenance. *IFAC PapersOnLine* (pp. 173-178). Luxembourg: ScienceDirect.

Labram. (2019). *Article : Fitting Data with XGBoost*. Retrieved from Institute and Faculty of Acturies: https://www.actuaries.org.uk/news-and-insights/news/article-fitting-data-xgboost

Minxing Si, K. D. (2020). Development of a predictive emissions model using a gradient. *Environmental Technology & Innovation 20*, 101028.

Nielsen, D. (2016). *Tree boosting with xgboost-why does xgboost win" every" machine learning competition?* Trondheim: Norwegian University of Science and Technology.

Reza Khoshkangini, P. S. (2020). Early Prediction of Quality Issues in Automotive Modern Industry. *Information, 11*(6 July 2020), 354.

Rodney Kizito, P. S. (2018). The Application of Random Forest to Predictive Maintenance. *Proceedings of the 2018 IISE Annual Conference* (pp. 354 - 359). Orlando, Florida: ResearchGate.

Serkan Ayvaz, K. A. (2021). Predictive maintenance system for production lines in manufacturing: A machine learning approach using IoT data in real-time. *Expert Systems With Applications*.

Shaowei Pan, Z. Z. (2021). An Optimized XGBoost Method for Predicting Reservoir Porosity Using Petrophysical Logs. *Journal of Petroleum Science and Engineering*.

Tomasz Nowakowski, A. T.-W. (2018). Evolution of Technical Systems Maintenance Approaches – Review and a Case Study. *Advances in Intelligent Systems and Computing, 835*(01 August 2018), 161-174.

Veronica Jaramillo Jimenez, N. B. (2020). Developing a predictive maintenance model for vessel machinery. *Journal of Ocean Engineering and Science*, 358-386.

Weiting Zhang, D. Y. (2019). Data-Driven Methods for Predictive Maintenance of Industrial Equipment: A Survey. *IEEE Systems Journal*.

Xiaohua Luo, F. W. (2021). Effectiveness Evaluation and Influencing Factor Analysis of Paveent Seal Coat Treatments Using Random Forests. *Construction and Building Materials*.

Yu, W. D. (2019). A global manufacturing big data ecosystem for fault detection in predictive maintenance. *IEEE Transactions on Industrial Informatics*, 183-192.

Business feasibility analysis Plan for the Acquisition of Oil and Gas Block C in Country Senegal

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ABSTRACT

Company X received an invitation to participate in an open tender to acquire the ownership portion of the Oil and Gas Block by Company Ws. Company Ws is an international oil and gas company operating the Oil and Gas Block C, offering a 40% share of the Block ownership of the total 82% owned with the condition that the Company remains as the operator of the Block.

The Oil and Gas Block C is located in the sea area, 90 Km from the coast and in the deep sea, has oil reserves in the reservoir / underground equivalent to 430 million barrels. This Block C oil exploitation project will be the first crude oil production in country Senegal.

The business feasibility method used is the capital budgeting method which calculates the variables Net Present Value (NPV), Internal rate of return (IRR), Profitability Index (PI), Payback Period, Discounted Payback Period. Calculation of Capital Budgeting by sensitive parameters of crude oil price, Expenditure, Oil production and Weighted Average Cost of Capital (WACC). The results obtained from the Capital Budgeting Analysis based on the sensitivity of these 2 parameters, show the value of a positive NPV, IRR is greater than WACC and PI >1. So, it can be said that the Oil and Gas Block C investment plan is feasible.

Keywords: Oil & Gas, Acquisition, Business Feasibility, Capital Budgeting.

1. INTRODUCTION

Oil and gas companies in order to increase oil and gas production and reserves through 2 ways of organic investment and inorganic investment. Organic investment is an investment made by the company in the existing field or block by increasing the number of wells, repairing and optimizing well production. while inorganic investments are carried out by means of mergers and acquisitions to obtain new oil and gas fields or blocks. There are many examples of cases of oil and gas companies in the world that carry out inorganic investment activities, such as the case of large companies such as Chevron, British Petroleum, ConocoPhillips, Exxon Mobile, Shell and others.

The condition that there is a large gap between oil and gas supply and demand in Indonesia is a big challenge that must be faced by Company X as a state-owned company seeking to strengthen Company X's role in managing the security of domestic energy supply, by increasing oil and gas reserves and production from overseas assets and operations. Until now, through its subsidiary, which was established in 2013, operates in 13 overseas regions including Malaysia, Iraq, Algeria, Gabon, Tanzania and Nigeria which provide oil production of 97.3 thousand BOPD and gas 310.8 million SCFD. Some of the challenges faced by Company X in investing in other countries such as the condition of the location where the target assets are located, investment regulations in the country, the applicable fiscal regime, and others.

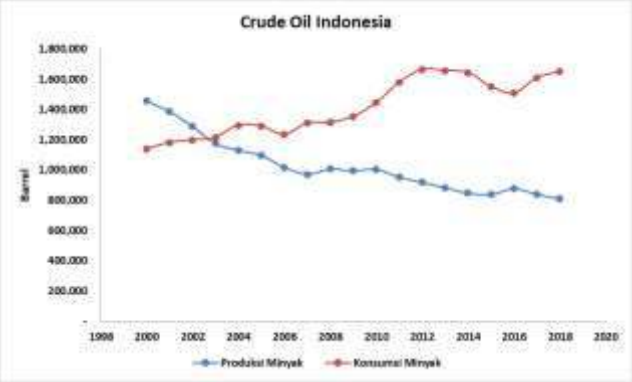


Figure 1. Production Vs Consumption Crude Oil in Indonesia

Company X received Invitation to join in open tender for investment acquire Oil and Gas Block in Country Senegal. Company Ws is international oil company (IOC) as existing operator in oil & gas block C offer up to 40 % participating interest from its 82 % participating interest and Company Ws will remain operator, and others participating interest owned by national oil company (NOC) of Senegal Country. Block C located in offshore located in Offshore Senegal country 90km from coast in deep sea, and holds total oil in place around 430 million barrels

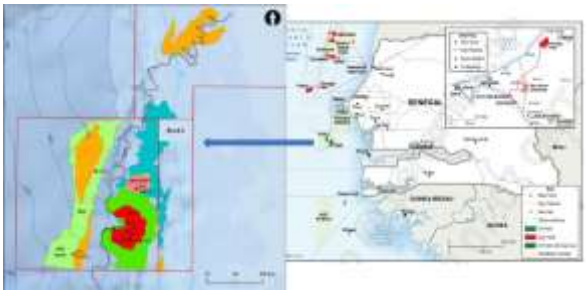


Figure 2. Area Block C

Block C has depth of sea level 900 – 1400 meters, and categorized as deep water Offshore. Block C has been explored since 2004, discovered oil reserves in 2014 through drilled well FAN-1 & SNE 1. Continued with drilled SNE-2, SNE-3,BEL-1, SNE-4 in 2016 and SNE-5, VR-1, SNE-6, FANS-1,SNEN-1 in 2017.
After successfully proving the existence of a petroleum resource, it enters the development stage by conducting a Front-End Engineering Design (FEED) study. FEED preparation is finished in 2019 and followed by submit Final Investment Decision (FID) document. Exploitation phase started in 2020.

In this case, the business in the oil and gas industry is a long-term investment so that precise capital budgeting preparation is needed. Capital budgeting is a job to analyze a project and to determine which projects will be included in the capital budget. The method commonly used to perform analysis and feasibility studies as well as valuation for a project is usually the Discounted Cash Flow method, which is where we will calculate the Net Present Value (NPV) and Internal Rate of Return (IRR) of the project. A project will be accepted for investment if the NPV of the project is positive and the IRR is greater than the Cost of Capital. In addition, it also takes into account how long the return on capital invested in the project will take.

2. LITERATURE REVIEW

Mergers and acquisitions are one of the strategic choices that organizations can carry out in existing business competition located at the corporate level, or corporate level strategy. Mergers and acquisitions will emerge as one of the options that arise when organizations want to get a competitive advantage. Merger is an activity of merging 2 companies into 1 company, where the company that carries out the merger will take / buy all assets and liabilities of the company to be merged. So that the merged company owns at least 50% of the shares of the company to be merged and the company that is merged will cease operations and the

shareholders of the merged company will receive compensation either in cash or shares of the new company (Brealey, Myers, & Marcus, 1999). Acquisition itself is the takeover of a company through the purchase of shares or assets of the company, with the condition that the acquired company remains (Brealey, Myers, & Marcus, 1999).

There are 3 types of mergers:

a) Merger Vertical
b) Merger Horizontal
c) Merger Konglemerasi

Acquisitions can be divided into 3 types:

a) Share Acquisition
b) Business Acquisitions
c) Asset Acquisition

According to Moint (2010) there are several reasons for a company to carry out Mergers and Acquisitions:

a) Economic reasons
there are also various other economic reasons such as reducing costs – time – risks when *entering the market*, having advantages and ownership over existing technologies and *branding*, increasing *market share*, having product diversification options, and others.

b) Reasons for strategies
The competitive advantage obtained through *cost leadership* and *market leadership* strategies, where *the cost leadership* is obtained by the company by achieving *an economic of scale* & *economic of scope* based on mergers & acquisitions.

c) Political reasons
The reason for mergers &acquisitions, which are usually carried out if there is government interference, can occur in state-owned and private companies. This reason is usually done by the government regarding the interests of the people and contributions to improving macroeconomics.

d) Reasons for taxation
The reason for taxation arises because the company has excess current assets and has slots for investment into the company's internals that are economical and feasible. These mergers and acquisitions can be done as a way to avoid taxes.

e) Reasons for synergist city
That mergers and acquisitions can be successful when the added value of the synergy results is greater than the *premium* value paid which makes the NPV positive owned by the company. Some forms of synergy (1) operations, are a combination of resources owned by the company to achieve effectiveness – efficiency – optimization; (2) Financial, mergers and acquisitions will provide a stronger new structure capital that makes the company able to have financial sources from the external side cheaper and easier so that the *company's capital costs* are reduced; (3) Managerial, with the addition of new personal individual skills as a result of exchanges or turnovers with companies that are merged or acquired are utilized; (4) and so on.

f) Reasons for diversification
Diversification is a strategy to create diversity in the business units owned. Where the diversity owned is obtained from mergers and acquisitions so that the company has a competitive position over new business activities that are more secure.

g) Non-Economic Reasons
Usually, the reasons for these mergers and acquisitions are based on the subjectivity of the owners of the company.

The success of mergers and acquisitions can be caused by things like the following (Moin, 2010):

- *Planning* integration and speed of merger and acquisition plans in implemented
- Objective of merger and acquisition efforts
- Similarities in work culture between each company that carries out mergers and acquisitions

- Have qualified information / knowledge about the business of the target company Meanwhile, the failure of merger and acquisition activities is usually caused by the following:
- Differences in the organizational culture of companies that carry out mergers and acquisitions with target companies
- Do not have a qualified knowledge of the complexity of the target company's business
- Non-achievement of integration after mergers and acquisitions

Capital Budgeting is a process carried out by an enterprise in determining whether a project is feasible or not. The cash inflows and outflows that will be obtained from a project are assessed to determine whether the estimated profit to be obtained is in accordance or not with the target that has been set. Capital budgeting is also known as investment appraisal, where the decision to make an investment requires various assessments of the estimated situation that may occur in the future. Therefore, assumptions are used to underlie an estimate of the estimate that will occur in the project plan due to internal or external factors.

There are various theories that explain the definition of *Capital Budgeting* such as, "Capital Budgeting is the process of identifying, analyzing, and selecting investment projects whose returns are expected to be more than one year," / "Capital Budgeting is the process of making investment decisions on fixed assets," (Horne, 2012). *Capital Budgeting* has a fundamental role in determining an investment, because *Capital Budgeting* can take into account the Cost Structure and Development of projects and companies in the long term.

Capital Budgeting Calculation Method

a) *Net Present Value* (NPV)

Net Present Value (NPV) is the difference between the current value of cash flow in and cash outflow in the upcoming period. *Net Present Value* (NPV) is used to provide an estimate of the current value of an investment plan / project / asset based on incoming cash flow in the future and while the value of cash flow out in the future will be adjusted first with the discount factor and investment price at the beginning. Using NPV calculations can help estimate how much the company's wealth will increase based on the project plan. The amount of Net Present Value can be formulated as follows:

$$NPV = -C_0 + \sum_{t=1}^{N} \left(\frac{C_t}{(1+r)^t} \right)$$

NPV = Net Present Value
C = cash flow in the year of the period "t"
Co = Value spent on investment at the beginning or 0th year
r = Discount rate or interest rate (%)

b) *Internal rate Of Return* (IRR)

The internal rate of return (IRR) is the percent discount rate on cash flows. IRR can also be referred to as the internal rate of return, the application of the IRR calculation is useful for providing a recorded NPV value of t0 in an investment. A plan based on the calculation of the IRR will be accepted if the project results are greater than the *Cost of Capital of* the project, and vice versa. Which is where this *Cost of Capital* parameter is considered as the minimum limit of the results of the project. The internal rate of return (IRR) can be formulated as follows:

$$IRR = i_1 + \frac{NPV_1}{(NPV_1 - NPV_2)} (i_2 - i_1)$$

IRR = Internal Rate Return
i_1 = Discount Factor that makes NPV worth positive
i_2 = Discount Factor that makes NPV worth Negative
NPV_1= NPV that has a positive value
NPV_2= NPV that has a negative value

Investment will be accepted if the IRR value is greater than the discount rate.

c) *Profitability Index* (PI)

Profitability Index (PI) is a comparison between the net value of future cash flows and the value of investments made at the beginning (0th year). The Profitability Index can be formulated as follows:

$$\text{PI} = \frac{Pv\ Of Future\ \ cash\ flow}{\text{Initial Investment}}$$

If the PI obtained is greater than 1, the company is expected to get investment returns with a value higher than the value it invested and vice versa, while if the pi value obtained is less than 1, it is estimated that the investment returns will get a value lower than the value invested at the beginning

d) *Payback Period*

Payback Period is an estimate of the duration of time required for a return on capital on investments made, based on the estimated profit of the project.

$$Payback\ Period = \frac{Initial\ \ Investment}{Annual\ \ Operating\ \ cash\ in\ flows}$$

In the calculation *of the Payback Period*, the smaller the value, the more likely it is to be approved by the project plan, because the faster the return on capital

3. METHODS

There are several steps of calculation that used in this research:

1. Gross Revenue
   Gross Revenue = Prod Oil * Oil Price
2. Capital Expenditure
   Capital Expenditure consist Of Drilling Offshore Well, Purchase of FPSO (Floating Production Storage & Offloading), Purchase Equipment Subsea & Gathering lines, budget for procurement general Infrastructure & support service.
   For FPSO
3. Operation Expenditure
   Operation Expenditure incurred for maintenance, repairment, operational subsea & gathering line. Moreover, annual expenditure that Contractor gives to training the government called "Training Fees"
4. Abandonment Expenditure
   Budget that expends by the company for closing the wells permanently at the end of the project. So that when the oil and gas block area is abandoned, there is no potential for leaks from underground that can damage the surface. Base on agreement between Contractor and Government in *Product Sharing Contract* (PSC) Blok C, there are two criteria for determine the start of payment:
   - Six years before end of contract
   - In the year, when reach 70% of cumulative production of project.

   Annual Abandonment Expenditure= Total of cost abandonment/ (Year End of Contract – Year of start expends)

   the cost will be submitted by the oil and gas company annually to the government of Senegal Country to be used as a guarantee of implementation commitments then save/keep and will be returned by the government of Senegal Country to the oil and gas company at the end of the contract for Abandonment work for surface and well facilities to be carried out.
5. Cost Recoverable
   Cost Recoverable is the return of the budget issued by oil and gas companies for field management in the form of Capex, Opex, Abex. In addition, based on the points on the PSC there are several taxes that can be included in the return, namely taxes on payments for Local Economic Contribution Tax – Contribution Rental Value FPSO (CRV),

Local Economic Contribution Tax – Contribution on value added (CVA), Custom Duty for FPSO Purchase on the previous year. The return budget for the costs incurred is called the Cost Recovery Ceiling, based on the provisions in the PSC is a nominal 75% of gross revenue.
Calculation of Capex base on PSC, will use method Deprecation Straight line basis with two criteria 5 years depreciated for cost drilling well, equipment subsea & gathering lines, general – infrastructure & support service; 10 years depreciated for purchase of FPSO

6. Profit Oil
   Profit Oil is obtained the remaining Cost Recoverable budget and the remaining gross revenue budget after deducting the cost recovery ceilling (25% gross revenue).
   To Determine share of profit Oil between government and contractor.

Table 1. Profit Oil Share

Daily Oil Production (barrels/day)	Contractor Profit Oil Share	Goverment Profit Oil Share
0 - 50000	85%	15%
50000 - 100000	80%	20%
100000 - 150000	75%	25%
150000 - 200000	70%	30%
> 200000	60%	40%

7. Local Economy Contribution (LEC) Tax & Custom Duty For FPSO
   - Custom Duty for FPSO
     Obtained from percentage of FPSO Price by several applicable such as Statistical Import Charge, Community solidarity levy, Economic Community of West African States, Senegalese Shippers Council
   - LEC (Contribution Value Added)
     Contribution Value Added = tax Rate*(Revenue Before tax-Opex)
     Revenue Before tax=Profit Oil Contractor share+Cost Recoverable Tax rate base on tax regulation Senegal is 1%
   - LEC (Contribution Rental Value)
     Contribution Rental value = CRV Rate*Agreed Cost of Hull* Rental Value Rate
8. Corporate Income Tax (CIT) & Brach Profit Tax (BPT)
   Earning before CIT = Revenue Before Tax – (LEC+Custom Duty)-Expenditure
   CIT=Earning Before CIT*CIT Rate (33%)
   Earning Before BPT = Earning Before CIT – CIT
   BPT= Earning before BPT*BPT Rate (10%)
9. Contractor Net Income
   Net Income = Earning Before BPT - BPT

4. RESULTS

In Upstream oil and gas industry, there are two ways to increase oil & gas production and reserves through organic and inorganic investment. Organic investment is an activity carried out to increase production and/or reserves in existing oil and gas fields through various activities such as increasing the number of wells, repair work - optimization of wells, etc. Meanwhile, inorganic investment is an effort to increase the company's oil and gas production and or reserves through mergers and acquisitions of new oil and gas fields.



Figure 3. Investment in Upstream Oil & Gas

According to company X's Long-term plan:

1. Managing Existing Assets
   Carry out initiatives to reduce decline and increase oil and gas production through optimization of field development in existing fields.
2. New Ventures
   Exploration activities to find new oil and gas fields (Green Fields)
3. Acquisitions and partnerships
   Looking for opportunities to increase oil and gas reserves and production through strategic alliances and acquire assets at home and abroad.

Purpose Company X to internationalization of business, according to Thompson et.al (2016):

- Open access to new customers
- To suppress prices through increasing economies of scale, increasing the bargaining power of purchasing, and adding new experiences.
- Gain access to additional resources and capabilities in the country to which you want to expand

In oil and gas there are several regulations of fiscal term, such as concession regimes and contractual regimes. In contractual regimes can divided into product sharing agreements and risk service contracts.

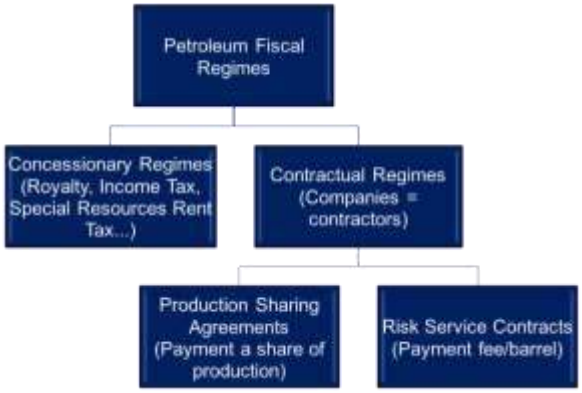


Figure 4. Petroleum Fiscal Term

Fiscal term regulations that apply in the country of Senegal is Product Sharing Contract. The following is schematic of Product Sharing Contract Block C.



Figure 5. Product Sharing Contract Block C

Crude oil production of Block C is the first crude oil production in Senegal, Crude oil pricing analysis is needed. In determining the price of oil based on 2 types of properties on the characteristics of the oil, sulfur content & specific gravity. Based on laboratory analysis Crude Oil has a sulfur content of 0.9% - 1.27% & API Specific Gravity 30.58 - 31.97.

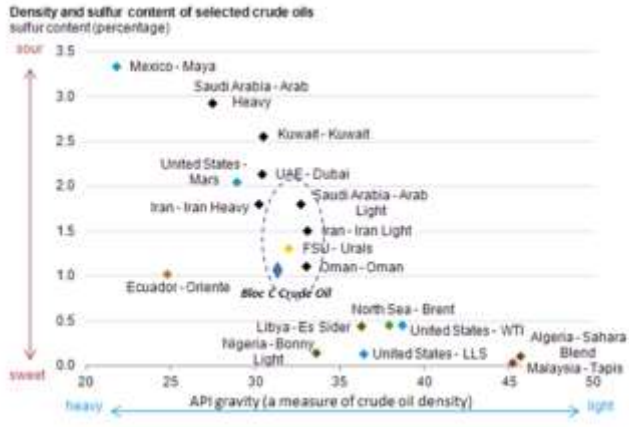


Figure 5. Characteristic of Crude Oil's

Accroding to characteristic of crude oil's, price of crude oil from Block C production

will use Arabian Light Crude as reference, related to geopolitical and regional aspect.

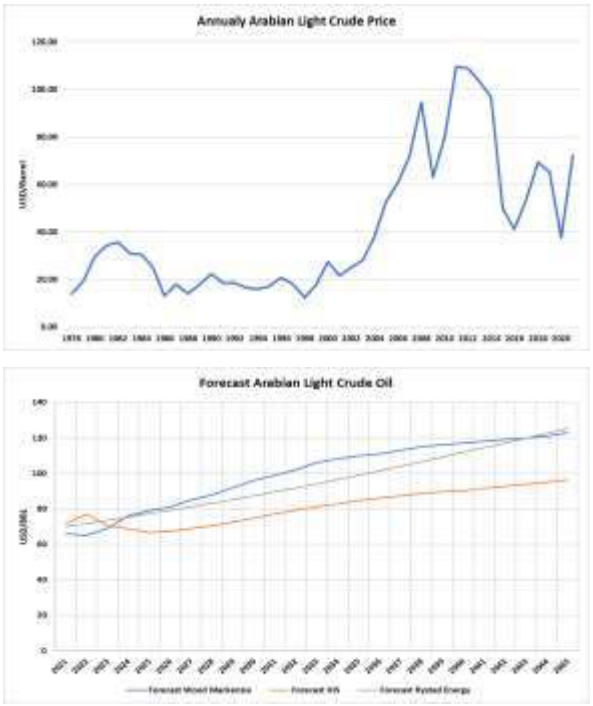


Figure 6. Arabian Light Crude Price

Base on FEED & FID Development of expoitation Block C divided into 2 phase:

1. Phase 1
   - Fied development in phase 1, focus on deeper reservoir with estimation cumulative oil production forecast 178 million barrels oil.
   - Planned drill 11 production wells, 10 water injection wells & 2 gas injection well.
2. Phase 2
   - Phase 2 will start drilling well in fifth year phase 1
   - Phase 2 will focus on upper reservoir with estimation cumulative oil production 165 million barrels oil
   - Planned drill 16 production wells, 15 water injection wells & 1 gas injection wells.

Table 2. Phase 1 Plan Of Development Block C

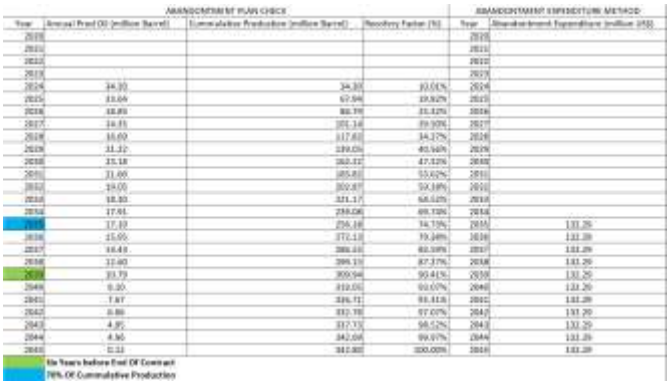
PHASE 1							
Year	Production Oil (million Barrel)	Capital Expenditures / Investment (million US$)				Opertion Expenditures (million US$)	
		Well	FPSO (Floating Production Storage and Offloading)	Subsea & Gathering Lines	General - Infrastructure and Support Services	FPSO (Floating Production Storage and Offloading)	Subsea & Gathering Lines
2020		8.4	406.4	221.1	68.89		
2021		267.6	583.4	254.2	136.69		
2022		510.0	368.5	317.8	153.49		
2023		562.6	243.3	165.6	138.88		
2024	34.30	135.0	14.1	41.9	33.14	130.18	14.38
2025	33.64					147.60	15.83
2026	18.85					213.20	12.69
2027	14.35					152.89	15.12
2028	11.20					152.54	17.64
2029	9.67					138.28	15.53
2030	8.55					171.65	18.01
2031	7.01					257.92	20.29
2032	4.77					174.89	17.39
2033	4.26					164.12	15.04
2034	4.14					175.46	20.36
2035	3.72					178.97	20.71
2036	3.47					182.55	17.53
2037	3.29					186.20	20.7
2038	3.09					189.92	20.01
2039	2.95					193.73	21.56
2040	2.74					197.60	17.59
2041	2.53					201.55	40.88
2042	2.32					205.57	25.66
2043	1.60					209.71	21.61
2044	1.52					213.91	23.32
2045	0.04					21.82	2.378

Table 3. Phase 2 Plan Of Development Block C

PHASE 2					
Year	Production Oil (million Barrel)	Capital Expenditures / Investment (million US$)		Opertion Expenditures (million US$)	
		Well	Subsea & Gathering Lines	FPSO (Floating Production Storage and Offloading)	Subsea & Gathering Lines
2020					
2021					
2022					
2023					
2024					
2025		16.3	45.5		
2026		71.6	69.6		
2027		233.7	152.3	2.17	3.00
2028	5.49	431.2	152.5	7.74	10.71
2029	11.54	448.6	159.2	13.53	18.73
2030	14.63	457.6	258.4	19.55	27.06
2031	14.59	521.7	175.5	26.98	37.35
2032	14.28	410.7	107.4	33.50	46.37
2033	14.03	304.7	109.5	39.05	54.06
2034	13.77			39.83	55.14
2035	13.38			40.63	56.24
2036	12.48			41.44	57.37
2037	11.14			42.27	58.51
2038	9.50			43.11	59.68
2039	7.84			43.97	60.88
2040	6.37			44.85	62.10
2041	5.14			45.75	63.34
2042	3.74			46.67	64.60
2043	3.35			47.60	65.90
2044	3.44			48.55	67.21
2045	0.08			4.99	6.86

Based on result technical & engineering analysis, estimation of abandonment expenditure 26 million US$ / well or 1,455 million US$. Abandonment expenditure will start in 2035.

Table 4. Method of Abandonment Expenditure



Next for calculate cost recovery capital expenditure use method Depreciation straight line basis.

Table 5. Capex Deprecation



So that the cashflow calculation of Project Block C as follows

Table 6. Gross Revenue Project Block C

Year	Gross Revenue			
	Annual Prod Oil (million Barrel)	Daily Production (BOPD)	Oil Price (US$/Barrel)	Gross Revenue (million US$)
2020			37.61	
2021			64.00	
2022			71.80	
2023			73.50	
2024	34.30	93,971	75.40	2,586.16
2025	33.64	92,174	77.30	2,600.65
2026	18.85	51,650	79.20	1,493.08
2027	14.35	39,304	81.20	1,164.91
2028	16.69	45,717	83.20	1,388.32
2029	21.22	58,132	85.30	1,809.92
2030	23.18	63,497	87.40	2,025.61
2031	21.60	59,167	89.60	1,934.99
2032	19.05	52,205	91.80	1,749.24
2033	18.30	50,125	94.10	1,721.62
2034	17.91	49,072	96.50	1,728.42
2035	17.10	46,839	98.90	1,690.80
2036	15.95	43,700	101.40	1,617.38
2037	14.43	39,529	103.90	1,499.08
2038	12.60	34,508	106.50	1,341.42
2039	10.79	29,571	109.20	1,178.65
2040	9.10	24,936	111.90	1,018.48
2041	7.67	21,011	114.39	877.28
2042	6.06	16,607	117.09	709.77
2043	4.95	13,567	119.79	593.22
2044	4.96	13,588	122.49	607.51
2045	0.12	319	125.19	14.59

Table 7. Expenditure Project

Year	Investentment Or Capex (Million US$)	Operation Expenditure (million US$)	Abandontment Expenditure (million US$)	Training Fees (million US$)
2020	705			0.4
2021	1,242			0.4
2022	1,350			0.4
2023	1,110			0.4
2024	224	145		0.4
2025	62	163		0.4
2026	141	226		0.4
2027	386	173		0.4
2028	584	189		0.4
2029	608	186		0.4
2030	716	236		0.4
2031	697	343		0.4
2032	518	272		0.4
2033	414	272		0.4
2034		291		0.4
2035		297	132	0.4
2036		299	132	0.4
2037		308	132	0.4
2038		313	132	0.4
2039		320	132	0.4
2040		322	132	0.4
2041		352	132	0.4
2042		343	132	0.4
2043		345	132	0.4
2044		353	132	0.4
2045		36	132	0.4
Total	8,757	5,782	1,455	10

Table 8. Cost Recovery Schematic Block C

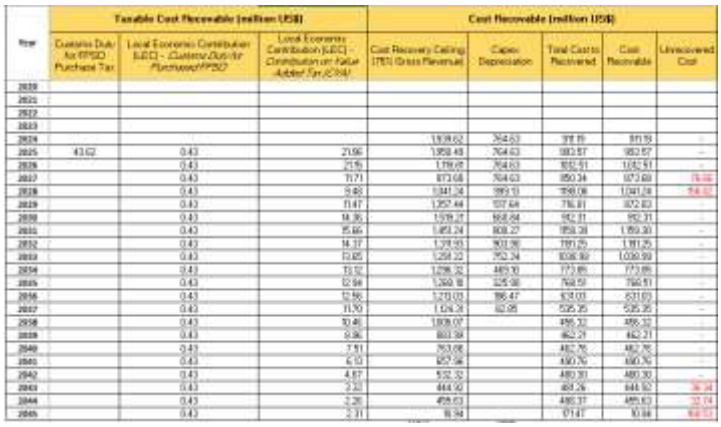


Table 9. Profit Oil Share

Profit Oil (million US$)				
Cost Rec Remaining Budget	Gross Rev - Cost Rec Ceiling	Profit Oil (PSC)	Production Share - Contr	Profit Oil - Contr
1,028	647	1,675	80%	1,340
957	650	1,607	80%	1,286
107	373	481	80%	384
-	291	291	85%	248
-	347	347	85%	295
485	452	937	80%	750
007	506	1,113	80%	891
292	484	776	80%	621
121	437	558	80%	446
252	430	683	80%	546
522	432	955	85%	811
500	423	922	85%	784
582	404	986	85%	838
589	375	964	85%	819
550	335	885	85%	752
422	295	716	85%	609
301	255	556	85%	472
167	219	387	85%	329
52	177	229	85%	195
-	148	148	85%	126
-	152	152	85%	129
-	4	4	85%	3

Table 10. Custom Duty/import tarift FPSO

Customs Duty for FPSO Purchase			
	FPSO Price	1,616	Million US$
Statistical Fee	1.00%	16.16	
Community Solidarity Levy	0.80%	12.93	
ECOWAS Levy	0.50%	8.08	
COSEC Levy	0.40%	6.46	
	Total Import Taxes	43.62	Million US$

Table 11. Company Rental value

Company Rental Value	*FPSO Purchase*
Applicable Rate	20.00%
cost of Hull (million US$)	31
Rental Value Rate	7.00%
CRV Tax per year (million US$)	0.43

Table 12. Other Taxes (taxes Recoverable)

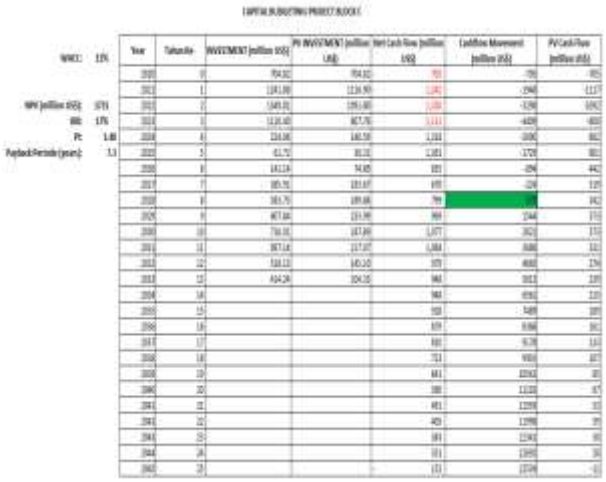
Year	Corporate Other Taxes (million US$)			
	Before Tax Income (PSC Revenue)	Customs Duty for FPSO Purchase Tax	Local Economic Contribution (LEC) - *Company Rental value*	Local Economic Contribution (LEC) - *Company on Value Added Tax (CVA)*
2020				
2021				
2022				
2023				
2024	2,251	43.62	0.43	21.06
2025	2,279		0.43	21.15
2026	1,397		0.43	11.71
2027	1,121		0.43	9.48
2028	1,330		0.43	11.47
2029	1,623		0.43	14.36
2030	1,803		0.43	15.66
2031	1,700		0.43	14.37
2032	1,638		0.43	13.65
2033	1,595		0.43	13.12
2034	1,569		0.43	12.94
2035	1,552		0.43	12.56
2036	1,467		0.43	11.70
2037	1,395		0.43	10.46
2038	1,209		0.43	8.96
2039	1,071		0.43	7.51
2040	935		0.43	6.13
2041	819		0.43	4.67
2042	676		0.43	3.32
2043	571		0.43	2.26
2044	565		0.43	2.31
2045	14		0.43	

Table 13. Corporate Income Tax & Brach Profit tax

Year	Corporate Income TAX (CIT) - million US$			Branch Profit Tax (BPT) - million US$			Contr Take or Net Income (million US$)	
	Earning Before CIT	CIT Payable	Earning After CIT	Earning Before BPT	BPT (Payable)	Earning After BPT	Cash Flow	Cumm Cash Flow
2020							- 705	- 705
2021							- 1,242	- 1,948
2022							- 1,350	- 3,298
2023							- 1,191	- 4,489
2024	2,186	721	1,465	1,465	146	1,318	- 1,318	- 3,030
2025	2,256	745	1,513	1,513	151	1,361	- 1,361	- 1,729
2026	1,385	457	928	928	93	835	- 835	- 894
2027	1,111	367	745	745	74	670	- 670	- 224
2028	1,324	437	887	887	89	799	- 799	575
2029	1,608	531	1,077	1,077	108	969	- 969	1,544
2030	1,787	590	1,197	1,197	120	1,077	- 1,077	2,622
2031	1,765	582	1,183	1,183	118	1,064	- 1,064	3,686
2032	1,624	536	1,088	1,088	109	979	- 979	4,665
2033	1,572	519	1,053	1,053	105	948	- 948	5,613
2034	1,572	519	1,053	1,053	105	948	- 948	6,561
2035	1,539	508	1,031	1,031	103	928	- 928	7,489
2036	1,457	481	976	976	98	879	- 879	8,368
2037	1,344	443	900	900	90	810	- 810	9,178
2038	1,199	396	804	804	80	723	- 723	9,901
2039	1,063	351	712	712	71	641	- 641	10,542
2040	929	306	622	622	62	560	- 560	11,102
2041	814	269	546	546	55	491	- 491	11,593
2042	672	222	450	450	45	405	- 405	11,998
2043	568	188	381	381	38	343	- 343	12,341
2044	582	192	390	390	39	351	- 351	12,692
2045	14	4	9	9	1	8	- 152	12,539

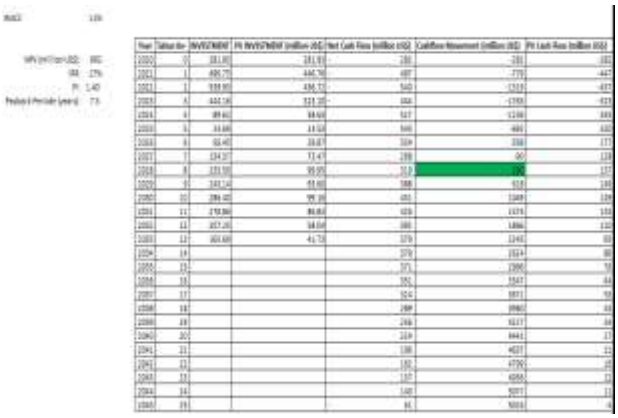
From cashflow of Block C Project, we can analysis the Capital Budgeting with WACC 11%, obtained:
NPV: 1,731 million US$
IRR : 17%
PI : 1.4
Payback Period : 7.3 Years

Table 14. Capital Budgeting Full Project Block C



Furthermore, capital budgeting analysis is carried out on the cash flow condition of 40% proportion according to the size of Block C ownership offered by the Ws company.

Table 15. Capital Budgeting adjust to 40% Participating Interest



After obtained capital budgeting analysis, followed by sensitivity with parameters WACC, Oil Price, Expenditure and Oil Production on the value of Net Present Value, Internal Rate Return, Profitability Index & Payback Period.

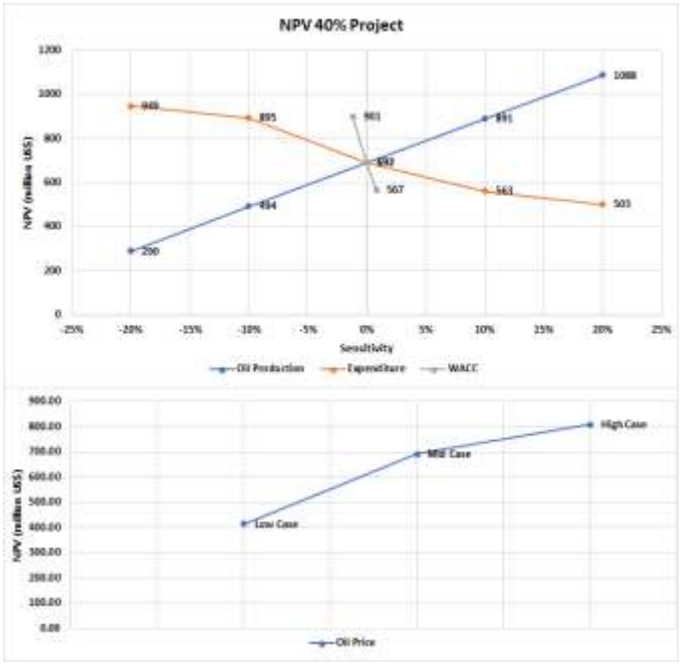


Figure 6. Sensitivity NPV

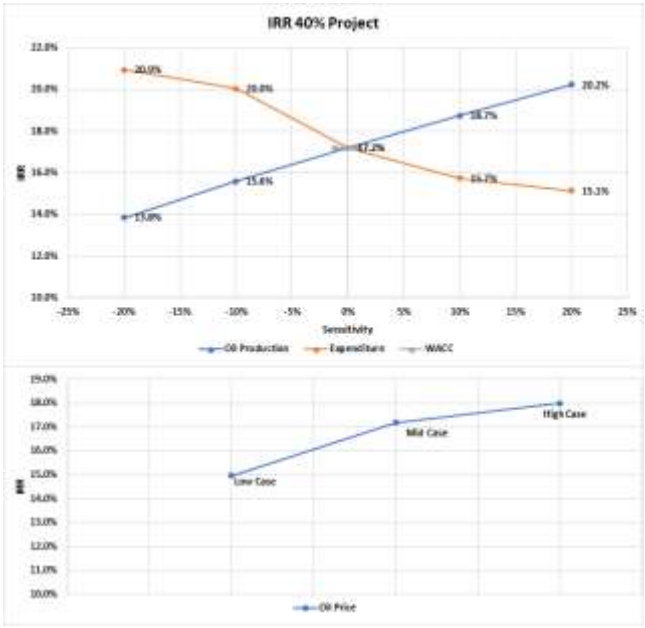


Figure 7. Sensitivity IRR

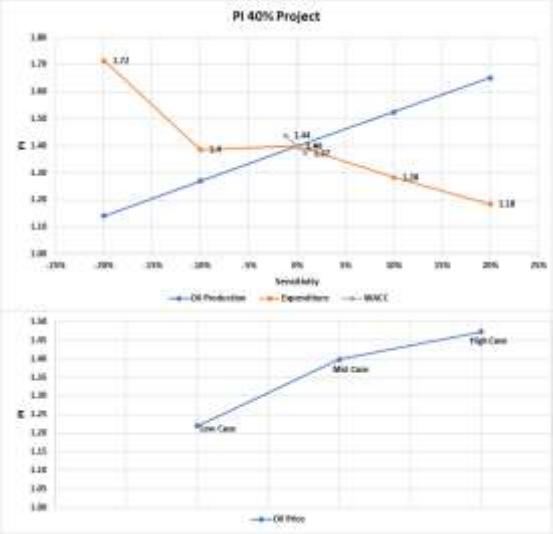


Figure 8. Sensitivity Profatibility Index

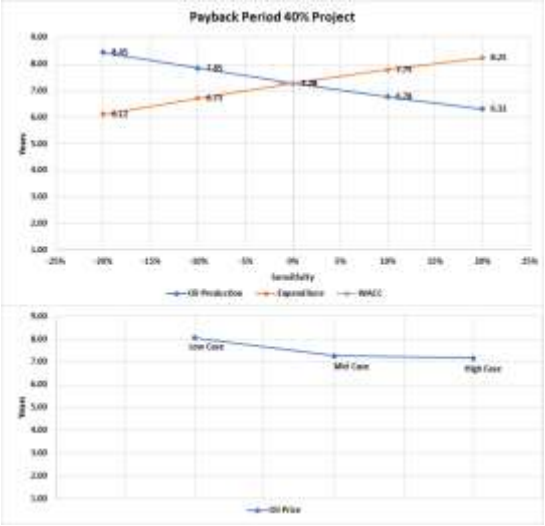


Figure 9. Sensitivity Payback Period



Figure 10. The Effect of Parameters on the NPV

6. CONCLUSIONS

It can be concluded based on the Capital Budgeting Analysis that the Block C project is feasible for investment:

1. Project NPV value > 0
   Full Project (726 million US$ up to 2.719 million US$)
   40% Project (290 million US$ up to 1088 million US$)
2. IRR value > WACC
   Full Project & 40% Project (13.8% to 20.9%)
3. PI value > 1
   Full Project & 40% Project (1.14 to 1.72)
4. Payback Period occurs in the range of the 6th year to the 8th year

Based on the results of the sensitivity of WACC parameters, Oil Price, Expenditure and Oil Production on the value of the Net Present Value of the project. It can be seen that the NPV value of the Block C project is the most sensitive to changes in the value of crude oil production, both within the scope of the full project and 40% of the project.

REFERENCES

Ahmed, I. E., & Sabah, N. (2020). *The Determinants of Capital Structure of the GCC Oil and Gas Companies*. *International Journal of Energy Economics and Policy*

African Development Bank Group. (2020). *Petroleum Code Reform in Senegal: Economic Implications and Policy Lessons*.

Brithis Petroleum. (2019). Statistical Review of World Energy (68th ed.)

Brithis Petroleum. (2021). *Statistical Review of World Energy* (70th ed.)

Brealey, RA Myers,S.C., dan Marcus A.J,(1999).*Fundamentals of corporate finance.Edisi kedua*.Irwin Mcgraw-Hill:Boston

Canadian Audit and Accountability Foundation. (2016). *Practice Guide to Auditing Oil and Gas Revenues*.

Komisi VI DPR-RI (2018). *Laporan Kunjungan Kerja Spesifik Komisi VI DPR RI Ke PT Pertamina (Persero) Di Provinsi Kalimantan Timur*. Jakarta

Fabozzi, F. J., & Peterson, P. P. (2002). *Capital Budgeting*. New York: John Wiley & Sons, Inc

Horne, James C. Van dan John M Wachowicz Jr. (2012). *Prinsip-Prinsip Manajemen Keuangan (Edisi 13)*. Jakarta : Salemba Empat.

Lubiantara, B., & Susanto, A.F. (2013). *Ekonomi migas : tinjauan aspek komersial kontrak migas*. Jakarta: Grasindo

Manurung, Adler Haymans. (2011). *Restrukturisasi Perusahaan: Merger, Akuisisi, dan konsolidasi, serta pembiayaanya*. Cetakan Pertama. Jakarta: STIEP Press.

Moin, A. 2010.Merger, Akuisisi dan Divertasi. Jilid Satu. Yogyakarta: Ekonisa.

Octaviani, Listi A. (2010).*Valuasi Nilai Akuisisi Matahari Department Store Dengan Menggunakan Discounted Cash Flow*, Universitas Indonesia, Magister Manajemen. Jakarta: Universitas Indonesia.

Pamungkas, J. (2004). *Pengantar Teknik Perminyakan*. Yogyakarta: Universitas Pembangunan Nasional "Veteran"

PricewaterhouseCoopers LLP. (2011). *Valuing the great shale play*.

Ross, S.A, Westerfield, R.W . (2016), *Corporate Finance 11th*. New York: McGraw-Hill Education

Sartono, Agus. 2010. *Manajemen Keuangan Teori dan Aplikasi*. Edisi 4. Yogyakarta : BPFE.

Wood Mackenzie. (2021). *Senegal upstream fiscal summary*.

Zahra, F. (2014). *VALUASI PROYEK MIGAS DENGAN MENGGUNAKAN METODE DISCOUNTED CASH FLOW DAN ANALISIS REAL OPTION*. Universitas Indonesia, Magister Manajemen. Jakarta: Universitas Indonesia.

"ConocoPhillips Completes $35.6B Purchase of Burlington Resources" (2006, August 22). *Naturalgasintel* www.naturalgasintel.com/conocophillips-completes-35-6b-purchase-of-burlington-resources/

"Conoco completes deal for Burlington" (2005, December 13). *The New York Times* www.nytimes.com/2005/12/13/business/worldbusiness/conoco-completes-deal-for-burlington.html#:~:text=HOUSTON%20%E2%80%94%20ConocoPhillips%2C%

20the%20energy%20company,the%20world's%20largest%20oil%20companies.

Endarwati, O. (2021). *Sejarah Blok Rokan, Dikuasai Chevron Hampir 1 Abad hingga Akhirnya Dikelola Pertamina*. economy.okezone.com/read/2021/08/11/320/2454220/sejarah-blok-rokan-dikuasai-chevron-hampir-1-abad-hingga-akhirnya-dikelola-pertamina

Mekari. (2019). *Perbedaan Merger dan Akuisisi, Mana yang Paling Cocok untuk Ekspansi Bisnis Anda*. https://www.jurnal.id/id/blog/definisi-dan-perbedaan-utama-dari-merger-dan-akuisisi/

Nakhle, C. (2018). *Driving Investment in the Oil&Gas Industry: The importance of the fiscal regime*. www.crystolenergy.com/media_posts/driving-investment-in-the-oilgas-industry-the-importance-of-the-fiscal-regime/

"Pertamina Bakal Beli Minyak Mentah Rusia untuk Kilang Balongan" (2022, Maret 28). Media Indonesia mediaindonesia.com/ekonomi/481472/pertamina-bakal-beli-minyak-mentah-rusia-untuk-kilang-balongan

"Refinery Unit IV Cilacap". *PT Pertamina Persero* www.pertamina.com/id/refinery-unit-iv-cilacap

Safii. (2018). *Setelah 50 Tahun, Blok Rokan Kembali Ke Pangkuan Ibu Pertiwi*. https://www.esdm.go.id/id/media-center/news-archives/setelah-50-tahun-blok-rokan-kembali-ke-pangkuan-ibu-pertiwi

"Senegal Taxes" (2022, January 19). *PricewaterhouseCoopers* taxsummaries.pwc.com/senegal

Setiawan, Verda N. (2021). *Medco Energi Akuisisi Aset Migas ConocoPhillips di Indonesia*. katadata.co.id/happyfajrian/berita/61b1573b94bba/medco-energi-akuisisi-aset-migas-conocophillips-di-indonesia

U.S Energy Information Administration. (2021). *Country Analysis Executive Summary: Indonesia*. https://www.eia.gov/international/analysis/country/IDN

U.S Landed Costs of Saudi Arabian Light Crude Oil

Petroleum & Other Liquid. May 1 2022. www.eia.gov/dnav/pet/hist/LeafHandler.ashx?n=pet&s=isa4990008&f=a

"Water Depth Vs Hars Environtmenr Offshore Drilling Categories" (2018, November 8). *Oea Consulting* www.oea-consulting.ca/post/30-water-depth-vs-harsh-environment-offshore-drilling-categories

WORK DESIGN IN THE MINING INDUSTRY WITH AN ERGONOMIC APPROACH CONSIDERING PHYSICAL DEMAND ANALYSIS (CASE STUDY: HEAVY EQUIPMENT OPERATORS IN PT. VALE INDONESIA, TBK)

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ABSTRACT

In the allocation of employees to certain positions/tasks, discrepancies are often found between the employees who are placed and the requirements of the position. This is also found a mining company that are the focus of this Case Based Thesis, where when the company allocates employees, both new employees (new hires) and old employees who are repositioned, there are many physical conditions of workers in terms of dimensions that are not in accordance with the conditions of the work environment or job demands. For example, mining work requires workers with certain physical characteristics such as having a certain height and arm reach to enable workers to complete their work well. The discrepancy between the dimensions of the worker's body and his work can cause work ineffectiveness and discomfort. In order for work to be carried out effectively, comfortably, safely, healthily, and efficiently, it is necessary to conduct a study related to job analysis that considers aspects of physical demand where an analysis will be carried out by finding the right body dimensions required by the job through an analysis called Physical Demand Analysis. The final result of the Case Based Thesis is expected to assist the company in defining the job characteristics of the needs for the dimensions of the worker's body in terms of the Physical Demand aspect of each job that is integrated into each job role profile so that in the process of selecting or recruiting employees, workers will be obtained who are in accordance with the needs of certain jobs so that workers can work effectively, comfortably, safely, healthy and efficiently.

Keywords: Physical Demand Analysis, Mining Industry, Industrial Ergonomic, role profile, fit to work.

1. INTRODUCTION

Fit to work is a physical and mental condition, which allows workers to complete the tasks given, in a way that does not threaten the health and safety of themselves, co-workers, property and the surrounding community (Serra, et al., 2007). Fit speaks not only of the absence of disease, disability, and infirmity but also of being mentally and socially healthy. Since workers must always

be healthy and safe at work, it is important to develop occupational safety and performance improvement programs in the workplace to prevent hazards and control risks that could result in work-related accidents or illnesses.

To ensure workers are fit for work, it is necessary to ensure a proper and correct selection process. The selection of workers is not only based on knowledge, understanding, and high achievement but must also be adjusted to the type of work that will be faced later. Employee readiness needs to be seen also physically and psychologically.

The company where the Case Based Thesis is conducted is an integrated nickel mining and processing company currently operating in East Luwu Regency, South Sulawesi Province. The company was founded on July 25, 1968, and it is part of an International multi-mining company which is a global leader in iron ore production and one of the largest nickel producers in the world.

The company mines nickel laterite to produce the final product in the form of nickel in matte. The average volume of nickel production per year reaches 75,000 metric tons. The nickel produced by this company is exported entirely to one of the metal mining companies in Japan as stated in a special long-term contract entered by the two companies. The large production of this company needs to be supported by workers who are fit at work. Therefore, it is necessary to conduct research to see the suitability of work and equipment with workers both physically and physiologically, or "analysis of physical demand" especially in mining and transportation areas where work accidents often occur.

Broadly speaking, this company has two major activities in production. The first activity is mining activity and the second activity is processing activity or production activity. Both activities are activities that continue 24 hours a day. Therefore, these activities require a lot of manpower to function as operators of all activities.

For mining activities, it can be found that there are operators who operate heavy equipment. These operators, in carrying out their work, will interact a lot with heavy equipment such as backhoes, shovels, dozers, haul trucks and various other heavy equipment normally operated at mining sites. Meanwhile, for production or process activities, it also involves operators interacting with heavy equipment, but it is slightly different from heavy equipment operated in mining activities. Most of the heavy equipment operated are heavy equipment that does not move or move.

Operators in carrying out their activities, encounter various problems in carrying out their work. One of these problems is that operators have many limitations in carrying out activities in terms of reaching work tools because they are limited by their body dimensions. One example is based on previous experience, reports that operators in mining areas are unable to climb into heavy equipment that will be used while working. This is because the footing to get on the Dump Truck to be operated is too high for the job while the height of the job is too short so that the leg reach is too short to reach the footing to climb onto the haul truck. Incidents like this often occur and are experienced by operators when they are about to work. So far, considerations regarding the limitations of body dimensions from work have never been considered when selecting workers who will be accepted to work in the company.

The incompatibility of the physical dimensions of the worker's body with his work can cause losses in the form of loss of working time and non-fulfillment of production targets. Once again, this case occurs because of the limitations of the operator's body dimensions at work.

Another example is a worker whose role is as a mechanic and works in a shop. As we know, work in a shop is a job that involves a lot of manual handling. One of the manual handlings is moving goods or work tools that are quite heavy. Considerations for using assistive devices in the process of moving these work tools cannot be used for various reasons related to the work completion process. Thus, SOPs or work steps are made by stipulating that the work must be done

by manual handling. In this case, workers in the shop were found to be unable to complete their work or were hampered by their work because they were unable to carry out manual handling of material because they were unable to lift the material to be moved. Once again, the loss occurred in this case where the work process was hampered, which resulted in the completion time of the work being hampered so that the target of the work could not be met.

Some of the events described above can bring greater losses if not handled immediately. Bigger losses can be in the form of work accidents or occupational diseases that will be experienced by the workers (operators). So far, the adverse effects that may have been felt and suspected because of the events mentioned above are the emergence of complaints from workers that they experience a problem known as Low Back Pain or pain in the lower spine. Although it has not been confirmed as a work-related illness because of doing work, studies on the emergence of Low Back Pain complaints continue to be carried out.

Low Back Pain based on its phase can be classified into 3, namely: Acute Low Back Pain, Sub-acute Low Back Pain, and Chronic Low Back Pain. The acute low back pain phase is the phase of pain that is felt within 0-3 months after there is a trigger for low back pain. Low Back Pain Sub-acute pain phase is felt within 2-3 months after there is a trigger for Low Back Pain. Meanwhile, chronic low back pain is felt in more than 3 months after the trigger is there (Anthony Delitto, 2012).

In Table 1, it can be seen the record of the number of complaints of Low Back Pain experienced by the workers of this mining company in the past few years. All data are summarized from the Occupational Health Section of PT. Vale Indonesia, Tbk are all cases of Low Back Pain diagnosed as Chronic Low Back Pain. From the table, it shows that since 2019 to 2021, there was a significant increase in the number of workers experiencing Low Back Pain.

Table 1. Chronic Low Back Pain Complaints from 2019 to 2021

Departemen	**Year**		
	2019	**2020**	**2021**
Mining	212	257	279
Process Plant	183	229	252
Maintenance & Engineering	153	185	210
Admin & Support	100	122	139
Total	**648**	**793**	**880**

Source: Preliminary Data from Occupational Health Section PT. Vale Indonesia, Tbk.

Since 2017, the company has done many things to reduce the number of workers experiencing Low Back Pain. Some of the things that have been done are providing knowledge to workers about tips for working well in connection with good work posture, especially for workers who work in work locations that do a lot of manual handling. There are several other tips carried out by this company such as curative measures in the form of treatment and healing efforts for workers who have already experienced Low Back Pain. Besides that, a risk assessment is also carried out for hazards in the work environment, especially for Ergonomics. Thus, the company has concluded that it is necessary to deal with this problem on an ongoing basis by continuing to carry out the tips that have been carried out in addition to conducting a study on Physical Demand Analysis.

From all that has been mentioned above, it can be said as a condition in which the worker does not meet the specifications required by the job in carrying out his work. Ideally, the working

environment conditions should be arranged in such a way that workers are fit to do the job. But this situation dictates that it is the worker who must be fit first before starting his work.

The purpose of this Case Based Thesis is to obtain information about the characteristics of workers in the form of a Physical Demand Analysis Matrix that is in accordance with the demands of the job so that it can be ensured that the workers owned by the company are workers who in addition to having the appropriate body dimensions can also be assured that the workers They can do their job effectively, comfortably, safely, healthily, and efficiently because they have no limitations on what the job demands.

Apart from that, from the Case Based Thesis, you will also get any recommendations that are possible to do in terms of the work environment through consideration of the control hierarchy priorities, namely elimination, substitution, engineering control, administrative control, and the use of PPE. (Darmiatun S, 2015).

2. LITERATURE REVIEW

This research is based on several previous studies which are used as a reference to determine the processing method of the data that has been collected and summarized in this literature study. Table 2 below is a summary of several previous research studies obtained through international journals.

Table 2. Reference from Previous Research

No	Title	Authors	Year	Bahasan jurnal
1	A Physical Demands description of paramedic work in Canada.	Brendan Coffey, Renee MacPhee, Doug Socha, Steven L. Fischer.	2014	Physical Demand analysis needs in the form of ergonomics analysis of manual handling, worker anthropometry, work posture, and physical strength of workers.
2	Analysis of Physical Demands during bulk bag closing and sealing.	Mahiyar F. Nasarwanji, Leanna M. Reardon, John R. Heberger, Patrick G. Dempsey.	2015	Analysis of the Physical Demand for manual handling work.
3	An anthropometric survey of Korean hand and hand shape types.	Soo-chan Jee, Myung Hwan Yun.	2015	Survey and processing of anthropometric data of workers' hands.
4	An improved Physical Demand Analysis framework based on ergonomic risk assessment tools for the manufacturing industry.	Xinming Lia, Mustafa Gül, Mohamed Al-Hussein.	2017	REBA and RULA tools in conducting Physical Demand Analysis to determine the risk of work posture from manual handling work.
5	Ergonomics assessment methods used by ergonomics professionals.	Brian D. Lowe, Patrick G. Dempsey, Evan M. Jones.	2019	Consideration of the psychological aspects of workers in conducting Ergonomic Assessment.

Table 2. Reference from Previous Research (Continued)

No	Title	Authors	Year	Bahasan jurnal
6	New easy to use postural assessment method through visual management.	Matteo Savino, Antonio Mazza, Daria Battini.	2013	Upper Limb and Lower Limb in the Ergonomic Risk Assessment method.
7	Psychological and physical job demands, decision latitude, and work-related social support among Iranian waste collectors	Mansour Ziaei, Alireza Choobineh, Mohammad Abdoli-Eramaki, Haleh Ghaem, Omid Jaberi.	2018	Psychological Job Demand - the need to analyze psychological aspects to assess the risks of a job.

3. METHODS

Case Based Thesis is done by doing several stages. Starting from data collection for primary data and secondary data. Primary data is collected by direct measurement of employees, while secondary data is obtained by taking historical data that has been collected by the Industrial Hygiene & Ergonomic Section at PT. Vale Indonesia, Tbk. The methods used to resolve cases in this case-based report can be seen in Figure 1 below.

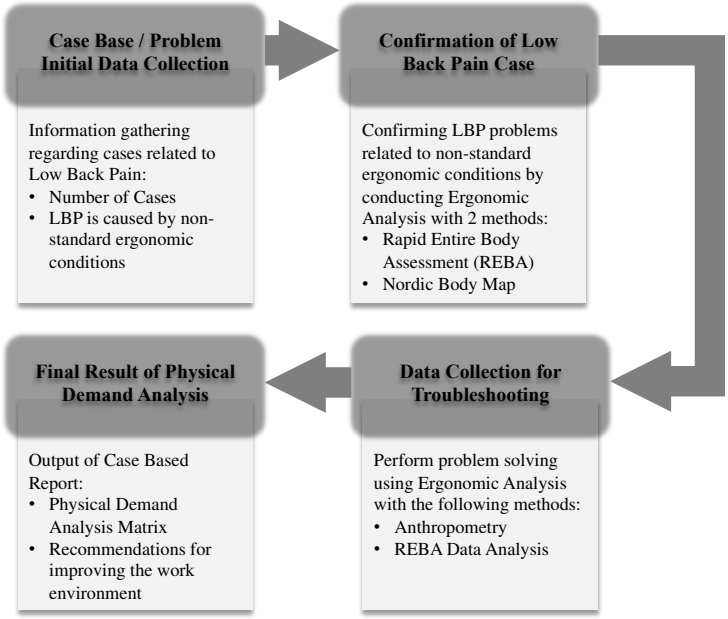


Figure 1. Ergonomic Methods Used to Solve Cases

4. RESULTS

After compiling the PDA Matrix as done, it can be made a PDA Matrix as shown in the following pictures.

Physical Demand Analysis Matrix

Anthropometry Data Requirements

Occupational Group/Similar Exposure Group : Operator Dozer - D65 Komatsu

Data Antropometri		Minimum Value (cm)	Maximum Value (cm)
Butt Width	:	37	37
Butt Length to Popliteal	:	-	43
Length from Fingertip to Elbow	:	-	39
Front Reach Length	:	-	82,2
Knee Height	:	-	46
Popliteal Height	:	40	48
Sitting Position Height	:	133	-

Figure 2. PDA Matrix for Dozer Operators - D65 Komatsu

Physical Demand Analysis Matrix

Anthropometry Data Requirements

Occupational Group/Similar Exposure Group : Operator Dozer - D8R Caterpillar

Data Antropometri		Minimum Value (cm)	Maximum Value (cm)
Butt Width	:	-	37
Butt Length to Popliteal	:	-	43
Length from Fingertip to Elbow	:	-	39
Front Reach Length	:	-	52,9
Sitting Shoulder Height	:	-	105
Knee Height	:	-	46
Popliteal Height	:	40	48
Sitting Position Height	:	133	-
Sitting Elbow Height	:	-	60

Figure 3. PDA Matrix for Dozer Operators – D8R Caterpillar

The picture above is an example of the PDA Matrix which is the result of this research. The pictures are only given as examples and the overall results of this study are not included in all of them.

In addition to the PDA Matrix obtained as a result of this research, there are also several recommendations for improvement in the form of engineering control recommendations for work stations from operators as shown in the table below.

Table 3. Reference from Previous Research

Dimension Name	Anthropometric Dimension Require	Explanation
Steering Wheel Diameter	Maximum Shoulder Width Percentile 50 Male	The diameter of a good steering wheel must follow the size of the shoulder width
Seat Distance to Control Board	Maximum Front Reach Length 5th Percentile Female	The distance between the seat and the control board is attempted to follow the length of the front reach so that when working it does not require a large effort and can reach the control board easily.
Seat to Pedal Distance	Maximum Knee Height 5th Percentile Female	The distance from the seat to the pedal follows the knee height if it is longer, the pedal will not be reached by the operator's feet and if it is too short, the operator will have difficulty operating the pedal because the foot is bent
Seat to Steering Distance	Maximum Front Reach Length 5th Percentile Female	The distance between the seat and the steering wheel is strived to follow the length of the front reach so that when working it does not require a large effort and can reach the control board easily
Seat Distance with Windshield	Maximum Front Reach Length 95th Percentile Male	The distance between the seats and the windshield is attempted to follow the length of the front reach so that when working it does not require a large effort and can reach the control board easily.
Seat Distance to Control Board	Maximum Front Reach Length 5th Percentile Female	The distance from the Chair to the Control Board is strived to follow the length of the front reach so that when working it does not require a large effort and can reach the control board easily.
Seat Seat Width	Minimum Buttock Width Percentile 95 Female	The seat holder will be comfortable when used if the width of the buttocks can be fully supported by the seat holder
Seat Seat Length	Maximum Buttocks Length to Popliteal 50th Percentile Male	The length of the seat is attempted to follow the dimensions of the length of the buttocks to the popliteal. If it is too long then the back will not be able to lean well against the backrest. And if it's too short then the thigh will not be fully supported by the seat
Backrest Length	Minimum Seating Height 50th Percentile Male - 50th Percentile Popliteal Height Female	The backrest is strived to support the entire back from the buttocks to the head
Armrest Length	Maximum Length from Fingertip to Elbow Female 5th Percentile	In working, the hands occasionally need to rest if they are not carrying out heavy equipment control activities and must be supported by armrests along the dimensions from fingertips to elbows.
Seat Seat Height (adjustable)	Lowest Adjustment Minimum Popliteal Height Percentile 5 Female and Highest Adjustment Maximum Popliteal Height Percentile 95 Male	The seat holder will indeed be very comfortable if the height can be adjusted according to the popliteal height so that it can be ensured when sitting the feet can still tread well on the floor (legs do not hang)

Table 4. Reference from Previous Research

Dimension Name	Anthropometric Dimension Require	Explanation
Cabin Height	Minimum Height Sitting Position 95th Percentile Male	The height of the cabin is attempted to follow the height of the body in the sitting position. Too low causes the operator to always bend over while in the cab
Monitor Screen Height	Maximum Sitting Eye Height Percentile 50 Male + Popliteal Height Percentile 50 Male	The monitor will be monitored very often when doing work, so it will be comfortable to monitor if the monitor position is adjusted to the height of the eye when sitting
Control Board Height	Minimum 50th Percentile Popliteal Height Male and Maximum 50th Percentile Sitting Shoulder Height Male	The control board will be easier to reach if its height is adjusted to the range between popliteal height and operator's shoulder height
Armrest Height	Maximum Sitting Elbow Height 5th Percentile Female	Hands will be well supported if the height of the armrest is in a position equal to the height of the elbow in the sitting position
Steering Height	Minimum Sitting Elbow Height Percentile 50 Male and Maximum Shoulder Height Sitting Percentile 50 Male + Popliteal Height Percentile 50 Male	The steering wheel as a steering tool should be adjustable in height so that it can be comfortably used. The range of the lowest position follows the elbow height in the sitting position and the highest follows the shoulder height in the sitting position

6. CONCLUSIONS

After observing, measuring, collecting data, and conducting analysis and obtained the Physical Demand Analysis Matrix and the recommendations in this Case Based Thesis, it can be concluded that:

1. The preparation of this Physical Demand Analysis will produce an output in the form of a Physical Demand Analysis Matrix which will then be taken into consideration in recruiting new workers, promoting workers, and transferring workers because with the Physical Demand Analysis Matrix, the Human Resource section will be able to determine workers with conditions which is like what can be declared fit to do one job.
2. In the process of preparing Physical Demand Analysis, there are several conditions where the anthropometric dimensions required by the job requirements do not match the anthropometric conditions of the workers. For this situation, it is necessary to modify the working environment as mentioned in the suggestions section of this Case Based Thesis. This modification becomes a recommendation that is needed as one of the goals to be achieved in this Case Based Thesis.
3. Physical Demand Analysis can be used as one of the methods in Ergonomics to ensure work can be done properly, safely, comfortably, and healthily. Through the method in Physical Demand Analysis, it can be seen what the needs of each job are for the physical condition of the workers so that workers can be declared fit to work.
4. In addition to the REBA method mentioned in previous studies, there are other ergonomic methods that can be used as tools in conducting or compiling Physical Demand Analysis. The Nordic Body Map method to confirm cases can be used, besides that the principles in anthropometry are also used in preparing Physical Demand Analysis.
5. Determination of sample size using the Similar Exposure Group Method where the data population is grouped by type of work (in Case Based Thesis this is the type of heavy

equipment operated by workers) can be used. In addition to obtaining a sample size that is not too large, it can also be ensured that the sample size can represent the conditions of the existing population.

6. The method used in preparing this Physical Demand Analysis can also be used as a template to perform Physical Demand Analysis in other departments at PT. Vale Indonesia, Tbk.

7. RECOMMENDATIONS

Based on the conclusions above, in accordance with the output obtained from this Case Based Thesis, the author can provide suggestions that can be considered and improved for future research. The suggestions are as follows:

1. The making of Physical Demand Analysis Matrix in this Case Based Report only considers ergonomic risk assessment using the Rapid Entire Body Assessment and Nordic Body Map methods. For a stronger analysis, other methods can be added as a complement or perhaps as a substitute method for the method used in this study, because each case of different ergonomics can also have different methods in carrying out risk assessments. Ergonomic risk assessment has various methods, for example, which is not used in this study is Biomechanics analysis.
2. For a smaller scope where the total population of workers who are the object of research is not too large, it is better if data collection is not carried out by sampling but is carried out by means of a census. Thus the data collected is not representative data but is overall data. So that the results of data processing will be more accurate data.
3. There is an opportunity to add considerations in the preparation of the Physical Demand Analysis Matrix. Anthropometric considerations used in this study can be added with other considerations so that the Physical Demand Analysis Matrix obtained does not only provide results in the form of body dimension requirements, but can be developed to limited physical abilities such as minimum hand grip strength, minimum lifting strength, weight range permitted, or it can be a requirement that it must not have certain physical disabilities.

REFERENCES

Anthony Delitto, S. Z. (2012). Low Back Pain. *Low Back Pain*, 1-18.

Ayoub, M. M., & Dampsey, P. G. (1999). The Psychophysical Approach to Material Handling Task Design. *Ergonomic Vol. 42. No. 1*, 17-31.

Bridger, R. (1995). *Introduction To Ergonomic.* Singapore: McGraw-Hill Bookco.

Coffey, B., Macphee, R., Socha, D., & Fischer, S. L. (2014). *A Physical Demands Description Of Paramedic Work In Canada.* International Journal Of Industrial Ergonomics.

Darmiatun S, T. (2015). *Prinsip-prinsip K3LH.* Malang: Gunung Samudera, Malang.

Elfeituri, F., & Taboun, S. (2002). An Evaluation Of The Niosh Lifting Equation: A Psychophysical And Biomechanical Investigation. *International Journal Of Occupational Safety And Ergonomics*.

Grandjean, E. (1993). *Fitting the Task to the Man, 4th ed.* London: Taylor and Francis Inc.

Hignett, S., & McAtamney, L. (2000). Rapid Entire Body Assessment (REBA). *Applied Ergonomics*, 201 - 205.

McAtamney, L., & Hignett, S. (1995). *Reba: A Rapid Entire Body Assessment, Method For Investigating Work Related Musculoskeletal Disorders.* Adelaide, Australia: Proceedings Of The Ergonomics Society.

McCormick, E. J., & Sanders, M. S. (1987). *Human Factor in Engineering and Design.* Singapore: McGraw-Hill Chong Moh, Ltd.

Nurmianto, E. (2003). *Ergonomi Konsep Dasar dan Aplikasinya.* Surabaya: Guna Widya.

Pulat, B. (1992). *Fundamentals of Industrial Ergonomics.* New Jersey: Prentice Hall International.

Serra, C., Rodriguez, M., Delclos, GL M, P., Gómez López, L., & Benavides, F. (2007). *Criteria And Methods Used For The Assessment Of Fitness For Work: A Systematic Review.* Occupational Environmental Medicine.

Taylor, G. K., & Roy, H. (2004). *Enhancing Occupational Safety and Health.* Oxford: Jordan Hill.

Wicken, C. e. (2004). *An Introduction To Human Factors Engineering.* New Jersey: Prentice Hall.

Wignjosoebroto, S. (1996). *Ergonomi Studi Gerak dan Waktu.* Surabaya: Guna Widya.

Xinming, L., Mustafa, G., & Mohamed, A.-H. (2017). An Improved Physical Demand Analysis Framework Based On Ergonomic Risk Assessment Tools For The Manufacturing Industry. *International Journal Of Industrial Ergonomics*.

ANALYSIS OF THE ADOPTION AND COMMERCIALIZATIONOF XYZ APP USING TRL, CRL, TRI2 AND TAM2

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ABSTRACT

Several efforts to control the rate of Covid-19 are by strengthening the tracing system, assessment, and accelerating information related to mitigation efforts. One of the points that play a key role in breaking the chain of transmission of Covid-19 is assessment activities. This activity requires doctors and health workers to continuously assess their health condition. For this reason, the use of XYZ apps is important in the application of the health conditions of doctors and health workers. Technology Readiness Index (TRI) refers to a person's readiness to use and utilize a technology. While the Technology Acceptance Model (TAM) is the level of acceptance of the use of a technology. Then measure the level of technology readiness using the Technology Readiness level (TRL) and Commercial Readiness Level (CRL). The results show that the level of readiness of the XYZ apps application technology is at level 9. The level of commercialization of technology based on the XYZ apps application CRL is at level 8. The factors that make up the TRI2 variable are divided into 3 components with an artificial variation of 64.67%. The TAM2 variable is formed by 5components where these components can explain the variation of the total factor of 73.826%.

Keywords: Covid-19, TRI2, TAM2, TRL, CRL.

1. INTRODUCTION

XYZ apps is an application that was developed with the aim of being a medium of education, information and communication in an effort to protect or prevent the doctors and medical workers in the face of the Covid-19. The XYZ application provides a self-assessment feature for doctors and medical workers in detecting conditions and risks for Covid-19 which can be one of the main parts of the prevent and transmission of Covid-19 cases. This technology provides Covid-19 Hotline feature and there are also provides some important links such as access to WHO information, the Indonesian Ministry of Health, etc. There are educational media such as videos, standard books of Personal Protective Equipment (PPE), standard medical service protocols which are very useful for doctors and medical workers in providing medical services. The Global Positioning System feature can be used to detect the position of the user and several Covid-19 referral hospitals.

The application also has features for any information on other diseases. For example, there are features of measuring blood pressure and oxygen pressure in the body using fingerprints. In addition, in the XYZ application there are some links related to certain diseases such as the first

treatment if you have a fever, how to reduce cholesterol levels, to various vitamins contained in certain fruits.

When the Covid-19 occurred, consumer behavior changed with the fear that arose because of the pandemic, where this feeling had a significant effect on a person's decision to use technology where consumers prefer to do everything online. Trust between patients and doctors is very important, trust is a belief that doctors will take the right action to help patients. The absence of face-to-face interaction between patients and doctors' results in a lack of patient trust in a health technology, so that consumer behavior in using a technology is minimal due to fear itself. When everything is being virtual and using technology in every aspect, the increasing penetration of the internet has changed the way people search for their information, especially health related issues. Moreover, 82% of the information circulating about Covid-19 is false (Islam, M., 2020)

In addition, the reality of using the XYZ application has not been maximized due to the lack of dissemination of the application among doctors and medical workers. From the aspect of facilities to support the commercialization of technology, ABC University already has several research centers and an Intellectual Property Rights (IP) service unit, but until now these services have not been well integrated. Therefore, research related to the commercialization of technology is needed to increase the level of deployment and use of these applications.

Due to the fact that its implementation is still considered ineffective, which may be due to the fact that the application is still not technically ready to be launched and also has never been measured on the readiness of the technology, the application of the XYZ application requires readiness both from the infrastructure side and from the organization that oversees the application system. the. The study conducted on the application was carried out in order to determine the level of technology readiness using the Technology Readiness Level (TRL) and Technology Readiness Index (TRI) methods. Meanwhile, to determine the level of commercialization of technology, the Commercial readiness Level (CRL) method can be used. Then to determine the acceptance of technology among HR companies/agencies, the Technology Acceptance Model (TAM) is the right method to be applied. By knowing the level of readiness of a technology, the technology provider can determine what strategy or policy will be carried out.

2. LITERATURE REVIEW

2.1 Technology Readiness Level

Technology Readiness refers to people's propensity to embrace and use new technologies for accomplishing goals in home life and at work (Parasuraman, 2000). One of the most frequently used is the NASA technology (TRL meter) where the concept shows the stages/steps from the basic principles of technology to the operation of the technology. Teknometer is a tool developed by BPPT with the aim of providing an overall picture of the maturity level of a technology as a whole and can be applied to measure and assess a certain type of technology.

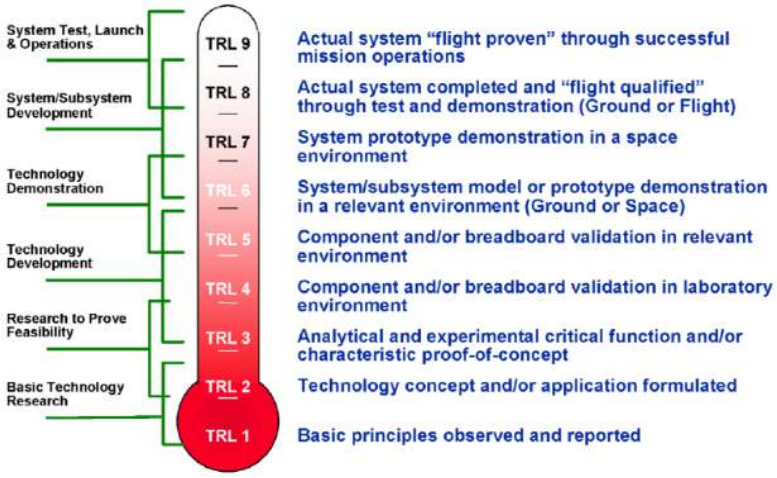


Figure 1. NASA Technology Readiness Level

2.2 Commercial Readiness Level

The Technology Readiness Level (TRL) measures the maturity of a technology developed by a project, then the Commercial Readiness Level (CRL) measures the commercial level of a technology in a particular market, including business strategy, business modeling, marketing strategy, etc. CRL itself has the intermediate benefit of describing the current state of the project and helping to identify the weaknesses of a project and the next steps. The commercial readiness level (CRL) has four phases, namely ideation, testing, traction, and scaling. New York State of Opportunity (NYSERDA) developed an excel workbook containing several questions about CRL to facilitate data processing.

2.3 Technology Readiness Index

Parasuraman (2000) has developed technology readiness index (TRI) scale to measure the level of readiness to use technology. TRI is multifaceted, it defines four groups of users separated by their prevailing personality trait with two factors being motivators of new technology use (optimism and innovativeness) and another two being inhibitors (discomfort and insecurity).

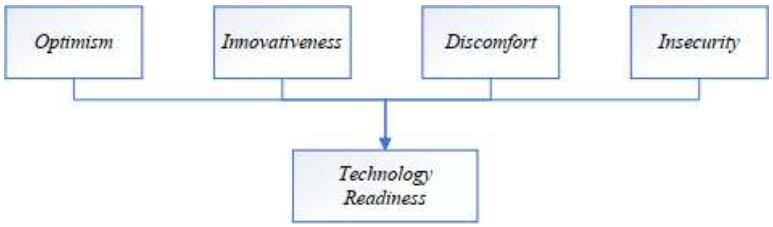


Figure 2. Four types of personalities in TRI

According to Parasuraman (2000) there are three categories in the application of the level of readiness or Technology Readiness Index (TRI), namely:

- Low Technology Readiness: TRI can be said to be low if the value of TRI is equal to or < 2.89 (TRI ≤ 2.89).
- Medium Technology Readiness: TRI can be said to exist in the medium stage if the TRI value is between 2.90 to 3.51 (2.90 ≤ TRI ≤ 3.51).

- High Technology Readiness: TRI can be assumed to be high if the value of TRI is > 3.51 (TRI > 3.51)

2.3 Technology Acceptance Model 2

Technology Acceptance Model (TAM) uses TRA as a theoretical basis for the relationship between perceived usefulness and perceived ease of use of technology to be able to clearly determine individual behavioral intentions/attitudes in using a technology (Venkatesh, et al., 2000)

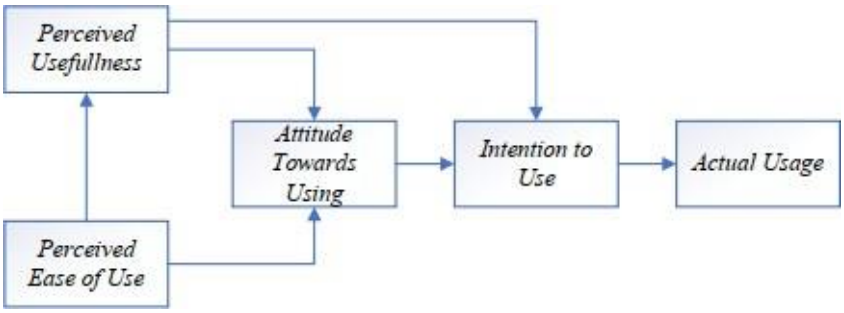


Figure 3. Technology Acceptance Model

Venkatesh and Davies (2000) studied and designed the TAM model which has the aim of adding indicators in terms of social impact and cognitive instrument processes that have an impact on perceived usefulness and intention to use. Below, it can be seen in the following image:

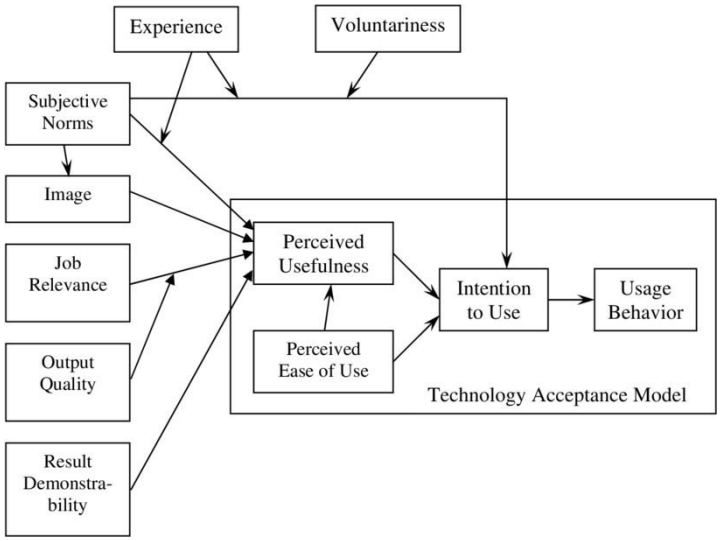


Figure 4. Technology Acceptance Model 2

2.4 Sample

There is a minimum number of respondents that must be fit so that the sample data of this study can represent the population. The minimum number of respondents can be determined by using the purposive sampling method.

$$n = (\frac{ZS}{e})^2$$

n = Sample size
Z = Confidence level (α = 95%, then Z = 1,69)
e = *Margin of error*
S = Standard deviation

3. METHODS

3.1 Sampling

The population involves all of hospitals and public health center in Surabaya, Indonesia. Because there are so many hospitals in Surabaya and have variations number of different doctors and medical workers, the minimum number of respondents can be determined by using the purposive sampling method. The purposive sampling method considers the limitations of health facilities that have a number of doctors and medical workers below 10 people.

3.2 Data Collection

The data for this study were obtained by using Teknometer for analysis of technology readiness level and New York State of Opportunity (NYSERDA) excel workbook for analysis of commercial readiness level.

Another data for this study were obtained by using a questionnaire and distributed to doctors and medical workers. This questionnaire was divided into three sections: respondent descriptions, technology readiness index and technology acceptance model 2. The questionnaire items were adopted from the TRI 2.0 and TAM 2.0. The questions were rated on a Likert scale, where (1) strongly disagree, (2) disagree, (3) neutral, (4) agree, (5) strongly agree. A total of 98 respondent's answers were included for further analysis using SPSS software.

4. RESULTS

The results of this, that the XYZ application is at the level of 9, meaning that the system in the application is truly technically tested, with a fulfilled indicator, which is 80%. Thus, it can be overcome that the level of readiness for the XYZ application has been technically tested, has been tested on actual and has been worth producing. In addition, it can also understand about differentiation with other technologies. The application of XYZ application technology has in accordance with the planned conditions as in utterances and operational evaluation, which is part of the fixing bug adjustment that occurs when accessing the app.

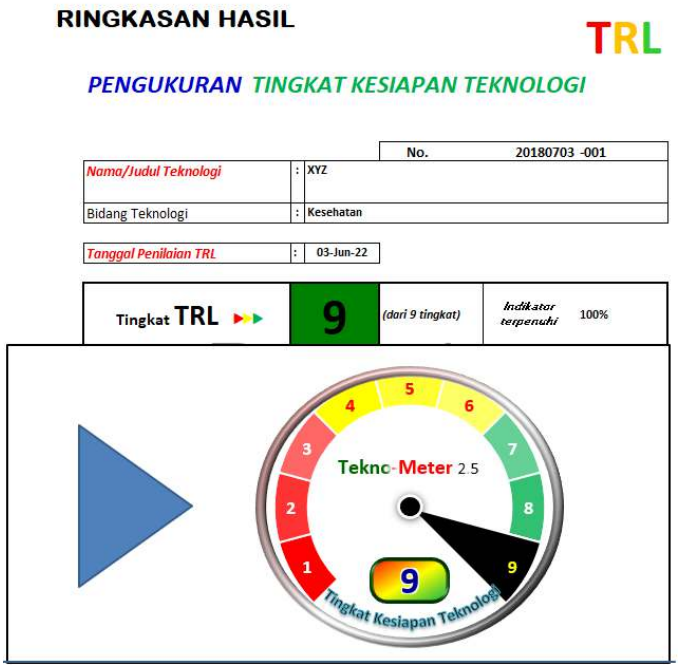


Figure 5. Result of Technology Readiness Level

Based on the results of the CRL analysis, it was received that the technology had waged very complete customer qualifications and has known how the target customers which will be addressed based on the model business that has been developed. In addition, strategies and commercialization approaches are also carried out widely and rapidly. Where during this pandemic condition, allowing health-based applications to carry out market penetration very quickly.

Commercialization Readiness Level: 8

Category	Answer
Technology	Initial testing of integrated product/system has been completed in a laboratory environment
Product Development	Actual product/system has been proven to work in its near-final form under a representative set of expected conditions and environments
Product Definition/Design	Comprehensive customer value proposition model has been developed, including a detailed understanding of product/system design specifications, required certifications, and trade-offs
Competitive Landscape	Competitive analysis to illustrate unique features and advantages of the product/system compared to competitive products/systems has been completed
Team	Balanced team with all capabilities onboard (e.g. sales, marketing, customer service, operations, etc.) running the company with assistance from outside advisors/mentors
Go-To-Market	Partnerships have been formed with key stakeholders across the value chain (e.g. suppliers, partners, service providers, and customers)
Manufacturing/Supply Chain	Products/systems have been pilot manufactured and sold to initial customers

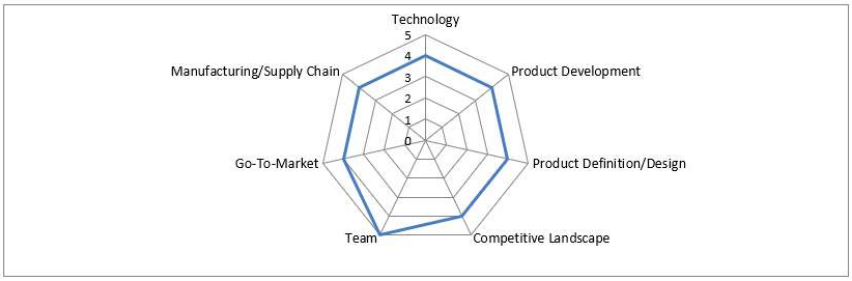


Figure 6. Result of Commercialization Readiness Level

The largest contribution until the smallest of contributions is obtained from the following variable: optimism contributes to 1.039 that means employees of XYZ applications have a positive view of technology, innovativeness contributes to 0,871, insecurity contributes to 0.612, and discomfort contributions to the smallest contribution of 0,494. In addition, it can be known if the value of TRI by 3.016; where this value is categorized as the readiness technology medium.

Table 1. Result of Technology Readiness Index

Variable	Score
Optimism	1,039
Innovativeness	0,871
Discomfort	0,494
Insecurity	0,612
TRI score	3,016

Based on the relationship between variables using the t-test, it is known that almost all variables have a significant relationship, except for the relationship between image and perceived usefulness.

Table 2. Result of the t-test

Hypothesis	T-Value	P-Value (Sig)	Decision
TRI with perceived of usefulness	2,712	0,008	Significant
TRI with perceived ease of use	2,905	0,005	Significant
subjective norm with image	3,927	0,000	Significant
subjective norm with perceived of usefulness	4,730	0,000	Significant
image with perceived of usefulness	0,633	0,364	Not
job relevance with perceived of usefulness	7,212	0,000	Significant
output quality with perceived of usefulness	10,576	0,000	Significant
Result demonstrability with perceived of usefulness	8,690	0,000	Significant
Experience with subjective norm	5,153	0,000	Significant
voluntariness with subjective norm	4,226	0,000	Significant
subjective norm with attitude toward using	3,078	0,003	Significant
perceived ease of use with perceived of usefulness	11,184	0,000	Significant
perceived ease of use with attitude toward using	8,454	0,000	Significant
perceived of usefulness with attitude toward using	8,618	0,000	Significant
Attitude toward using with actual behaviour	3,942	0,000	Significant

6. CONCLUSIONS

The level of technology readiness based on the readiness level of XYZ application is at the level of 9 and technology commercial level of technology based on commercial readiness application level is at the 8 level. Based on the results of the analysis using readiness index technology, it is known that TRI's value of 3.016; where this value is categorized as the readiness technology medium. The company's readiness/agencies were formed by 3 components where the components explained the cumulative variant of a total factor of 64.673%, where this result is in line with the theory from Davis et al, (1989). Based on the results of the analysis using acceptance model technology, formed by 5 components where the component could explain the cumulative variant of the whole factor of 73.826%

REFERENCES

Davis, F. D. (1989). Perceived Usefulness, Perceived Ease of Use, and User Acceptance of Information Technology. *MIS Quarterly Vol. 13*, 319-340.

Erdogmuş, N., & Esen, M. (2011). An investigation of the effects of technology readiness on technology acceptance in e-HRM. *Procedia-Social and Behavioral Sciences*, *24*, 487-495

Faida, Eka (2019). Medical Journal: Analysis of Electronic Medical Record Using Technology Readiness Index Methods at Airlangga University's Hospital, Vol.7, No.3, pp. 140-154.

Ferguson, G. A., dan Takane, Y. (1989). *Statistical Analysis in Psychology and Education*. New York: McGraw Hill Book Company

Galib, M. H., Hammou, K. A., & Steiger, J. (2018). Predicting Consumer Behavior: An Extension of Technology Acceptance Model. International Journal of Marketing Studies, 10(3), 73

Godoe, P., & Johansen, T. S. (2012). *Understanding Adoption of New Technologies: Technology Readiness and Technology Acceptance as An Integrated Concept. Journal of European Psychology Students, Vol. 3,* 38-53

Guritno, S., Sudaryono, & Rahardja, U. (2011). Theory and Application of IT Research: Information Technology Research Methodology. First Edition. Andi. Yogyakarta.

Hallikainen, H., & Laukkanen, T. (2016, June). How Technology Readiness Explains Acceptance and Satisfaction of Digital Services in B2B Healthcare Sector? *PACIS* (p. 294).

Islam, M., et, al. (2020) Covid-19 related pandemic and its impact on public health: a global social media analysis. *Am J Trop Med Hyg*.

Jasmine, T. L. (2020). Strategy of Adoption and Diffusion of Innovation of a Polimoda Application in a Logistics Company. Faculty of Creative and Digital Business. Sepuluh Nopember Institute of Technology

Lin, C.H., Shih, H.Y. & Sher, P.J., (2007). Integrating technology readiness into technology acceptance: The TRAM model. *Psychology and Marketing*, pp.641–657.

Mankins, John C. (1995). *Technology Readiness Levels: A White Paper.* Advanced Concepts Office. Office of Space Access and Technology. NASA. April 6, 1995.

Nolte, William. (2005). *Technology Readiness Level Calculator.* Presented at Assessing Technology Readiness & Development Seminar. April 28, 2005.

Taufik, Tatang A. (2003), Concept and Methods of Technology Readiness Level/TRL. Badan Pengkajian dan Penerapan Teknologi (BPPT).

Panday, R. (2015). The Effect of Technology Readiness on Technology Acceptance in Using Service Delivery of Academic Information System (pp. 978-979).

Parasuraman, A. (2000). *Technology Readiness Index (TRI) a multiple-item scale to measure readiness to embrace new technologies. Journal of Service Research. 2 (4): 307-320.*

Parasuraman, A., & Colby, C. L. (2001). *Techno-Ready Marketing: How and Why Your Customer Adopt Technology.* New York: Free Press.

Poetri, A. D. (2010). Adoption of E-Commerce with methods Technology Acceptance Model (TAM*)* for UKM. *Thesis*. Faculty of Economics Sebelas Maret University.

Prayitno, K. dan Arwanto. (2017). *Tekno-Meter Analysis for Technology Readiness Level*. Badan Pengkajian dan Penerapan Teknologi.

Saeed, H., Ahmed, M. uddin, Hussain, S., & Farid, S. (2018). Online Support Services in e-Learning: A Technology Acceptance Model. Sukkur IBA Journal of Computing and Mathematical Sciences, 2(2), 22–29

Urbaczewski, A. dan Lee, Y., (2020) *Information Technology and the pandemic: a preliminary multinational analysis of the impact of mobile tracking technology on the Covid-19 contagion control*, 405-414

Venkatesh, V., Morris, M. G., Davis, G.B., & Davis, F. D, (2003), User acceptance of information Technology: Toward a unified view., *MIS Quarterly*, 27(3), 425- 478.

ANALYSIS OF FACTORS INFLUENCING SKIN CARE BRAND SELECTION WITHIN TWO-STAGE CHOICE PROCESS FRAMEWORK

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ABSTRACT

Indonesian market for skin care products is undeniably competitive, pushing companies to have a better understanding of their consumer behaviours. According to research on two-stage choice process, different decision rules are used at consideration stage and choice stage. The primary goal of this study is to identify influencing factors at both consideration and choice stages, as well as the relationship between them. Primary data was collected through an online questionnaire using purposive sampling. Respondents were limited to women over the age of 15 who had purchased serum. The collected data was examined using Second-order Confirmatory Factor Analysis (CFA). This study confirmed that there are different set of factors influencing between two stages. Consideration stage is influenced by recommendation & review, advertisement, and quality & credibility of the brand; meanwhile choice stage is influenced by advertisement, price & promotion, and quality & credibility of the brand. Recommendation & review is the most influencing factor at consideration stage, whereas advertisement is the most influencing at choice stage. Study also found that there is high correlation between consideration and choice stage. For managerial contribution, this research gave insight to compose marketing strategy for skin care brand within two-stage choice process framework.

Keywords: two-stage choice process, skin care brand, consumer behavior, factor analysis

1. INTRODUCTION

Skin care is considered as unseparated part of a lifestyle of Indonesian women. In the time of economic slow-down, Indonesian women were still buying beauty products (Wibowo, 2021). Based on National Agency of Drug & Food Control (BPOM) data, there are 204,143 beauty products that registered. This numbers even pass food and beverages categories, enough to describe how much competition there is in the market.

In high-saturated market, company success depends on the understanding of consumer behavior. Makarewicz (2013) stated that consumer behavior is starting point for company strategies. One point regarding consumer behavior is that people have a limited capability for brand recollection. Therefore, not all of the brands available will be considered, instead only a few will (Hauser & Wernerfelt, 1990). For example, from 30 shampoo brands available, only 4 brands that were considered.

Two-stage choice process has been mentioned in several studies whereas they suggested that at first consumer choose some of the product available and set a consideration or choice set, and from the consideration set, one product is chosen to be bought (Bettman 1979; Gensch 1987; Shocker et al. 1991; Wright & Barbour 1977). Two-stage choice process is divided into 2 stages: (1) Consideration stage, where consumer choose only a few brands and create a consideration set; and (2) Choice stage, where consumer select one final brand that being taken from his/her consideration set. Moe (2006) suggested that decision rules used between stages were different. Choice stage used a more complex decision rules rather than consideration stage.

McKinsey (2009) found that some of skin care brand were very strong in initial consideration rather than in final evaluation stage. This indicates that the brand image was strong so it was being considered, but when consumer was doing a thorough evaluation, it no longer appealed. McKinsey also found that on average there are 1.5 skin care brands in initial consideration and the number is increased to 1.8 brands after consumer doing more research. This finding shows that brand can interrupt consumer buying decision process by entering consideration stage and be consumer final choice. What makes a brand being considered and what makes it is chosen among other brands in consideration set are questions to ask. According to McKinsey research, a brand that is initially being considered may not be picked, and vice versa, a brand may disrupt the consideration stage and become a final choice.

If we consider a two-stage decision-making process, presumably what happened is that there are different factors affect why some brands are considered and some that are picked. As skin care also is a high-involving purchase, consumer would carefully choose a brand by doing extensive research, thus, it is assumed that numerous factors may and would influence their decisions. Research and evaluation would require a lot of time. In other words, it means that companies have time and chances to make the most of their marketing initiatives in order to have their brand chosen. It would be preferable if those efforts were successful by acknowledging the variables that affected the stage of consideration and choice. This study aims to reveal what factors that influenced both stages – are they different – and how two stages are correlated. Confirmatory factor analysis (CFA) is method chosen to analyze the data as it able to confirm what factors have significant influence at each stage.

2. LITERATURE REVIEW

2.1 Two-stage Choice Process

According to Moe (2006), a two-stage choice process consists of the consideration stage and the choice stage. Consumers select some brands to include in their consideration set during the consideration stage, and then they choose one final brand from their consideration set during the choice stage. Gaskin et al (2007) proposed that consideration set was formed because it would be more convenience to consumer consider only some brands rather than evaluating all brands available. Average number of brands in consideration set is vary in every product category. In America, the average Fast-Moving Consumer Goods (FMCG) product consideration set consists about 1/10 of all items offered in a given category (Hauser, 2014). Each stage uses a different decision rule. Moe (2006) described decision rule as attributes used by consumer to evaluate a product to buy. A simplified decision rule is employed at consideration stage to speed up the choosing process and make it easier for consumers to choose due to the overwhelming quantity of brands available. In contrast, despite the fact that there are less options available (as now consumers only consider those in their consideration set, not all of the brands), it is more crucial for customers to make the right choices in choice stage. Therefore, more complex decision rules are applied.

2.2 Confirmatory Factor Analysis

Confirmatory factor analysis (CFA) is a method of factor analysis used when researcher already have prior knowledge of latent factor structure, adopted from previous theoretical study of observed variable to latent variable (Laili & Totok, 2013). There are two techniques of CFA: First-order CFA and Second-order CFA. On First-order CFA, the latent variable is directly observable on the other hand, on Second-order latent variable must be observed through its observable indicator.

According to Afthanorhan et al (2014), there are several steps that should be notice when executing CFA. Those are (1) to obtain all the factor loadings of the item, (2) to delete factor loading less than 0,6 from the lowest factor first (0,6 is not a compulsory; this research used 0,5 as benchmark), (3) to delete one item at a time and respecify every time, (4) to obtain the fitness indexes, (5) if fitness index is not achieved, look at Modification Index (MI) and do modification to items with high value of MI (above 15 or 10). Wan Mohamad (2013) and Holmes-Smith (2006) recommended to use at least three fit indexes by including at least one index from each category of model fit. Three categories mentioned are absolute fit index, incremental fit index, and parsimonious fit index.

3. METHODS

This study was using quantitative approach, with primary data was collected through online questionnaire. Purposive sampling was used, implied to limit respondents to women over the age of 15 who had purchased serum. Serum is skin care product used as study case due to its advances and high indication risk which would make consumer more carefully to choose a brand before purchasing. Data collected from 398 respondents then was being analyzed with Second Order Confirmatory Factor Analysis (CFA) to confirm what factors influence the selection of skin care brands at both stages. Variables and indicators used are taken from various consumer behavior literatures as shown in Table 1. Adopting a 5-point Likert scale in the questionnaire, the options were divided into different categories of importance from “very agree” (5 points) to “very disagree” (1 point).

Fig 1 illustrates model used in this study. Variables & indicators used at both stages were the same, therefore any difference in each stage will be uncovered. At first, first-order CFA was applied in each variable. Goodness fit of indexes of each variable must be achieved. Indicator(s) with loading factor below 0.5 was eliminated. Modification of indices was done if it was necessary. Second-order CFA then used in each stage after every variable model has already fit. Variable with loading factor below 0.5 was eliminated. Overall model then being ran to find out the relationship between two stages.

Table 1. Variables and indicators

Variable	Indicator	References
Pricing & Promotion	Product price, discount, voucher, product bundle, gift (7 indicators)	Al- Salamin & Al Hassan (2016); Zap Clinic & Markplus (2020); Jakpat (2020)
Recommendation & Review	Recommendation from close circle and public figure, recommendation and review from internet (6 indicators)	Zap Clinic & Markplus (2020); Jakpat (2020); Sutanto & Aprianingsih (2016); Hermanda et al (2019); Zak & Hasprova (2020)
Advertisement	Awareness, presentation, brand ambassador (5 indicators)	Awan et al (2016); Anggoro & Purba (2020)
Brand Quality & Credibility	Trust, brand expertise, brand image & value, packaging & social media design, product quality, product information, origin country of the brand, availability (7 indicators)	Zap Clinic & Markplus (2020); Jakpat (2020); Erdem & Swait (2004); Chovanová et al (2015); Katawetawaraks & Wang (2011)

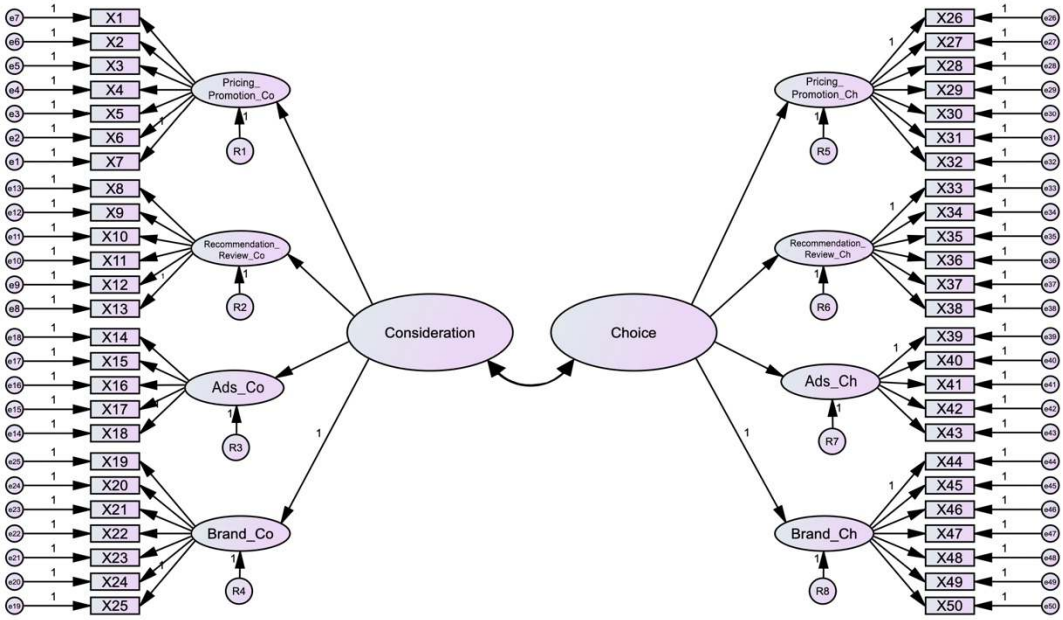


Figure 1. Model of the study

4. RESULTS

4.1 CFA at Consideration Stage

The analysis started with performing first-order CFA at each variable. Table 2 shows fitness indexes of each variable at consideration stage. **I** represents values for the original models, whereas **II** represents value after model modifications. Modifications are employed as some factor loadings are less than 0.5 and some items have high MI value. After goodness of fit of each variable is overall achieved, second-order CFA is performed to consideration model with only valid indicators. Fig 2 shows original model of consideration stage and after modifications. It can be seen that pricing & promotion has factor loading less than 0.5 so it be required to be removed. As results in the new model, it can be shown that factors influencing at consideration stage are review & recommendation, advertisement, and brand quality & credibility. Review & recommendation is the most influencing factors. Table 3 shows estimated parameter CFA of consideration stage model. There are 14 indicators out of 25 indicators evaluated, significantly affecting consideration stage. Five indicators with highest weight are shown in Table 4.

4.2 CFA at Choice Stage

In the same manner with consideration stage, first-order CFA is applied first at each variable. Table 5 shows fitness indexes of each variable at choice stage. Modifications are also employed to factor loadings less than 0.5 and items with high MI value. Second-order CFA is performed with remained valid indicators once overall goodness of fit of each variable is met. Fig 3 shows original model of choice stage and after modifications. Recommendation & review has factor loading less than 0.5 which means it be required to be removed. In the new model, it is confirmed that factors influencing at choice stage is pricing & promotion, advertisement, and brand quality & credibility. Advertisement is proven to have the highest impact. Table 6 shows estimated parameter CFA of choice stage model. There are 14 indicators out of 25 indicators evaluated, significantly affecting choice stage. Five indicators with highest weight are shown in Table 7.

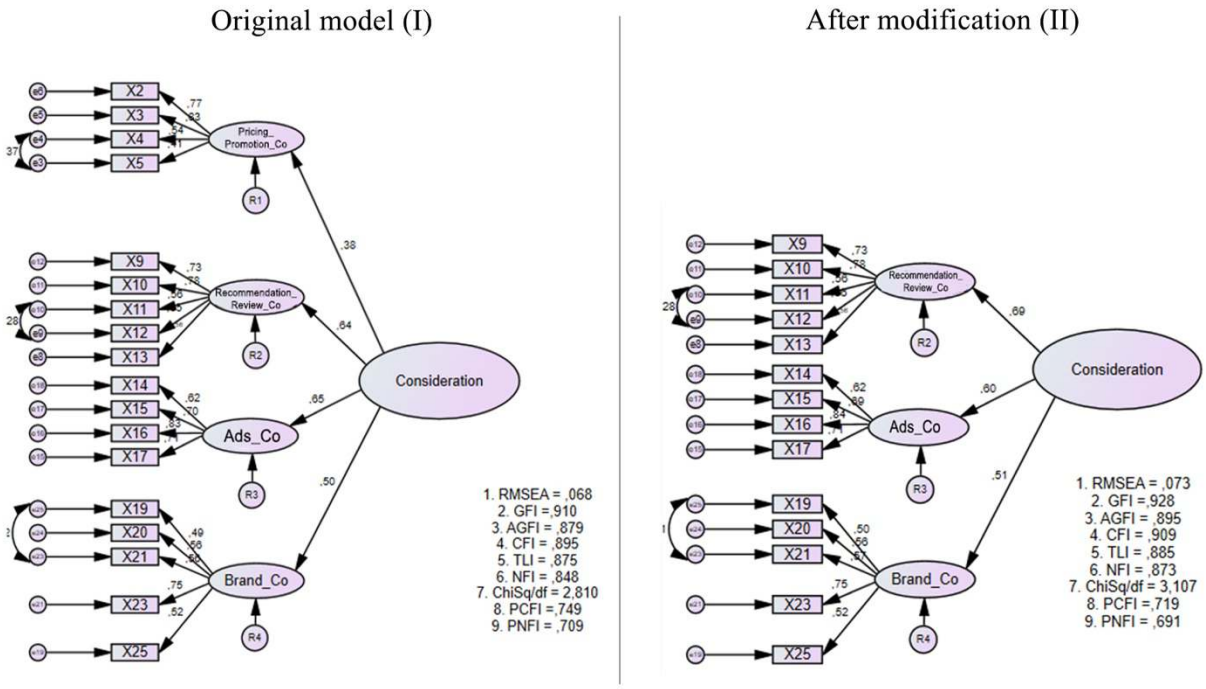


Figure 2. Original model of consideration stage and after modification

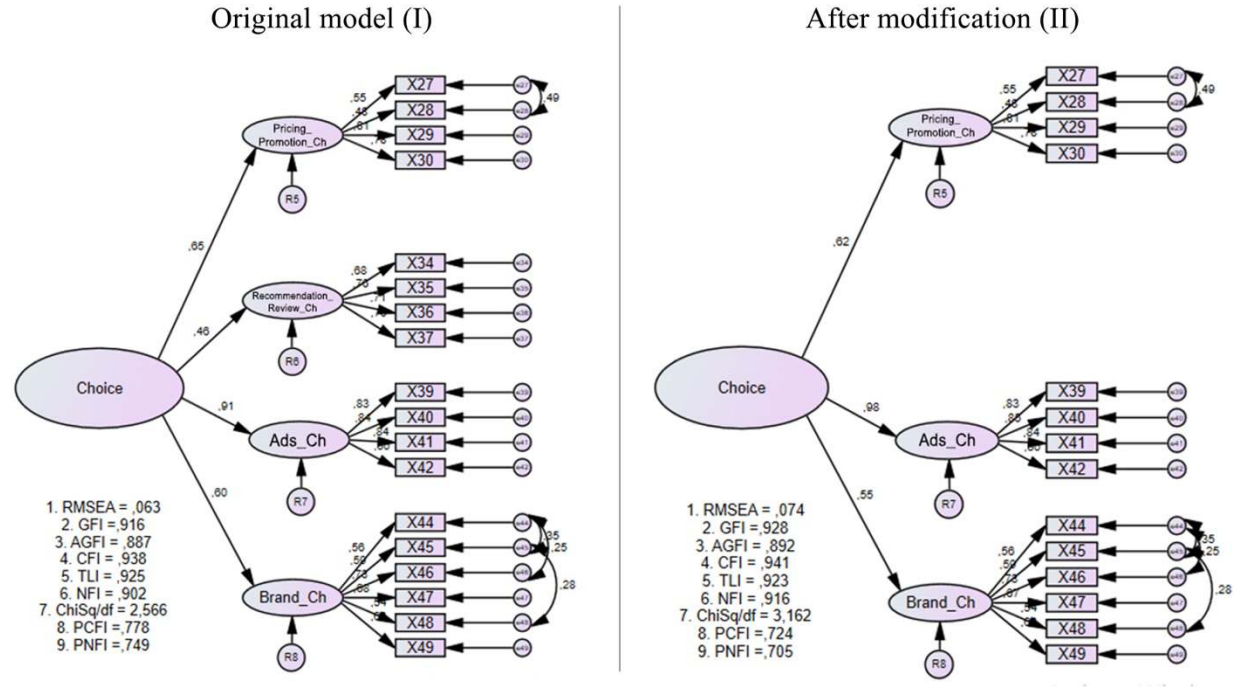


Figure 3. Original model of choice stage and after modification

Table 2. Fitness of indexes of each variable at consideration stage

Evaluation indexes	Suggested value	Pricing & Promotion		Recommendation & Review		Advertisement		Brand Quality & Credibility	
		I	II	I	II	I	II	I	II
Absolute Fit Index									
RMSEA	< 0.10	0.174	0.000	0.089	0.000	0.053	0.055	0.082	0.057
GFI	> 0.90	0.883	1.000	0.968	0.996	0.989	0.994	0.961	0.991
Incremental Fit Index									
AGFI	> 0.90	0.766	1.000	0.925	0.986	0.968	0.971	0.923	0.965
CFI	> 0.90	0.721	1.000	0.956	1.000	0.990	0.995	0.920	0.985
TLI	> 0.90	0.581	1.014	0.927	1.001	0.981	0.986	0.880	0.964
NFI	> 0.90	0.708	1.000	0.944	0.994	0.982	0.991	0.895	0.975
Parsimonious Fit Index									
Chi-sq/df	≤ 5	13.018	0.009	4.123	0.928	2.112	2.213	3.683	2.304
PCFI	> 0.50	0.480	0.167	0.574	0.400	0.495	0.332	0.613	0.394
PNFI	> 0.50	0.470	0.167	0.566	0.397	0.491	0.330	0.597	0.390

Note : *I represents findings for the original model, whereas II represents outcomes after model modifications.*

Table 3. Estimated parameter CFA of consideration stage model

Variable/Indicator	Factor Loading	P-value	Note
Consideration → Recommendation & Review	0.688	< 0.001	Significant
Consideration → Advertisement	0.598	< 0.001	Significant
Consideration → Brand Quality & Credibility	0.511	< 0.001	Significant
Recommendation & Review → X9	0.732	< 0.001	Significant
Recommendation & Review → X10	0.777	< 0.001	Significant
Recommendation & Review → X11	0.567	< 0.001	Significant
Recommendation & Review → X12	0.658	< 0.001	Significant
Recommendation & Review → X13	0.559	< 0.001	Significant
Advertisement → X14	0.623	< 0.001	Significant
Advertisement → X15	0.692	< 0.001	Significant
Advertisement → X16	0.836	< 0.001	Significant
Advertisement → X17	0.713	< 0.001	Significant
Brand Quality & Credibility → X19	0.500	< 0.001	Significant
Brand Quality & Credibility → X20	0.557	< 0.001	Significant
Brand Quality & Credibility → X21	0.566	< 0.001	Significant
Brand Quality & Credibility → X23	0.751	< 0.001	Significant
Brand Quality & Credibility → X25	0.516	< 0.001	Significant

Table 4. Indicators with highest impact at consideration stage

Indicator	Factor Loading	Description
X16	0.836	I'm considering those brands because its compelling and convincing advertisement.
X10	0.777	I'm considering those brands because recommendation & review on social media.
X23	0.751	I'm considering those brands because detail and accessible product information.
X9	0.732	I'm considering those brands because recommendation & review from beauty influencer/expert/famous people.
X17	0.713	I'm considering those brands because its advertisement make me curious and feel fear-of-missing-out.

Table 5. Fitness of indexes of each variable at consideration stage

Evaluation indexes	Suggested value	Pricing & Promotion		Recommendation & Review		Advertisement		Brand Quality & Credibility	
		I	II	I	II	I	II	I	II
Absolute Fit Index									
RMSEA	< 0.10	0.162	0.000	0.060	0.109	0.117	0.060	0.127	0.063
GFI	> 0.90	0.888	1.000	0.981	0.985	0.967	0.994	0.929	0.987
Incremental Fit Index									
AGFI	> 0.90	0.777	0.998	0.956	0.925	0.900	0.969	0.859	0.956
CFI	> 0.90	0.773	1.000	0.982	0.982	0.975	0.997	0.896	0.987
TLI	> 0.90	0.660	1.010	0.969	0.947	0.950	0.991	0.844	0.968
NFI	> 0.90	0.759	1.000	0.969	0.979	0.970	0.995	0.883	0.980
Parsimonious Fit Index									
Chi-sq/df	≤ 5	11.418	0.144	2.412	5.728	6.438	2.406	7.370	2.584
PCFI	> 0.50	0.516	0.167	0.589	0.327	0.487	0.332	0.597	0.394
PNFI	> 0.50	0.506	0.167	0.581	0.326	0.485	0.332	0.558	0.392

Note: *I represents findings for the original model, whereas II represents outcomes after model modifications.*

Table 6. Estimated parameter CFA of choice stage model

Variable/Indicator	Factor Loading	P-value	Note
Choice → Pricing & Promotion	0.620	< 0.001	Significant
Choice → Advertisement	0.976	< 0.001	Significant
Choice → Brand Quality & Credibility	0.548	< 0.001	Significant
Pricing & Promotion → X27	0.552	< 0.001	Significant
Pricing & Promotion → X29	0.807	< 0.001	Significant
Pricing & Promotion → X30	0.782	< 0.001	Significant
Advertisement → X39	0.832	< 0.001	Significant
Advertisement → X40	0.848	< 0.001	Significant
Advertisement → X41	0.844	< 0.001	Significant
Advertisement → X42	0.802	< 0.001	Significant
Brand Quality & Credibility → X44	0.562	< 0.001	Significant
Brand Quality & Credibility → X45	0.594	< 0.001	Significant
Brand Quality & Credibility → X46	0.731	< 0.001	Significant
Brand Quality & Credibility → X47	0.673	< 0.001	Significant
Brand Quality & Credibility → X48	0.537	< 0.001	Significant
Brand Quality & Credibility → X49	0.627	< 0.001	Significant

Table 7. Indicators with highest impact at choice stage

Indicator	Factor Loading	Description
X40	0.848	I choose that brand because I love its brand ambassador the most.
X41	0.844	I choose that brand because its advertisement is the most compelling and convincing.
X39	0.832	I choose that brand because its advertisement I see more often than others.
X29	0.807	I choose that brand because there is product bundling when I'm about to purchase.
X42	0.802	I choose that brand because its advertisement make me curious and feel fear-of-missing-out the most.

4.3 CFA on Overall Models

After CFA is applied to both stages, analysis is continued by running CFA on overall research model. The model has already been modified as result of CFA applied before. Overall model shows by Fig 4. The model has achieved most of fitness of indexes. With a correlation value of 0.85, it may be said that both stages have a high correlation.

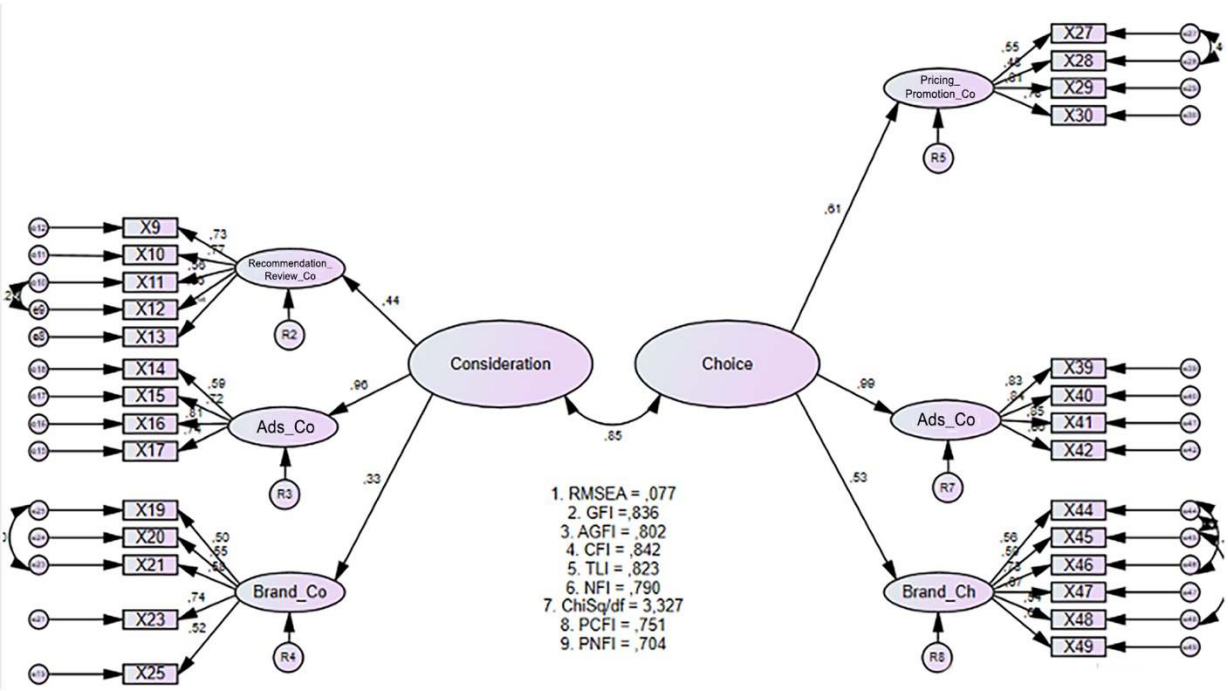


Figure 4. Final model of the study model

4.4 Results analysis

According to analyzed data above, it can be concluded that consideration stage is influenced by recommendation & review, advertisement, and brand quality & credibility. Meanwhile, choice stage is influenced by advertisement, pricing & promotion, and brand quality & credibility. At the consideration stage, recommendations & reviews have the most influence. Highest weight is given to social media and beauty influencer/expert recommendations & reviews. It has been noted that recommendations & reviews are only taken into account during the consideration stage. Meanwhile at choice stage, advertisement has the biggest influence. Advertisement features having the most significance is known incorporate brand ambassadors and compelling presentations.

Additionally, pricing & promotion are also only taken account during the choice stage. Gifting and product bundling was shown to have the highest impact. Other than that, though brand quality & credibility has impact at both stages, it is the detail of product information which has highest weigh at consideration stage, while brand image and value is noted as most important at choice stage. It is also recognized that brand quality & credibility has much bigger impact at choice stage. Among all of above, this study also found that there is high correlation between consideration and choice stage. This should encourage company to make their brand into consumer consideration set.

6. CONCLUSIONS

The fundamental purpose of this research is to discover influencing factors at both the consideration and choice stage, as well as their relationships. In order to confirm the factors, data analysis using second-order CFA is employed. This study supported the notion that there are different factors affecting both stages. Consideration stage is influenced by recommendation & review, advertisement, and brand quality & credibility. Meanwhile, choice stage is influenced by advertisement, pricing & promotion, and brand quality & credibility. This study also found that there is high correlation between consideration and choice stage.

As managerial implications, it is recommended to invest more on endorsement of beauty influencers or expert to do reviews to give more exposure to the brand. Provide consumer a detail information of the products and make them easily accessible, as it is one of key factors that make brand considered. Given that advertising has a significant impact on all stages, it is also advised to invest in both the quality and quantity of the advertising. Product bundling and gifting are two strategies that may be used to gain value from other brands in consideration set. It is advised to provide mini product packaging in order to promote purchasing as it more affordable. Utilizing a loveable brand ambassador is also necessary for increasing brand attractiveness.

REFERENCES

Afthanorhan, W., Ahmad S. & Mamat I. (2014). Pooled Confirmatory Factor Analysis (PCFA) Using Structural Equation Modeling on Volunteerism Program: A Step by Step Approach. *International Journal of Asian Social Science* 4 (5), 642 – 653.

Al-Salamin, H. & Al-Hassan, E. (2016). The Impact of Pricing on Consumer Buying Behavior in Saudi Arabia : Al-Hassa Case Study. *European Journal of Business and Management* 8 (12), 62 – 73.

Awan, A. , Ismail M., & Majeed F. (2016). Effects of Advertisement on Consumer's Buying Behaviour with References to FMCGs in Southern Punjab-Pakistan. *Journal of Marketing and Consumer Research* 19, 22 – 30.

Badan Pengawas Obat dan Makanan. (2021). *Statistika Produk yang Mendapat Persetujuan Izin Edar*, accesed on September 24th 2021 . https://cekbpom.pom.go.id.

Bettman, J. R. (1979). Memory Factors in Consumer Choice: A Review. *Journal of Marketing* 43 (Spring), 37–53.

Chovanova, H., Korshunov A., & Babcanova D. (2015). Impact of Brand on Consumer Behavior. *Procedia Economics and Finance* 34, 615 – 621.

Court, D., Elzinga D., Mulder S., & Vetvik O. J. (2009). The Consumer Decision Journey. *McKinsey Quarterly,* No. 3.

Erdem, T. & Swait, J. (2004), "Brand Credibility, Brand Consideration, and Choice", *Journal of Consumer Research* 31 (1), 191 – 198.

Gensch, D. H. (1987). A Two Stage Disaggregate Attribute Choice Model. *Marketing Science*, 6 (Summer), 223–231.

Hauser, J. R. (2014). Consideration-set heuristics. *Journal of Business Research* 67 (8), 1688 – 1699.

Hauser, J. R. & Wernerfelt, B. (1990). An Evaluation Cost Model of Consideration Sets. *Journal of Consumer Research* 16 (3), 393 – 408.

Hermanda, A., Sumarwan U. & Tinaprillia N. (2019). The Effect of Social Media Influencer on Brand Image, Self-Concept, and Purchase Intention. *Journal of Consumer Sciences,* 04 (02), 76 – 89.

Holmes-Smith, P. (2006). *School socio-economic density and its effect on school performance*. New South Wales Department of Education and Training, Australia.

Jakpat. (2020). *Beauty Trend Report 2020.* Sleman, Indonesia.

Laili, M. & Otok, B.W. (2014), Second-Order Confirmatory Factor Analysis pada Kemiskinan di Kabupaten Jombang. *Jurnal Sains dan Seni POMITS* 3 (2), 279 – 283.

Makarewicz , A. (2013). Consumer behavior as a fundamental requirement for effective operations of companies. *Journal of International Studies* 6 (1), 103 – 109.

Moe, W. M. (2006). An Empirical Two-Stage Choice Model with Varying Decision Rules Applied to Internet Clickstream Data. *Journal of Marketing Research* XLIII, 680 – 692.

Shocker, A. D., Ben-Akiva M., Boccara B., & Nedungadi P. (1991). Consideration Set Influences on Consumer Decision-Making and Choice: Issues, Models and Suggestions. *Marketing Letters* 2 (August), 181–197.

Sutanto, M. & Aprianingsih, A. (2016). The Effect of Online Consumer Review Toward Purchase Intention: A Study In Premium Cosmetic Inindonesia. *International Conference on Ethics of Business, Economics, and Social Science* 53 (2), 1689 – 1699.

Wan Mohamad, A.B.W.A. & A. Sabri. (2013). Modelling-the-multigroup-moderator-mediator-on-motivation- among-youth-in-higher education institution towards volunteerism program. *International Journal of Scientific & Engineering Research* 4 (7), 108 – 109.

Wibowo, A. (2021). *Paying for the 'Glow': Indonesian Skincare Market Insights,* accesed on September 24th 2021. https://janio.asia/id/articles/indonesia-skincare-ecommerce-trends/.

Wright, P. & Barbour, F. (1977), Phased Decision Strategies: Sequels to Initial Screening, in *Multiple Criteria Decision Making: North Holland TIMS Studies in the Management Science*, M. Starr and M. Zeleny, eds. Amsterdam: North- Holland Publishing Company, 91–109.

Zak, S. & Hasprova, M. (2020). The Role of Influencers in The Consumer Decision-Making Process. *SHS Web of Conferences* 74.

Zap Clinic & Markplus. (2020). *Zap Beauty Index 2020.* Jakarta, Indonesia.

USAGE MODEL ANALYSIS OF INTERNET SERVICE PROVIDER CUSTOMER MOBILE APPLICATION IN MILLENIAL GENERATION

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ABSTRACT

In this digital era, the internet has become part of people's daily lives to support the formation of a digital society, especially for the millennial generation who are the highest internet consumers in Indonesia. One of the leading internet service providers in Indonesia is PT. Telkom Indonesia, Tbk. They offer internet services known as Indonesia Digital Home (IndiHome), currently, the users are widespread and will likely continue to grow as a digital touch point to manage indihome services, the MyIndihome application was launched. Referring to the annual report in 2020, there were only 814 thousand active users. While IndiHome users themselves have now reached 8 million users, when compared to active myIndiHome users, it is known that only 10% of IndiHome service users use MyIndiHome. This encourages the author to conduct research to find out what factors can influence millenial intention to use myindihome application and how the correlation between millenial intention to use myindihome app and purchase intention to subscribe indihome. This study applies the Unified Theory of Acceptance and Use of Technology (UTAUT) model approach with the addition of attitude and user satisfaction constructs. This is descriptive quantitative research based on the study of empirical rational principles. Data was collected using online questionnaires to 196 respondent then the data were analyzed using SEM-GSCA. Based on the results of the study, it is known that the significant factors that influence millennial interest in using the MyIndiHome application are the performance expectancy, facilitating condition, attitude, and user satisfaction variables. In addition, it was found that there was a significant relationship between interest in using the MyIndiHome application and interest in buying subscriptions to IndiHome

Keywords: IndiHome, MyIndiHome, UTAUT, Purchase Intention, SEM-GSCA

1. INTRODUCTION

There are more than 63 million Indonesians in the millennial generation category where the majority of millennials are the most internet consumers in Indonesia (IDN Research, 2019). The millennial lifestyle is very closely related to the digital world, this creates opportunities for digital companies to take advantage of this moment. One of the BUMN companies (State Owned Enterprises) engaged in the largest information and communication technology services in Indonesia, namely PT Telkom Indonesia Tbk as one of the internet service provider companies. Indonesia Digital Home or IndiHome is one of the service products from Telkom

in the form of communication and data service packages such as home telephone, internet, and interactive television services. To serve the needs of Indihome customers in terms of requests for new installations, Telkom provides several channels such as coming directly to the nearest Telkom Plaza or Open Booth, Telkom 147 Call Center, and direct selling by Sales Force. In addition, Telkom also provides a mobile application, namely MyIndiHome, as a self-care service checking the availability of the indihome network, indihome registration, order tracking, billing management, reporting, and monitoring network problems (Setiotirin, 2016). Not only for new installations, MyIndiHome app also makes it easier for customers to add services (add-ons), to get bill payment information, and promo information, and exchange Indihome points that can be used at various merchants that have collaborated.

Based on the annual report of PT. Telkom Indonesia in 2020 it is known that now the number of active users using MyIndiHome is only 814 thousand users. it is also known that the number of IndiHome subscribers reaches 8 million subscribers, meaning that only 10% of IndiHome customers are actively using MyIndiHome. The small number of MyIndiHome application users is a concern for management to continue to increase the number of users and the intensity of mobile application usage, so it is necessary to know about the behavior intention to use MyIndiHome by finding what factors affect the intention to use MyIndiHome application and how the relationship between purchase intention IndiHome and MyIndiHome is by focusing research on the millennial generation. This will be done with the modified UTAUT model. UTAUT is a model that can explain acceptance and use technology. UTAUT uses Performance Expectancy, Effort Expectancy, Social Influence, and Facilitating Conditions variables. The difference from previous studies, this study conducted research on the MyIndiHome application using the UTAUT method by adding 2 (two) construct variables, namely Attitude and User Satisfaction. The Theory Planned of Action (TRA) explains that a person's intention to behave is influenced by Attitude and Subjective Norms (Ajzen and Fishbein, 2008). In research conducted on E-Commerce, it is stated that User Satisfaction has a significant influence on Behavior Intention (Anca et al., 2021). This is the basis for adding the User Satisfaction variable in this study. Other research confirms that satisfaction can be used to positively predict purchase intention (Deng et al., 2010; Dixit et al., 2018; Lee et al., 2013; Rejikumar & Ravindran, 2012; Svecova & Odehnalova, 2019). This statement is used as the basis for adding the Purchase Intention variable to this study. This study will use the GSCA SEM method to assist in generalizing the results obtained in the research model for all IndiHome customers The final result expected in this study is an analysis report on the use of mobile applications for internet service provider customers or the so-called MyIndiHome application in the millennial generation. This report is expected to be a reference for developers in improving and developing the researched MyIndiHome application so that they can evaluate how to use the MyIndiHome application and provide benefits to PT. Telkom Indonesia, Tbk.

2. LITERATURE REVIEW

2.1 IndiHome

IndiHome is a leading digital service product using fiber optic technology that offers triple play services consisting of home internet (fixed broadband internet), home telephone (fixed phone) and interactive tv (useetv). IndiHome is a manifestation of Telkom's commitment to support the creation of a digital lifestyle for all levels of Indonesian society. The need for high-quality fixed broadband services will remain high, to support a variety of people's daily activities ranging from work, study, shopping, entertainment and even entrepreneurship. Indihome has triple play services as well as several additional features.

2.2 MyIndiHome Mobile App

MyIndiHome mobile application is a digital touch point which is a mobile application-based IndiHome self-care service to make it easier for customers to request new installations and manage bills and payments. Then, the myIndiHome mobile application has many easy-to-use features for

customers who want to install IndiHome through myIndiHome customers can manage IndiHome services at home easily, comfortably and definitely, according to the wishes of the digital community, with just a few finger touches using a smartphone and not using a smartphone. need to come to plasa Telkom to queue for a long time.

2.3 **Unified Theory of Acceptance and Use Technology (UTAUT)**

Unified Theory of Acceptance and Use of Technology or abbreviated as UTAUT is a model to identify technology acceptance where the model is formulated based on six theories of technology acceptance (Venkatesh, 2003). This method measures the factors of acceptance or rejection of users against a technology. The UTAUT model has been tested in various Information Technology work environments, is found to be useful for evaluating the level of user acceptance of technology. UTAUT itself can be used to examine what factors influence the application of the technology, to make it easier to design a technology update so that it can be more accepted by users.

2.4 GSCA-SEM

Generalized Structured Component Analysis (GSCA) is a Structural Equation Modeling based on variance which is not related to the assumption of a morality distribution multivariate. This method was proposed by Hwang and Takane (2004) as a solution to overcome the weakness of the PLS method where in the PLS method has no measure of global fit. According to Hwang (2010), GSCA is viewed as a component-based SEM in which the latent variable is defined as a component of the supreme variable.

3. METHODS

A survey was conducted among a sample of the population using questionnaire. A likert scale from1 to 5 used to calculate the responses from the questionnaire. The initial sample was determined based on three user characteristics : gender, experience, and income.

3.1 Data Collection

Data collection in this study was done by using an online survey method. Online surveys were carried out by using Google Forms. This study attributes refer to previous studies. Questionnaires were distributed by online to all Indihome service users in ranging age from 22-41 years old in Central Jakarta. Each indicator from each variable used a likert scale interval data measurement with a measurement scale as follows (Bagranoff, 2010):

- Strongly Agree (SS) score = 5;
- Agree (SS) score = 4
- Neutral (KS) score = 3
- Disagree (KS) score = 2
- Strongly Disagree (KS) score = 1.

The following were references related to questions that have been used in previous studies and became the material for questionnaire questions in this study which were described in **Table 1**.

Tabel 1. Research Questionnaire

Variable	Indicator
Performance Expectancy (PE)	System Benefit (PE1)
	Time Efficiency (PE2)
	Increase Productivity (PE3)
Effort Expectancy (EE)	Fast Skilled (EE1)
	User Friendly Interface Design (EE2)
	Easy to Use (EE3)
Social Influence (SI)	Others Influence (SI1)
	Service Provide Influence (SI2)
	Advertisement Influence (SI3)
	Online Review (SI4)
Facilitating Condition (FC)	Availability Facilities (FC1)
	Knowledge (FC2)
	Compatibility (FC3)
	Help From Others (FC4)
Attitude (ATT)	Happy (ATT1)
	Interesting (ATT2)
	Good Idea (ATT3)
	Wise (ATT4)
User Satisfaction (US)	Satisfied with Information Quality (US1)
	Satisfied with Service (US2)
Behavior Intention to Use MyIndiHome (BIUM)	Intention (BIUM1)
	Interest (BIUM2)
	Recommendation (BIUM3)
Purchase Intention to Subscribe IndiHome (PISI)	Price Promotional (PISI1)
	Reward (PISI2)
	Purchase (PISI3)
	Continue to Subscribe (PISI4)

3.2 Model Conceptual

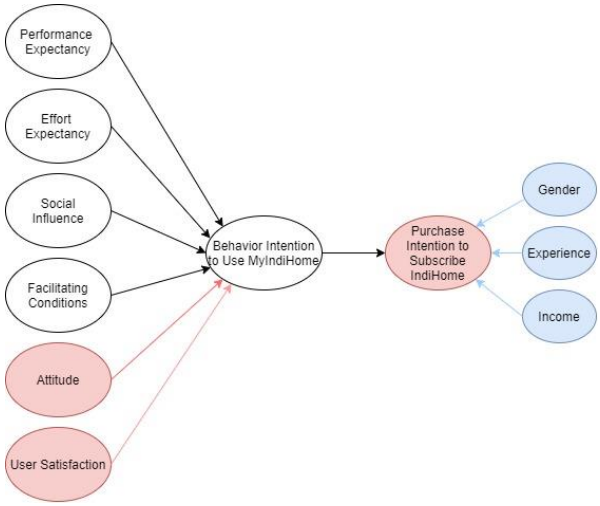


Figure 1. Model Conceptual

Figure 1 shows that the moderator variables were gender, experience, income which describe the latent variables that form behavioral intention to use myindihome and purchase intention to subscribe indihome. The latent variables in UTAUT are: performance expectancy, effort expectancy, facilitating conditions, social influence. There are three additional variables, i.e. attitude, user satisfaction, and purchase intention. Attitude is a variable to measure inner feelings on someone who shows feelings of pleasure or displeasure towards myindihome app services (Asiegbu et al., 2012). User Satisfaction is judgment that a myindihome app feature, or the product service itself, provided (or is providing) a pleasurable level of consumption (Nidal Yousef et al., 2019).

3.3 Hypothesis

In this study, a hypothesis will be determined based on the UTAUT model developed by Viswanath Venkatesh, et al., in 2003 which will be combined with research conducted by Asiegbu in 2012, Nidal Youssef's research in 2019.

Table 1. Research Hypothesis

Code	Description
H1	Performance Expectancy → Behavior Intention to Use MyIndiHome
H2	Effort Expectancy → Behavior Intention to Use MyIndiHome
H3	Social Influence → Behavior Intention to Use MyIndiHome
H4	Facilitating Condition → Behavior Intention to Use MyIndiHome
H5	Attitude → Behavior Intention to Use MyIndiHome
H6	User Satisfaction → Behavior Intention to Use MyIndiHome
H7	Behavior Intention to Use MyIndiHome → Purchase Intention to Subscribe IndiHome

Viewed from **Table 1**, there are 7 research hypotheses formulated.

4. RESULTS

4.1 Data Collection

The number of questionnaire respondents obtained in this study were 196 respondents. The survey method used a web google form, where users could directly filled out the questionnaire form instantly

and was recorded directly by the system. The descriptive statistical analysis of the questionnaire that was obtained when the data had been collected is described in **Table 2**.

Table 2. Desriptive Statistic

Scale	Frequency	Percent
Gender		
Male	110	56.12
Female	86	43.88
Experience		
0-2 year	103	52.55
> 2 year	93	47.45
Income		
Rp0-Rp5.000.000	104	53.06
>Rp5.000.000	92	46.94

4.2 Analysis Measurement Model

Measurement model analysis was used to see whether the indicators or question items in the study were able to properly measure the research variables (valid and reliable). The evaluation of the outer model in GSCA was divided into three parts which are convergent validity, discriminant validity, construct reliability

Table 3. Convergent Validity Evalution

Variable	Indicator	Estimate Loading	Variable	Indicator	Estimate Loading
Performance Expectancy (PE)	PE1	0.9302	Attitude (ATT)	ATT1	0.8925
	PE2	0.9118		ATT2	0.8240
	PE3	0.9295		ATT3	0.8617
Effort Expectancy (EE)	EE1	0.9175		ATT4	0.9053
	EE2	0.9240	User Satisfaction (US)	US1	0.9305
	EE3	0.9222		US2	0.9287
Social Influence (SI)	SI1	0.8484	Behavior Intention to Use MyIndiHome (BIUM)	BIUM1	0.9046
	SI2	0.8113		BIUM2	0.9332
	SI3	0.8373		BIUM3	0.9044
	SI4	0.8378	Purchase Intention to Subscribe IndiHome (PISI)	PISI1	0.8412
Facilitating Condition (FC)	FC1	0.8763		PISI2	0.8639
	FC2	0.8833		PISI3	0.8578
	FC3	0.8691		PISI4	0.8213
	FC4	0.6877			

Convergent validity is assessed based on the estimate loading value of each indicator latent variable. A latent variable of valid or good value if the estimated value loading factor more than 0.5 (Ghozali, 2013). The results of the convergent validity test showed that each indicator/question item in this study had an outer loading value greater than 0.5. The test results showed that each indicator/question item had good convergent validity as described in **Table 3.**

Discriminant validity is assessed by comparing the value of each latent construct with the correlation between the variables related to other variables in the model. If the square root value of AVE for every variable is greater than the correlation value between variables with other variables in the model can be said to have a good discriminant validity value (Ghozali, 2013).

Table 4. Discriminant Validity

	PE	EE	SI	FC	ATT	US	BIUM	PISI
PE	**0.9239**	0.7534	0.4792	0.5353	0.7690	0.7918	0.7743	0.6495
EE	0.7534	**0.9211**	0.4926	0.5020	0.7674	0.8334	0.7001	0.6169
SI	0.4792	0.4926	**0.8337**	0.1963	0.5378	0.5441	0.5189	0.5052
FC	0.5353	0.5020	0.1963	**0.8330**	0.5982	0.5332	0.5958	0.6134
ATT	0.7690	0.7674	0.5378	0.5982	**0.8714**	0.8371	0.8425	0.7153
US	0.7918	0.8334	0.5441	0.5332	0.8371	**0.9216**	0.8100	0.6791
BIUM	0.7743	0.7001	0.5189	0.5958	0.8425	0.8100	**0.9141**	0.8319
PISI	0.6495	0.6169	0.5052	0.6134	0.7153	0.6791	0.8319	**0.8462**

The results of the discriminant validity evaluation showed the AVE root value which was shown through the bold diagonal value in **Table 4**. The AVE root value on performance , effort expectancy, social influence, facilitating condition, attitude, user satisfaction, behavior intention to use myindihome, and purchase intention to subscribe indihome was greater than the each correlation value with other variables. It was also the same as the other variables which was known to have the AVE root value greater than the variable correlation value with other variables in the model. Thus, it can be stated that the question items in this study had good discriminant validity, so that the question item of a variable could only described the variable and could be distinguished from other variable question items in the research model.

Table 5. Composite Reliability Evaluation

Variable	**Composite Reliability**	**Status**
Performance Expectancy	0.9141	Reliable
Effort Expectancy	0.9108	Reliable
Social Influence	0.8537	Reliable
Facilitating Condition	0.8494	Reliable
Attitude	0.8939	Reliable
User Satisfaction	0.8428	Reliable
Behavior Intention to Use MyIndiHome	0.9016	Reliable
Purchase Intention to Subscribe IndiHome	0.8680	Reliable

Composite reliability measures a latent construct that can be evaluated in two ways measures, namely internal consistency and cronbach alpha. The value of composite reliability that recommended greater than or equal to 0.7. As can be seen in **Table 5** composite reliability value on

each variable was greater 0.7. Thus, which meant that each variable in this study had reliable/credible indicators/question items.

4.3 Hypothesis Testing

The next stage aims to test the correlation between latent variables and the overall structural model. In this analysis, the structural model is divided into 7 categories according to the different characteristics of the respondents. The first characteristic is differentiated based on the gender who uses it, namely male and female. Viewed from the myindihome usage experience, the characteristics are divided into two parts, namely 0 -2 years and more than 2 years. While the latter structural model is distinguished by income. The grouping of respondents is adjusted based on income of Rp0 – Rp 5,000,000 and more than Rp5,000,000. Based on the path coefficient value and *p-value*, hypothesis testing was significant. **Table 6** shows the hypotheses that were formulated.

Table 6. Result Hypothesis Research

Code	Structural Model Category	Path Coefficient		
		Correlation	Estimate	*p-value*
H1	Overall Model	PE → BIUM	0.2195	0.0012
	Male		0.2014	0.0055
	Female		0.2651	0.0103
	Experience 0-2 year		0.2033	0.0298
	Experience >2 year		0.1739	0.0243
	Income Rp0-Rp5.000.000		0.2468	0.0039
	Income >Rp5.000.000		0.1532	0.0479
H4	Overall Model	FC → BIUM	0.1245	0.0072
	Male		0.1273	0.0206
	Experience 0-2 year		0.1501	0.0241
	Income >Rp5.000.000		0.2447	0.0061
H5	Overall Model	ATT→BIUM	0.4154	0.0000
	Male		0.3336	0.0000
	Female		0.5132	0.0000
	Experience 0-2 year		0.3201	0.0034
	Experience >2 year		0.4792	0.0000
	Income Rp0-Rp5.000.000		0.4174	0.0000
	Income >Rp5.000.000		0.3640	0.0031
H6	Overall Model	US → BIUM	0.2778	0.0007
	Male		0.5380	0.0000
	Experience 0-2 year		0.4045	0.0050

	Experience >2 year		0.1640	0.0992
	Income Rp0-Rp5.000.000		0.3326	0.0084
	Income >Rp5.000.000		0.2707	0.0303
H7	Overall Model	BIUM→PISI	0.8319	0.0000
	Male		0.8442	0.0000
	Female		0.8216	0.0000
	Experience 0-2 year		0.8278	0.0000
	Experience >2 year		0.8472	0.0000
	Income Rp0-Rp5.000.000		0.8275	0.0000
	Income >Rp5.000.000		0.8438	0.0000

4.4 Effect of Latent Variable Correlation

Hypothesis testing aims to analyze tests an assumption regarding a population parameter determine the relationship between the latent variables . This test can be known through the relationship between independent variables and dependent variables, also between dependent variables with other dependent variables. So that it can be known whether the hypothesis of the study is significant or not based on available empirical data.

Table 7. R Square

R Square of Latent Variable	
Behavior Intention to Use MyIndiHome	0.728
Purchase Intention to Subscribe IndiHome	0.692

Based on the **Table 7**, it shows that the R-Square test value of the dependent variable Behavior Intention to Use MyIndiHome (BIUM) is 0.728 or 72.8%. This value shows the variance of changes in the dependent variable which can be strongly explained by the dependent variables that influence it (Performance Expectancy, Effort Expectancy, Social Influence, Facilitating Conditions, Attitude, User Satisfaction) of 72.8%, while the remaining 27.2% can be explained by other variables outside the studied. The R-square test value of the dependent variable Purchase Intention to Subscribe IndiHome (PISI) is moderately influenced by Behavior Intention to Use MyIndiHome which is 0.692 or 69.2%. These results indicate that the structural model of the development model proposed in this study has a high level of predictive effect.

6. CONCLUSIONS

The result show that UTAUT method was used successfully in a study of MyIndihome App. The following are some results obtained by using behavioral intention and use behavior. Based on the value of path coefficients and p-value, it can be concluded that performance expectancy, facilitating condition, attitude, user satisfaction, behavior intention to use myindihome, and purchase intention to subscribe indihome variables significantly influence behavioral intention to use myindihome and purchase intention to subscribe indihome. It can also be concluded that millennial user which characteristics are men, app usage experience 0-2 year, income >Rp5.000.000 are more interested than other category. This study contributes to the development of MyIndiHome App. By knowing the public's response to its products, so the developer able to implement strategies that can increase purchase to subscribe IndiHome or purchase add-on through MyIndihome app therefore can generate more revenue for Telkom Indonesia.

REFERENCES

A. W., & W. S. (2022). Understanding Factors Determining The Use of Mobile Apps by Customer : Customer Mobility as An Extension Construct of UTAUT2. *Journal of Theoretical and Applied Information Technology*, 958-970.

Alfanzi, L. (2021). Factor affecting the use e-money in millennial generation : Research model UTAUT 2. *Jurnal Manajemen dan Pemasaran Jasa*, 109-122.

Al-Qeinsi, K., & Al-Abdallah, G. M. (2014). Webiste Design and Usage Behaviour : An Application of the UTAUT Model for Internet Banking in UK. *International Journal of Marketing Studies*, 75-89.

Daduk, S., Santalla-Banderali, Z., & Siqueira, J. R. (2020). Acceptance of mobile commerce in low-income consumers: evidence from an emerging economy. *Heliyon*, 1-15.

Dakduk, S., Santalla-Banderali , Z., & Siqueira, J. R. (2020). Acceptance of mobile commerce in low-income consumers: evidence from an emerging economy. *Heliyon(6)*, 1-15.

Dinh, H. V., & Ngoc, N. T. (2021). The factors influence the intention to use mobile applications for room-sharing in Vietnam. *International Journal of Data and Network Science*, 502-510.

Dwaikat, N. Y., Khalili, S. A., & Hassis, S. M. (2019). Customer Satisfaction Impact on Behavioral Intentions : The Case of Pizza Restaurants in Nablus City. *Journal of Quality Assurance in Hospitality & Tourism*, 1-20.

Dwindasari, H., & Sarno, R. (2020). ANALYSING PUBLIC INTEREST IN SHARIA. *2020 International Sem in ar on A pplication for Te ch n o lo gy of Inform ation and Com m unication (iSem antic)*, 499-504.

F, A. I., M., B. Sc, P. D., & H, I. C. (2012). Consumer Attitude:Some Refelctions on Its Concept, Trilogy, Relationship with Consumer Behavior, and Marketing Implications. *European Journal of Business and Management*, 38-50.

F. P. (2021). Modeling e-commerce adoption factors among Gen-Z in a developing country : the case of Ghana. *Marketing & Menedzsment*, 81-94.

H, H., Y, T., & K, J. (2017). Generalized Structured Component Analysis. *Frontiers in Psychology*, 1-12.

Haris, C. A., WA, B. S., & Nasiri, A. (2020). Evaluasi Aplikasi Ruang Guru Menggunakan Model UTAUT 2 dan Model Kesuksesan DeLone and McLean. *JURTI*, 1-10.

Hwang, H., Takane, Y., & Jung, K. (2017). Generalized Structured Component Analysis with Uniqueness Terms of Accomodating Measurement Error. *Frontiers in Psychology*, 1-12.

Isaac, O., Abdullah, Z., Adholay, A., & Ameen, A. A. (2018). Antecedents and outcomes of internet usage within organisations in Yemen: An Extension of Unified Theory of Acceptance and Use of Technology (UTAUT) Model. *Asia Pacific Management Review*, 1-20.

Jasmine, N. A., & Saraswati, T. G. (2021). Analisis Pengaruh Konsep SGCC (Conformity to Social Norms, Quality Perception, Social Prestige, Internet Technology Readiness, dan Brand Credibility) Terhadap Minat Beli Netlfix Pada Generasi Milenial. *Jurnal Ilmiah MEA (Manajemen, Ekonomi, Akutansi)*, 1355-1366.

Jatavongso, S., & Fusiripong, P. (2021). Ethics, big social data, data sharing and attitude among millennials generation : A case in Thailand. *Wiley*, 1-16.

Kurniawan, A., Agus Rahayu, Wibowo, L. A., & Hendrayati, H. (2020). The Effects of Factors in Modified UTAUT on Millennial Generation Customer Satisfaction. *Processing of the 5th*

CONFLICT CAUSING FACTOR IDENTIFICATION ON PUBLIC-PRIVATE PARTNERSHIP PROJECT IN INDONESIA

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ABSTRACT

Public-Private Partnership (PPP) is a scheme that has been widely implemented by governments in developing countries especially in infrastructure sectors of Indonesia as an effective procurement for rapid economic development as a way to cover the gap funding. However, of all risks exist in PPP, there are risks that have negative implications, namely conflicts between parties in the PPP project. With so many parties in the PPP project and the long contract period, it is prone to conflict. Conflicts seem inevitable due to high differences in interests among the project parties. This is the reason why exploring the causal factors of conflict in PPP projects in Indonesia is important to minimize the negative impacts such as poor team performance and decision making, increased costs, time and service delays. The purpose of this study was to identify conflict causing factors in the PPP project. Relative Importance Index (RII) was used to measure the dominant conflict factors in PPP projects. The results shows that five dominant factors were the causes of conflict in the PPP project, namely field conditions, land acquisition, design planning, construction changes, compensation for affected parties.

Keywords: Conflict, PPP, Relative Importance Index.

1. INTRODUCTION

The concept of Public-Private Partnership (PPP) from 1990s until now has been widely applied in various infrastructure sectors in Indonesia. PPPs are perceived by many governments in developing countries as an effective provision for rapid economic development (Osei-Kyei & Chan, 2017). Its main characteristics include a competitive bidding process, the right balance of project risks, namely the efficiency of development financing due to the collaboration between the government and business entities, there is innovation and expertise from the private sector, and is guided by improvement of public services and facilities.

From the various risks in the PPP, there are risks that have negative implications, namely conflicts between parties. All construction projects are prone to conflict, but PPP projects are more prone to conflict because basically there are 2 large parties between the public parties with the interests of social benefits and the private parties with the interests of corporate profits. Conflicts seem inevitable due to high differences in interests among the project parties. The conflict progressed from harmful to benefit for the project team. However, most studies agree that uncontrolled conflict has the potential to harm projects (Jaffar et al., 2011). If both parties have invested in large amounts, the loss is not only harm to the parties bound by the PPP project contract, but also to the community who will be delayed in consuming the services or outputs of

this PPP project. Meanwhile, some types and levels of conflict, if managed constructively, can increase creativity and innovation (Villax & Anantatmula, 2010).

There have been many projects that experienced several types of conflict and some of them have caused project failures such as the Lekki Toll Road Concession (Nigeria), Ghana National Housing Project (Ghana), Bangkok Elevated Transport System (Thailand), West Cultural Kowloon District (Hong Kong), The Ngone Bridge Project (Laos) (Osei-Kyei, Chan, Yu, et al., 2019). In previous studies, conflict management has been carried out, especially in PPP projects. Osei-Kyei et al. (2019) and Osei-Kyei et al. (2018) conducted research on the root causes of the PPP project conflict with case studies of Ghana and China. In Indonesia area, there is still few research on conflicts between parties and stakeholders in PPP projects. Several studies such as Rachmawati et al. (2018), Adiyanti & Fathurrahman (2021) comprehensively discuss critical success factors of the PPP projects in Indonesia. In addition, referring to data from the Ministry of Public Works and Public Housing in 2021, there are 45 PPP projects which are divided into 4 Water Resources projects, 28 Road and Bridge Projects, 13 Housing Projects.

From the description above, the purpose of this study was to identify the causes of conflict from the literature review in PPPs so that they can find out about the steps and strategies that need to be observed to resolve conflicts to ensure investment value, increase economic and social benefits, and user satisfaction at PPP projects in Indonesia.

2. LITERATURE REVIEW

The American National Council for Public–Private Partnership defines PPP as "a contractual arrangement between a public sector agency and a private sector developer seeking resources and risks for the purpose of providing public services or building public infrastructure" (Tang et al., 2010). In Canada, the Council for Public-Private Partnerships defines PPP as "a collaborative effort between the public and private sectors, which builds on the expertise of each sector in meeting clearly defined public needs through the allocation of resources, risks, and returns appropriately". In Indonesia, the PPP concept according to Presidential Regulation Number 38 of 2015 defined as cooperation between the Government and Business Entities in the Provision of Infrastructure for the public interest by referring to the specifications set together. PPP projects have their own characteristics when compared to conventional project models (Widjaja, 2017). The main characteristics of a PPP project consist of:

- Long-term cooperation contract, more than 20 years;
- Contracts in PPP projects must accommodate all phases of the PPP project, risk sharing, investment, responsibility, and payments;
- The PPP project contract must specify the output specification parameters required as the final result to be achieved;
- The public sector will be the party that determines the PPP objectives for social benefits and establishes the requirements for construction, maintenance, operation and services to achieve the project goals;
- The private sector dares to take risks, although the risk allocation may differ in each PPP from the public sector;
- The public can pay "fees" to the private sector for the operation and construction of the PPP project and also undertake the responsibility so it can be used according to the goals in the contract agreement;
- After the end of the contract period, ownership of the project assets must be transferred to the public sector according to the contract agreement

In general, the project structure in PPP projects refers to the pattern of contractual relationships and cash flows that regulate the development and timing of project implementation. The PPP project structure related to contracts is based on the scope of the contract which describes the responsibilities of the business entity (The Public-Private Infrastructure Advisory Facility Organization et al., 2009).

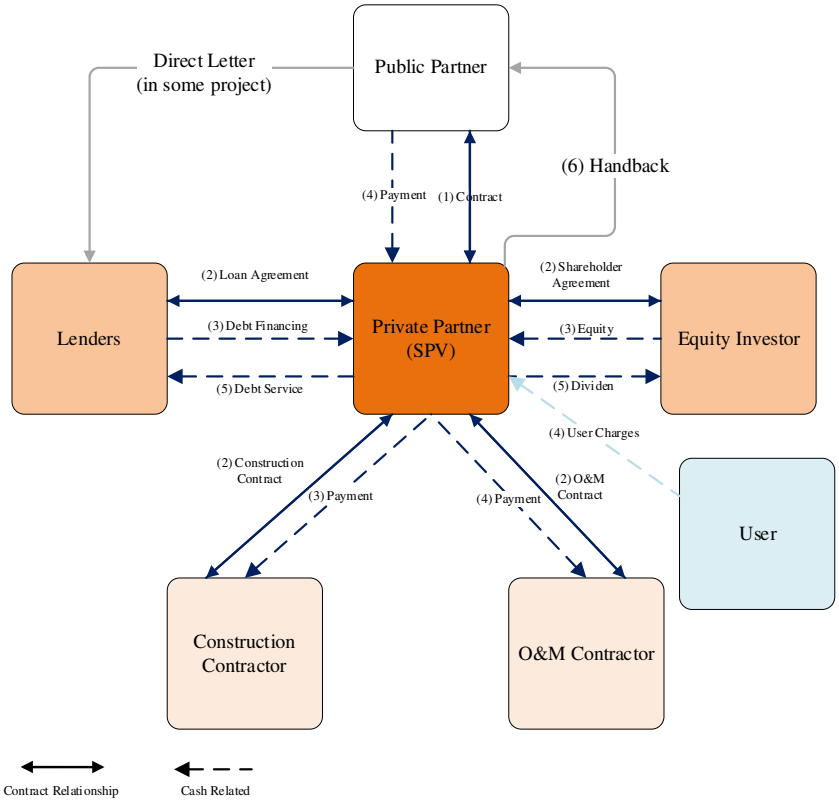


Figure 1. PPP Project Structure

(1) The public party enters into an agreement with a business entity. Private business entities are usually in the form of a Special Purpose Vehicle (SPV), which is a company created to develop and manage projects. (2) In achieving the obligations contained in the contract, the SPV also allocates responsibilities, obligations, risks, and cash flows from the SPV to various parties through agreements. (3) When the construction phase is about to start, SPV gets funds from lenders and equity from investors. (4) At the operation stage, SPV will receive revenue from users and/or from the public. (5) At the stage of loan repayment and equity distribution, payments are usually determined in advance in the financial agreement. Then most of the returns to investors are in the form of dividends. (6) The handover of assets to the public is the practice of the SPV handing back infrastructure under certain conditions to the public.

Villax & Anantatmula (2010) defined the concept of conflict as differences in perceptions, opinions, or beliefs between parties. Usually, conflict occurs when there are incompatible goals, thoughts, or emotions between individuals resulting in disagreement and disagreement. Then according to Acharya et al. (2006), the concept of conflict is different from risk, claim, and dispute. Many factors cannot be identified at the start of the project and if they occur can have negative consequences, it is called construction risk. The inability to assess risk can lead to conflict later on. Conflict is defined as a difference between two or more beliefs, ideas, or interests. Claims are disagreements as an extension of the conflict, which applies to recover losses.

Cannot be resolved by mutual agreement in a claim can become a dispute that must be resolved through arbitration, litigation or other alternative dispute resolution methods as stipulated in the contract. The concept of different conflicts with risks, claims, and disputes can be seen in the image below:

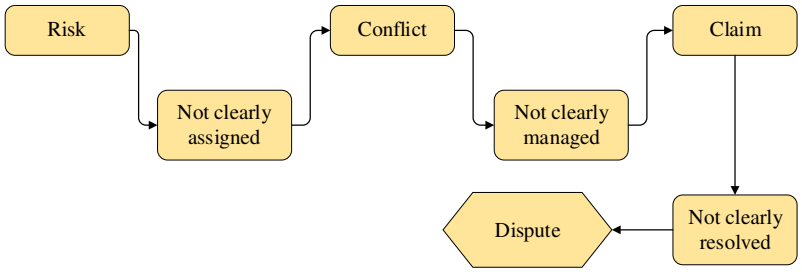


Figure 2. Theory concepts of risk, conflict, claim, and dispute

There are several causes of conflict that have been discussed in previous studies. Research by Osei-Kyei et al. (2019) takes case studies in Ghana and China. In the country of Ghana, the dominant conflict causing factor is related to poor governance and contractual arrangements. Because basically Ghana has a multi-organizational politic system where there are frequent changes of government. Meanwhile in China, the dominant conflict causing factor is related to weak risk management and communication. In this study, it was explained that the factors causing weak risk management were starting from being too practical in implementing PPP projects where there was an inability to carry out a proper feasibility study.

Villax & Anantatmula (2010) discuss about understanding and managing conflict in the project environment. This study analyzes the sources of conflict, impacts, and strategies. By conducting a literature study, there are several sources of conflict with the strategies that have been suggested in the study, one of which is conflict starting from role incompatibility. This conflict stems from the perception that the individual's given role is inappropriate because he or she works in an environment with a different information base. In this regard, the strategy can be carried out by improving organizational processes, increasing effective communication, ensuring that people are assigned to tasks related to their skills, experience, and previous positions.

Osei-Kyei et al. (2018) conducted a study looking for the causes of conflict in a PPP infrastructure project in Ghana. By adapting research Osei-Kyei et al. (2019) on the causes of conflict, a factor analysis method was used to classify the causes of conflict in PPP project infrastructure. There are 5 factors sequentially that have the most influence on the causes of conflict, namely poor community relations and interactions, poor contractual agreements and political interference, lack of knowledge about PPP project governance, low interaction between PPP project parties, poor leadership.

In the research of Acharya et al. (2006) identify and explore conflicting factors in construction projects to assist practitioners in assessing and taking proactive action to reduce the adverse effects of conflict. This study found six relevant construction conflict factors in Korea, namely differences in site conditions, public demonstrations, differences in the evaluation of the change order, design errors, excessive variations in contract quantity, and ambiguity of specifications. There is also the creation of a construction conflict prevention model framework starting from the identification, planning, implementation, and continuous monitoring stages.

After conducting a literature review on previous studies, the factors that cause conflict in this study are listed as follows:

Table 1. Factors causing conflict in PPP projects from several literatures

No	Factor	Definition	Source
1	Design Planning	Ignorance of field conditions and lack of experience of planners	(Acharya et al., 2006)
2	Construction Change	There are changes made during the construction process that can affect construction costs and time	(Osei-Kyei & Chan, 2017)
3	Contract	Improper arrangements in the contract such as improper distribution of roles and responsibilities	(Cheung & Chan, 2011)
4	Field Condition	Inadequate investigation of field conditions and misinterpretation of field investigation results	(Acharya et al., 2006)
5	Project Specification	The parties want to benefit from interpreting the specifications in their own way.	(Acharya et al., 2006)
6	Project Maintenance	Delays in correcting defects during operation	(Osei-Kyei et al., 2018)
7	Target Time	Projects are taking longer than estimated time to complete	(Cheung & Chan, 2011)
8	Land acquisition	Unavailability of location to start project construction on time due to land dispute	(Osei-Kyei & Chan, 2017)
9	Risk Allocation	Unfair allocation of risk as a result of changes to the law in favor of one of the parties	(Osei-Kyei et al., 2018)
10	Communication	Insufficient or incomplete information received by the communicating parties	(Mitkus & Mitkus, 2014)
11	Risk Transfer	Still lacking in analyzing factors that have negative consequences at the beginning of the project	(Osei-Kyei, Chan, Yu, et al., 2019)
12	Project Goals and Objectives	Unclear understanding of goals and objectives in the initial briefing process	(Villax & Anantatmula, 2010)
13	Decision-making	Parties make wrong or bad decisions due to lack of knowledge or interest	(Osei-Kyei & Chan, 2017)
14	Information Clarification	Reluctance to seek clarification	(Osei-Kyei, Chan, Yu, et al., 2019)
15	Leadership	Important parties responsible for making decisions on behalf of the general public are inconsistent with their decisions.	(Osei-Kyei & Chan, 2017)
16	Tariff Change	Unexpected changes in fare prices	(Cheung & Chan, 2011)
17	Compensation of Affected Parties	Inadequate compensation to displaced persons	(Osei-Kyei & Chan, 2017)
18	Political interference	Government dominates in making decisions and influencing PPP project arrangements	(Osei-Kyei & Chan, 2017)
19	Changes in Market Demand	Changes in demand, changing needs for services and facilities	(Cheung & Chan, 2011)
20	Roles and Responsibilities	Still lacking in clarifying roles clearly	(Tang et al., 2010)
21	Personality Character	Inability to manage multiple personalities encountered	(Villax & Anantatmula, 2010)
22	Trust	Lack of willingness to be open between parties	(Tang et al., 2013)
23	Commitment	Lack of commitment and enthusiasm from project parties that slows down project implementation	(Osei-Kyei & Chan, 2017)

3. METHODS

Based on the explanation on the background and the research objective, exploratory research was conducted by compiling literature review, research questionnaires, and interview which were distributed to practitioners who have experiences in PPP projects. Explorative research is research conducted to seek information about a new topic or problem for the purpose of deepening or further research. In this study, research measurements were carried out using a likert scale with a level of 1-5 to rate the factors causing conflict in the PPP project. 15 respondents were involved in the process of distributing questionnaires and interviews about their opinions regarding the conflict in the PPP project. Respondents were taken from parties involved in the PPP project in accordance with the PPP project structure such as construction contractors, ministry of public works, O&M contractors, investors, and SPV. 8 respondents have more than 15 years of PPP experience both as academic and/or industrial practitioners and the rest of the respondents have 5-15 years of experience in PPP projects.

Previous research has used several methods such as Kendall's Coefficient of Concordance, Factor Analysis, One way ANOVA analysis (Acharya et al., 2006) (Osei-Kyei et al., 2018) (Osei-Kyei et al., 2019) (Osei-Kyei, Chan, Yu, et al., 2019). The Relative Importance Index (RII) method is used in this study to determine the level of influence of several research factors. In addition, respondents were also interviewed their direct opinion on factors that influence conflict causing factor in the PPP project. The method to calculate the relative importance index (RII) using the following equation (Challal & Tkiouat, 2012):

$$\text{RII} = \frac{\sum W}{A \; x \; N} \Rightarrow (0 \leq \text{RII} \leq 1)$$

Notes:

- W = weight given to each factor by respondents (ranging from 1 to 5)
- N = total number of respondents
- A = highest weight (in this case 5)

4. RESULTS

Data analysis begins with the RII formula with data taken from the results of distributing questionnaires to respondents who have experience in PPP projects. The RII value is in the 0-1 interval, which means that if the value is getting closer to 1, the influence of the factor is more high. The calculation simulation with RII analysis can be seen as follows by taking the example of the design planning factor:

$$RII\ (Design\ Factor) = \frac{3+5+4+4+1+4+4+2+5+3+4+5+5+4+4}{5\ x\ 15}$$

$$RII\ (Design\ Factor) = \frac{53}{70} = 0{,}76$$

Table 2 Result analysis of the dominant factors causing conflict in the PPP project

No	Factor	RII Value	Rank
1	Design Planning	0,760	3
2	Construction Change	0,747	4
3	Contract	0,680	12
4	Field Condition	0,787	1
5	Project Specification	0,667	17
6	Project Maintenance	0,680	9
7	Target Time	0,667	12
8	Land acquisition	0,773	2
9	Risk Allocation	0,653	19

10	Communication	0,627	20
11	Risk Transfer	0,667	12
12	Project Goals and Objectives	0,653	17
13	Decision-making	0,680	12
14	Information Clarification	0,640	20
15	Leadership	0,707	6
16	Tariff Change	0,707	9
17	Compensation of Affected Parties	0,720	5
18	Political interference	0,680	9
19	Changes in Market Demand	0,640	20
20	Roles and Responsibilities	0,707	6
21	Personality Character	0,613	23
22	Trust	0,680	12
23	Commitment	0,707	6

From the above results, five dominant conflict-causing factors have been analyzed using RII, namely Field Conditions with a value of 0.787 or 78.7%, Land Acquisition with a value of 77.3%, Design Planning with a value of 76.0%, Construction Changes with a value of value of 74.7%, and Compensation of Affected Parties with a value of 72.0%.

When viewed from previous research, there are studies that have been conducted regarding the factors causing conflict in PPP projects. Research by (Osei-Kyei, Chan et al., 2019) taking studies in the countries of Ghana and China. The dominant causal factors are different from those in this study. In the country of Ghana, the dominant factor causing conflict is related to weak governance and contractual arrangements. Because basically Ghana has a multi-party system where there are frequent changes of government. Interestingly, if the new government takes office, mainly from the opposition, it will almost certainly not continue the projects/contracts that have been implemented by the previous government. Meanwhile in China, the dominant factor causing conflict is related to poor risk management and communication. In the study, it was explained that the factors causing poor risk management stem from the rush in implementing the PPP project where there is an inability to conduct a proper feasibility study.

In contrast to the case study conducted by (Osei-Kyei, Chan, Yu, et al., 2019), in this research case study the dominant factor is related to field conditions and land acquisition. The Field Condition factor is the dominant conflict causing factor in the toll road PPP project where this factor belongs to the technical category. This field condition is often related to the existing condition of the soil structure that is not suitable (Acharya et al., 2006). This discrepancy can be related to other factors, namely design planning factors and construction changes. Planners and Owners should provide complete and detailed design information to the construction team.

The land acquisition factor in the PPP project is the dominant conflict causing factor because it relates to impacted communities. If referring to (Osei-Kyei & Chan, 2017), the land acquisition factor is a significant factor in the project, the problem of land acquisition related to reclamation land in the project case study is because the available land is very limited. In Indonesia especially infrastructure projects, it is common knowledge that infrastructure development is delayed due to land acquisition constraints. This is closely related to the factor for compensation of affected parties. The problem of acquisition occurs because of differences in the assessment by the appraiser in valuing the land to be purchased.

6. CONCLUSIONS

This study were found 23 factors that were related as factors causing conflict in the PPP project. After distributing research questionnaires and RII analysis to obtain the dominant factors causing conflict, it was found that five dominant factors were the causes of conflict in the PPP project, namely Field Conditions, Land Acquisition, Design Planning, Construction Changes, Compensation for Affected Parties. This study contributes to the body of knowledge on PPP especially in conflict management. In terms of practical implication in this research, the output provides an overview the potential sources of conflict in the PPP project. This study can help the practitioners to be able to consider the factors that exist in the development of strategies in the PPP project so that social benefits and value for money become wider. This study recommends further research involving more respondents so that the level of truth of the research data is more guaranteed.

REFERENCES

Acharya, N. K., Dai Lee, Y., & Man im, H. (2006). Conflicting factors in construction projects: Korean perspective. *Engineering, Construction and Architectural Management*, *13*(6), 543–566.

Adiyanti, N. P., & Fathurrahman, R. (2021). Assessing Critical Success Factors for PPP Water Project in Indonesia: Lessons from West Semarang. *Policy & Governance Review*, *5*(2), 164.

Challal, A., & Tkiouat, M. (2012). Qualitative Approach Risk Period in Construction Projects. *Journal of Financial Risk Management*, *01*(03), 42–51.

Cheung, E., & Chan, A. P. C. (2011). Risk Factors of Public-Private Partnership Projects in China: Comparison between the Water, Power, and Transportation Sectors. *Journal of Urban Planning and Development*, *137*(4), 409–415.

Jaffar, N., Abdul Tharim, A. H., & Shuib, M. N. (2011). Factors of conflict in construction industry: A literature review. *Procedia Engineering*, *20*, 193–202.

Mitkus, S., & Mitkus, T. (2014). Causes of Conflicts in a Construction Industry: A Communicational Approach. *Procedia - Social and Behavioral Sciences*, *110*, 777–786.

Osei-Kyei, R., & Chan, A. P. C. (2017). Risk assessment in public-private partnership infrastructure projects: Empirical comparison between Ghana and Hong Kong. *Construction Innovation*, *17*(2), 204–223.

Osei-Kyei, R., Chan, A. P. C., Xiaohua, J., Osei-Kyei, R., & Jin, X. (2018). *Factor Analysis of the causes of conflict in Public-Private Partnership infrastructure projects in Ghana*. *2014*, 1–6.

Osei-Kyei, R., Chan, A. P. C., Yao, Y., & Mazher, K. M. (2019). Conflict prevention measures for public–private partnerships in developing countries. *Journal of Financial Management of Property and Construction*, *24*(1), 39–57.

Osei-Kyei, R., Chan, A. P. C., Yu, Y., Chen, C., & Dansoh, A. (2019). Root causes of conflict and conflict resolution mechanisms in public-private partnerships: Comparative study between Ghana and China. *Cities*, *87*(January 2018), 185–195.

Rachmawati, F., Soemitro, R. A. A., Adi, T. J. W., & Susilawati, C. (2018). Critical success factor for partnership in low-cost apartments project: Indonesia perspective. *Pacific Rim Property Research Journal*, *24*(2), 149–160.

Tang, L., Shen, Q., Skitmore, M., & Cheng, E. W. L. (2013). Ranked Critical Factors in PPP Briefings. *Journal of Management in Engineering*, *29*(2), 164–171.

Tang, L. Y., Shen, Q., & Cheng, E. W. L. (2010). A review of studies on Public-Private Partnership projects in the construction industry. *International Journal of Project Management*, *28*(7), 683–694.

The Public-Private Infrastructure Advisory Facility Organization, Yuksel, B., Greenough, A., Pârvu, D., Voicu-Olteanu, C., Fischer, K., Leidel, K., Riemann, A., Alfen, H. W., Buket, O., APMG, Dong, X., Du, Y., Wu, X., Chan, A. P. C., Yeung, J. F. Y., Yu, C. C. P., Wang, S. Q., Ke, Y., … Cheung, E. (2009). The APMG Public-Private Partnership (PPP) Certification Guide Acknowledgments. *Transylvanian Review of Administrative Sciences*, *1*(3), 260–282.

Villax, C., & Anantatmula, V. S. (2010). Understanding and managing conflict in a project environment. *PMI® Research Conference*, 1–24.

Widjaja, G. (2017). Implementation of public-private partnership in Indonesia. *International Journal of Economic Research*, *14*(15), 235–245.

EVALUATION OF QUALITY DECREASE AND EFFORTS TO IMPROVE THE QUALITY OF HOUSE BUILDINGS ON THE CITRALAND UTARA SURABAYA PROJECT

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ABSTRACT

Along with the increase of demand for housing, the competition among developer companies is also getting tighter. Therefore, Citraland Utara as one of the big developer in Surabaya have to maintain the consistency of the building quality to compete for a potential market. In the last 5 years, it is estimated that there has been a decline in the quality of house construction at the Citraland Utara. This can be seen from the increasing number of houses with defects from 24.05% to 40.0% of the number of houses handed over in the 2016-2020 period. This event immediately became the main concern of top management. The final result of the Root Cause Analysis and Failure Mode and Effect Analysis through Focus Group Discussion, obtained 3 main factors causing the decline in building quality with each mitigation strategies: method factor with 6 mitigation strategies, material factor with 5 mitigation strategies, and measurement factor with 5 mitigation strategies. Through priority weighting using Analytical Hierarchy Process involving relevant stakeholders, a priority sequence of mitigation strategies is obtained from each factor causing the decline in building quality which can be used as an effort to improve the quality of housing in the future.

Keywords: House defect, Quality improvement, Root Cause Analysis, Failure Mode and Effect Analysis, Analytical Hierarchy Process

1. INTRODUCTION

The business property is a business based on trust, image, and reputation. With the increasing number of housing growth in Surabaya, the developers are competing to provide good quality service and good product quality to create and maintain a good brand image for customers and the wider community. According to Kotler & Armstrong (2007) consumer satisfaction is closely related to quality, where quality has a direct impact on consumer satisfaction.

In 2015 Citraland Utara Surabaya scored a milestone by launching a unique project called Northwest. Before the Northwest project was handed over to the homeowners, the buyer's assessment of the finishing quality of their home units at the time of handover was still very good, which was above 90%. However, there was a drastic overall decline during the handover of the Northwest housing units to buyers in 2018.

Based on the problems above, it is necessary to conduct research that aims to identify the factors causing the decline in quality and identify efforts to improve the quality of house buildings in the Citraland Utara Surabaya project.

2. LITERATURE REVIEW

Design and construction are two important phases of the project life cycle that significantly affect the quality outcome of a construction project (Ashokkumar, 2014). However, quality control or supervision during the construction process is often ineffective. The quality of the project results that are not in accordance with the specified standards will have an impact on the company's brand image. Construction failures can be detected after the construction process is completed or even during the maintenance process (Wiyana, 2012). Therefore, quality is one of the most important keys to developing building products in support of sustainable success.

According to Russell and Taylor (2013), the high demand for high-quality products has encouraged companies to implement quality improvement initiatives. FMEA or Failure Mode and Effect Analysis or FMEA has proven to be one of the most important and relevant failure prevention techniques in various fields, such as manufacturing, civil engineering, medical and automotive. However, traditional FMEA has weaknesses that need to be elaborated for further improvement. One of the problems with FMEA is the failure mode which is often not detected (Bluvband Z and Grabov P, 2009). To curb the demand for high quality products and services, a comprehensive and extensive failure analysis such as Root Cause Analysis or RCA has been integrated into FMEA to enhance FMEA risk analysis. The combination of these two methods are able to make practitioners solve problems related to quality (Kiran, 2017).

Table 1. Classification of Tools

Categories	Author	Sector	Types of FMEA	Tools Integrated
Inneficiency of Failure Analysis	Mariajayaprakash	Manufacturing	Process	Ishikawa diagram
	Ji	Health	Process	Ishikawa diagram
	Chong	Project management	System	Ishikawa diagram
	Sharma	Mechanical	Process	RCA, NHPPP
	Sharma	Mechanical	Process	RCA, Fuzzy method
	Panchal	Water treatment	System	RCA

The study above outlines the important role of the 7 basic quality tools in the integration of FMEA. The Ishikawa diagram enhances FMEA risk analysis while the Pareto diagram prioritizes actions for process improvement. In addition, RCA enhances FMEA risk analysis by providing a knowledge base of the process.

3. METHODS

At the problem identification stage, the researcher will integrate the RCA method with Pareto diagram tools and Cause Effect diagrams into the FMEA method to help evaluate various parameters as a tool for compiling FMEA tables so that research is more comprehensive. After the causes of disability have been analyzed, the root causes of the problem and potential defects have been identified and the risk assessed, a proposal for improvement will be made based on the highest to lowest RPN values by conducting FGDs and brainstorming with parties who are in

direct contact with the house construction process.

Meanwhile, to give priority scale and validate that the proposed formulation/step is acceptable, Multi Criteria Decision Making will be used using tools in the form of Analytical Hierarchy Process. By involving stakeholders in the AHP process, acceptable and valid research proposal priorities will be obtained which can be immediately applied to improve the quality of the house.

The AHP method helps solve complex problems by structuring a hierarchy of criteria, stakeholders, outcomes and by drawing various considerations to develop weights and priorities (Saaty T, 2008).

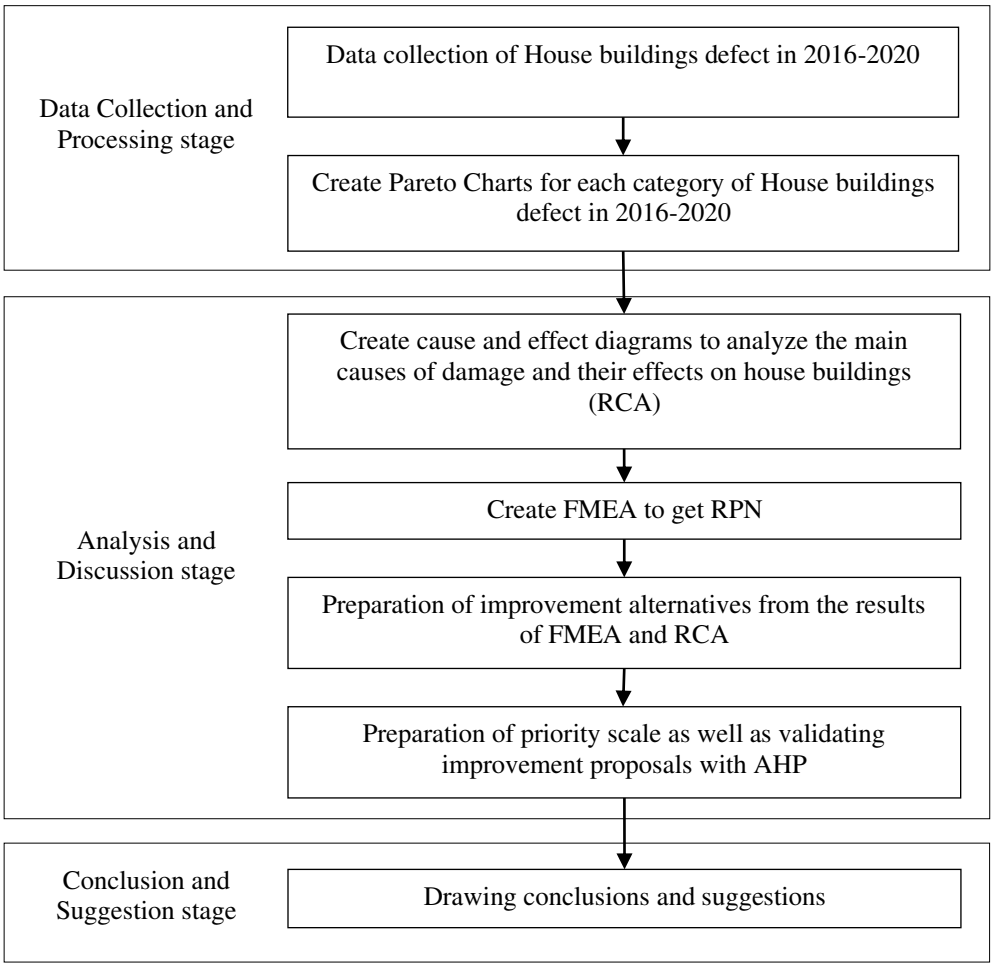


Figure 1. Research Stages

In brief, the data collection and processing stage consists of the following steps: The first step is to identify complaints based on 7 categories of complaints, namely Roof, Walls, Floors, M/E and Accessories, Windows Doors and Accessories, Ceilings, and other categories. -other. The second step is to identify the sub-categories of complaints from each category. The third step is the grouping of complaints based on the Pareto chart to compare several categories according to the intensity of their occurrence which are arranged according to their frequency.

The analysis and data processing stage is a process of further analysis of results to find alternative solutions to existing problems. Analysis and processing of this data consists of three methods, namely RCA, FMEA, and MCDM. Any dominant damage to house buildings with a

construction period of 2016-2020 will be searched for the root cause using the RCA method. Identification of the root cause of this problem will be carried out by FGD. The dominant problems resulting from the Pareto Chart are then compiled into a fishbone diagram. Then the problem is identified the root of the problem using 5 whys. The identification is based on 6 aspects, namely people, material, environment, method, machine/equipment and measurement. Of the 6 aspects, only the 3 highest in each aspect were taken to determine the severity, occurrence and detention values with FGD to get the RPN value using the FMEA method. Mitigation identification for the dominant causative factor was obtained from FGD with the same respondents. After identifying the mitigation for the priority causal factors, the next step is to determine the weight of the mitigation that should be prioritized. Mitigation weight calculation is done by using Analytical Hierarchy Process in Expert Choice software.

The final stage of this research is the stage of drawing conclusions on the research results that have been obtained.

4. RESULTS

The data used in this research is the defect repots on house building collected from 2016 to 2020 period. Based on the collected defect reports, the highest defect case is found in wall defect category, with contribution of 48% cases from the total defect reports collected.

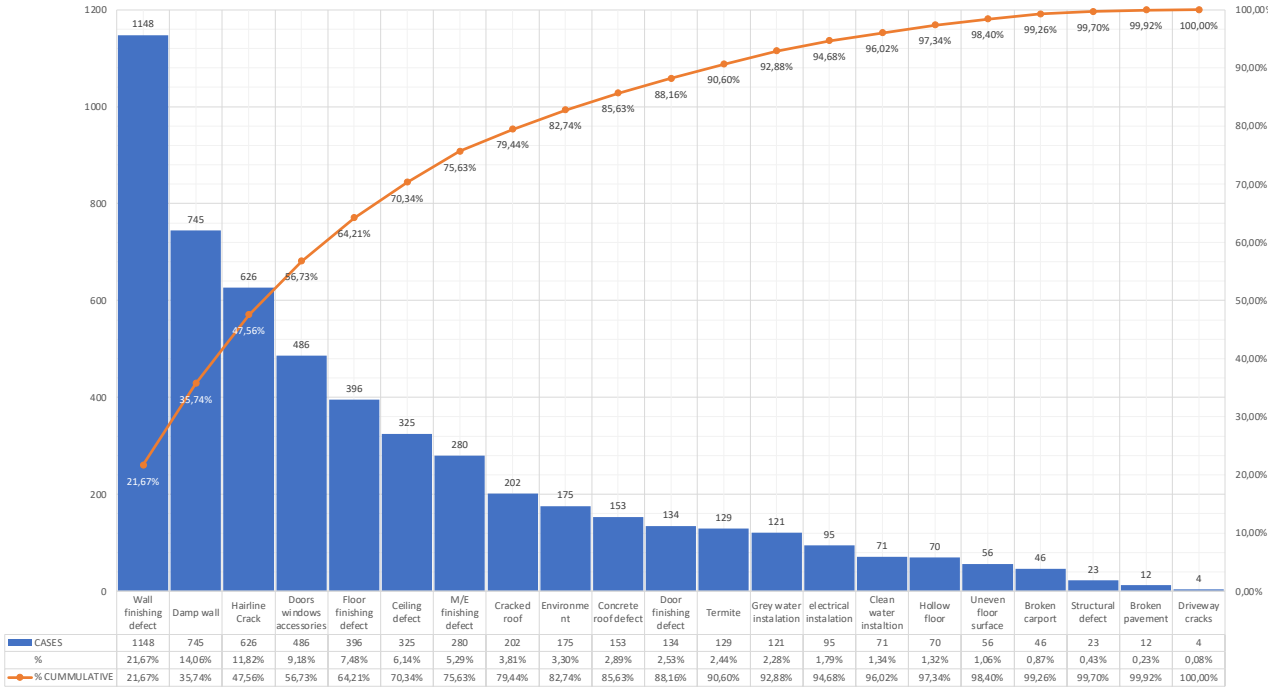


Figure 2. Recapitulation of defect reports on house building based on sub-caterogy (2016-2020 period)

Figure 2 shown that based on sub-category, the highest defect case is found in these sub-categories: (1) Finishing defects, which contributes 21,67% cases from the total defect reports collected; (2) Damp wall, which contributes 14,08% cases from the total defect reports collected; (3) Hairline crack, which contributes 11,82% cases from the total defect reports collected. From these results, FGD was conducted to analyze the factors causing defects using the RCA method with fishbone diagram. Griffith (2003) recommends using 6 factors in the fishbone diagram,

namely human, methods, materials, tools, measurements, and environment. The results of the fishbone diagram generated by RCA methods are analyzed using FMEA to make the research more extensive. The RPN value is obtained from the multiplication of the severity, occurrence, and detection values. Each value of severity, occurrence, and detection is obtained from the FGD results.

Table 2. FMEA table for wall defect in the Citraland Utara Surabaya project (2016-2020)

Causative	Sub-category	Potential Causes(s) of Failure	S	O	D	RPN	Total
Methods	Finishing defects	Plastering head too thick	5	4	4	80	602
		Unfinished plaster work at once	5	4	4	80	
		ME installation work after wall	5	5	3	75	
		The joint between fields is not	3	5	1	15	
		Poor plaster quality	3	5	3	45	
	Damp wall	Not using *trasram*	5	5	4	100	
		No column around the opening	5	3	2	30	
		House walls gap	4	3	3	36	
	Hairline crack	No column around the opening	3	3	2	18	
		ME installation work after wall	3	5	3	45	
		No wires wrapping around the	3	4	1	12	
		Excessive use of sealer	3	2	3	18	
		Unfinished plaster work at once	3	4	4	48	
Material	Finishing defects	Poor quality mortar mix	5	3	2	30	296
		Inconsistent plaster thickness	5	5	5	125	
		Poor quality of paint mixture	3	5	5	75	
	Damp wall	Seepage around the opening	5	3	2	30	
	Hairline crack	Poor quality of the mortar mix	3	3	4	36	
Measurement	Finishing defects	Plaster is too thick	5	3	5	75	215
	Damp wall	Unmeasured wall pH	5	4	1	20	
		Incorrect opening measurement	5	5	3	75	
	Hairline crack	Incorrect opening measurement	3	5	3	45	
Man	Finishing defects	Poor plastering skill	5	1	2	10	94
		Poor painting skill	3	3	4	36	
	Damp wall	Poor inter-brick spec	5	2	3	30	
	Hairline crack	Poor inter-brick spec	3	2	3	18	
Tools	Finishing defects	Inconsistent mortar mix	5	2	5	50	83
		Paint defect	3	3	1	9	
	Hairline crack	Inconsistent mortar mix	3	2	4	24	
Environment	Finishing defects	No air circulation	3	3	3	27	27

Table 2 shows the main factors causing the wall defect based on the calculation of the RPN: (1) Methods factor; (2) Material factor; (3) Measurement factor. From these findings, FGD were conducted to proposed the mitigation actions from each causal factors. From the FGD, 5 to 6 mitigation actions were proposed for each causal factors. To rank the priority scale of mitigation actions for each causal factor, priority weighting is carried out by conducting AHP using Expert Choice application. AHP was carried out by distributing pairwise comparison questionnaires to 5

stakeholders involved in the process of building houses in Citraland Utara Surabaya. All of these 5 stakeholders are assumed to have the same subjectivity as well as justification for the assessment.

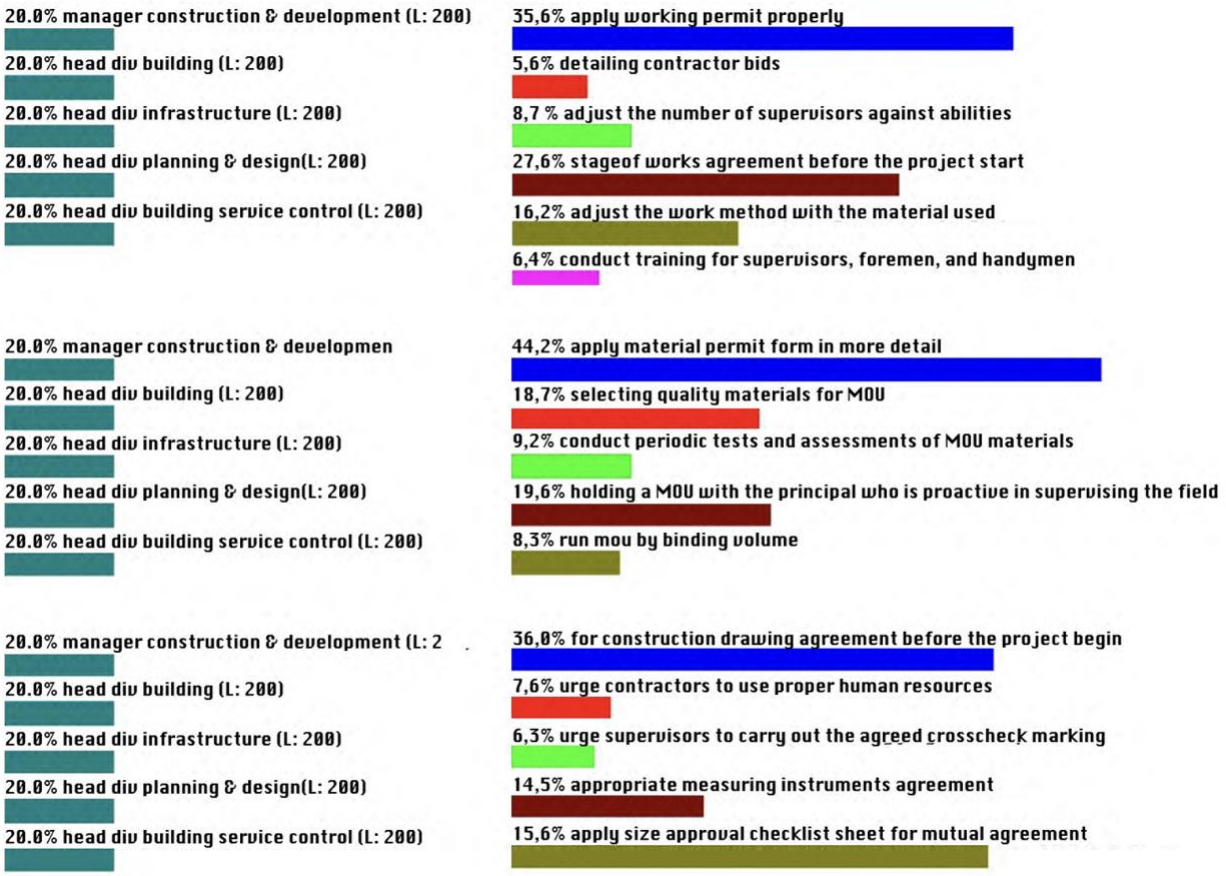


Figure 3. Recapitulation of priority mitigation weight calculation for each factor

Figure 3 shows the priority ranking of mitigation actions from each causal factor based on the results of the AHP. For methods factor: (1) Apply working permit properly; (2) Stage of works agreement before the project start; (3) Adjust the work method with the material used. For material factor: (1) Apply material permit form in more detail; (2) Holding a memorandum of understanding with the principal who is proactive in supervising the field. For measurement factor causal: (1) For construction drawing agreement before the project begin; (2) Hold a size approval checklist sheet for mutual agreement.

5. CONCLUSIONS

Based on the results of the evaluation of quality degradation, there are 3 main factors causing the decline in the quality of house buildings in Citraland Utara Surabaya: (1) the method factor, (2) material factor, (3) measurement factor. Based on the FGD and AHP, priority steps for mitigation are arranged as an effort to improve the quality of buildings based on each of the factors causing the decline in quality: (1) Implementing a working permit in the field better, (2) running a material permit form in more detail, (3) agree on drawings for construction before the project starts. All of these mitigation steps will make the supervision and control easier, and minimize errors that occur in the field with clearer project agreements.

REFERENCES

Ashokkumar, D. (2014). International Journal of innovative Research in Science Engineering and Technology. Study of quality management in construction industry., 36-43.

Bluvband, Z. & Grabov, P. (2009). Failure Analysis of FMEA. Annual Reliability and Maintainability Symposium. (Texas: United States of America) 344–7.

Chong, W., Asce, M., & Low, S. (2006). Latent Building Defects : Causes and Design Strategies to Prevent Them.

Griffith, Gary K. (2003), The Quality Technician's Handbook. 5th ed. Upper Saddle River, NJ: Prentice Hall.

Ji, Y, et al. (2014). Design and Optimization of a Chromatographic Purification Process for Streptococcus Pneumoniae Serotype 23F Capsular Polysaccharide by a Design of Experiments Approach. Journal of Chromatography A 1348.

Kiran D. R. (2017). Total Quality Management: Key Concepts and Case Studies. Oxford: Butterworth Heinemann.

Kotler, Philip, and Gary Amstrong (2007). Principles of Marketing, New Jersey: Prentice Hall, Inc.

Mariajayaprakash, A. & Senthilvelan, T. (2013). Failure Detection and Optimization of Sugar Mill Boiler Using FMEA. Elsevier: Engineering Failure Analysis Volume 30.

Panchal, D. & Kumar, D. (2016). Integrated Framework for Behaviour Analysis in a Process Plant. Journal of Loss Prevention in the Process Industries 40.

Russell R. S. & Taylor B. W. (2013). Operations Management Along the Supply Chain vol 8 (New Jersey: John Wiley & Sons).

Sharma, R. K. & Sharma, P. (2010). System Failure Behavior and Maintenance Decision Making Using RCA, FMEA and FM. Journal of Quality in Maintenance Engineering 16.

Wiyana, Y.E. (2012). Analisis Kegagalan Konstruksi dan Bangunan dari Perspektif Faktor Teknis. *Jurnal Wahana Teknik Sipil Vol. 17 No. 2*, 77-86.

SELECTION OF SHIPYARD REPAIR FOR FERRY RORO SHIP USING THE INTEGRATION OF THE DELPHI METHOD AND ANALYTICAL HIERARCHY PROCESS (AHP)

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ABSTRACT

The maritime industry has stakeholders, such as shipping companies, ship owners, and shipyards. They function to maintain the industrial sustainability of the industry. They have an essential role in fulfilling shipping safety aspects. The shipping companies or ship owners should be able to take good care of their ships according to the schedule and apply safety rules strictly. Therefore, the ship owners should choose and operate the best shipyards to meet these aspects. A ferry also functions to carry more than 12 passengers based on applicable regulations. It is required to carry out docking once in 12 months. The ferry ship owners operating on the Ketapang – Gili Manuk, Lembar – Padangbai, and Kayangan – Pototano crossing lanes prefer to repair their ships at the shipyards in East Java.

This research focuses more on selecting the best repair shipyards for ferry ships and developing a framework for a decision support system for the best shipbuilding repairs. This research integrates the Delphi method to build some criteria and sub-criteria. Analytical Hierarchy Process (AHP) is used to weight the criteria and sub-criteria. Next, the best shipyards are determined by rating each by multiplying the sub-criteria weight value by the assessment value of each shipyard at the sub-criteria level.

Based on the Delphi method, there are 7 (seven) main criteria for selecting repair shipyards: Ship delivery time (delivery), Experience, Facilities, Quality & Certificates owned, Financial, Dock type, and Geographical conditions. The method also generates 23 (twenty-three) sub-criteria. The weighting of the criteria and sub-criteria results in the "Delivery time" criterion as the priority and the "financial" criterion in the second place. The first-ranked shipyard is shipyard I, and shipyards G and D take the second position.

Keywords: Analytical Hierarchy Process (AHP), Delphi method, *ferry roro*, shipyard repair decision making.

1. INTRODUCTION

Ferry ships function to connect people and deliver goods among islands within short distances. They are important to maintain and sustain supply chains of community and industrial needs. The ferry ships act as bridge substitutes. They should get deep concern because they can transport and move land vehicles such as two-wheeled, four-wheeled, medium size, and large trucks. They can also lift the passengers. Therefore, safety is the most crucial factor to consider.

Indonesia has thousands of islands, so the ferry is the most effective means of transportation to connect them all. The ships holding docking activities in the East Java include ferry ships that operate on four crossing routes, including Lembar – Padangbai, Ketapang – Lembar, Ketapang – Gilimanuk, and Kayangan – Pototano. The number of ferry ships on each lane is in the following table:

Table 1 Number of ferry ships on each sailing route

Nu.	Sailing Route	Number of ships
1	Lembar – Padangbai	24 Units
2	Ketapang – Lembar	6 Units
3	Ketapang – Gilimanuk	46 Units
4	Kayangan – Pototano	27 Units

There are two main things before selecting the best shipyard, i.e. economic and technical factors. They must be described specifically and in detail. Generally, the selection of repair shipyard is affected by some factors or criteria. More factors or criteria reflect that the shipyard will become the first alternative to be used to have docking or ship repairing.

The service quality must be improved in terms of procedures, repair work expertise, facilities, services, shipyard conditions, and work safety. They often affect ship repair work delays. (Nurwanti, 2016).

There is also a gap in customer satisfaction with the repair services provided by the shipyards. 24% of respondents are the ships /shipping companies' owners. They stated that the shipyards are not on-time. 24% of the respondents said that repair costs are expensive. 20% of respondents said that the results are not as they expect. 12% of respondents stated that the procedures are complicated and confusing. 10% of the respondents complain that the provided services are not satisfactory, and 10% of the respondents said that the damage survey is not carried out by the shipyards (Siallagan, 2005). The following diagram displays the gap in customer satisfaction for ship repair at the East Java repair shipyards.

This research aims to identify some criteria that influence the selection of shipyard repairs for ferry ships, calculate the weight value of the influence of each criterion on the existing alternatives, and develop a framework for a decision support system for shipyard repair decisions that are appropriate for ferry ships. The results can provide an overview to the ship owners in determining shipyard repairs. Also, the findings can be used to observe the latest conditions to fulfill the ship owners' desires based on the value of excellence. The studied ships operate in East Java, Bali, and Lombok islands. The shipyards in question are those located in East Java province.

2. LITERATURE REVIEW

2.1 Ferry Ships

A ferry is a ship built for commercial needs to earn profits. The regulation of the Minister of Transportation of the Republic of Indonesia Number PM 104 of 2017 concerning the implementation of ferry transportation explains the definition of ferry transport ships and crossings with short and long routes.

A ferry is a motorized water vehicle driven by mechanical power and functions as a moving bridge to transport passengers and vehicles. Their cargo enters and leaves through different ramps. It has a double bottom hull construction and at least two main engines (INDONESIA, 2017).

2.2 Repair Shipyard

Docking means moving a ship from the water to the land. This process is to inspect the hull below the waterline and repair the ship. The ship docking consists of some steps, including the reception of the ship at the dock, preparation for docking, docking, cleaning of the hull, inspection of plate thickness & damage to the hull/other construction, inspection of the system below the waterline, execution of work (construction, machinery, electricity, and others), testing the work results, painting the hull, installing cathodic protection, lowering the ship from the dock (Undocking), completing work on the water, and trial and delivery to the ship owner.

There should be a basic understanding of how docks are designed and constructed, so there will be good knowledge of how and why shipyard operational constraints must be on the types (Heger, 2005).

There are several types of shipyard repairs, including:

a. Graving dock
b. Floating dock
c. Marine Railways or slipways
d. Marine travel lifts

Commonly, shipyards have specific workshops and rooms, such as mechanical, electrical, steel sandblasting, docking, painting, and others. Mechanical and electrical, steel, plumbing, and routine docking work such as washing, sandblasting, coating, sea chest cleaning, propeller disassembly, polishing, repair, or maintenance of propeller shafts can be grouped as the main facilities in ship repair works on the dock (Celik, 2009).

A shipyard generally contains some facilities specifically to facilitate material flows and assembly. There is no typical shipyard layout. Usually, the shipyard is built according to land and waterfront availability and production requirements (Storch, 1995).

Shipyard workers are classified into some departments or sections. They are responsible for some specific aspects. Although each company already has variations in its organization, the workers are divided into some divisions like Administration, Production, Engineering, Purchasing, Quality Assurance, and Project management.

2.3 Multi-Criteria Decision Making (MCDM)

Multi-Criteria Decision Making (MCDM) is an important part of modern science. It is applied in many industries and government agencies. MCDM helps the decision-makers in dealing with multi-criteria and multi-alternatives. A structured approach to multi-criteria decision-making requires the following steps (Benjamin, 2009):

a. Setting the expected goals and criteria
b. Identifying needs that must be met
c. Defining the boundaries associated with and affected by the decisions
d. Making a choice or alternative decision
e. Applying an appropriate multi-criteria decision model
f. Making the final decision

2.4 Delphi Method

The Delphi method was introduced by Olaf Helmer, Norman Dalkey, and Nicholas Rescher on the RAND project in 1950-1960. Since then, this method has been used with many modifications and reformulations. The Delphi method is appropriate for gathering opinions for the

formulation of visions and objectives based on the following considerations (Ciptomulyono, 2000):

a. Its ability to accommodate individual subjective opinions iteratively and controlled feedback in the assessment of group responses

b. Anonymous nature of the withdrawal of the survey allows the expression of opinions freely without affecting the domination over someone's influence having higher authority in generating ideas.

c. All respondents are actively involved from the beginning of the survey process, so it will be easier to find the most promising solutions and provide high effectiveness in implementing decisions.

Traditionally, the Delphi approach controls response to feedback from participants by creating a panel consisting of some survey rounds. Then, it develops and updates a relevant questionnaire. Each time a response is taken from the survey round, the marketing sector will present the summary once again. Therefore, each participant has the same opportunity to re-evaluate each response compared to the response from his group to anticipate response evaluation in the next survey round (Ciptomulyono, 2000).

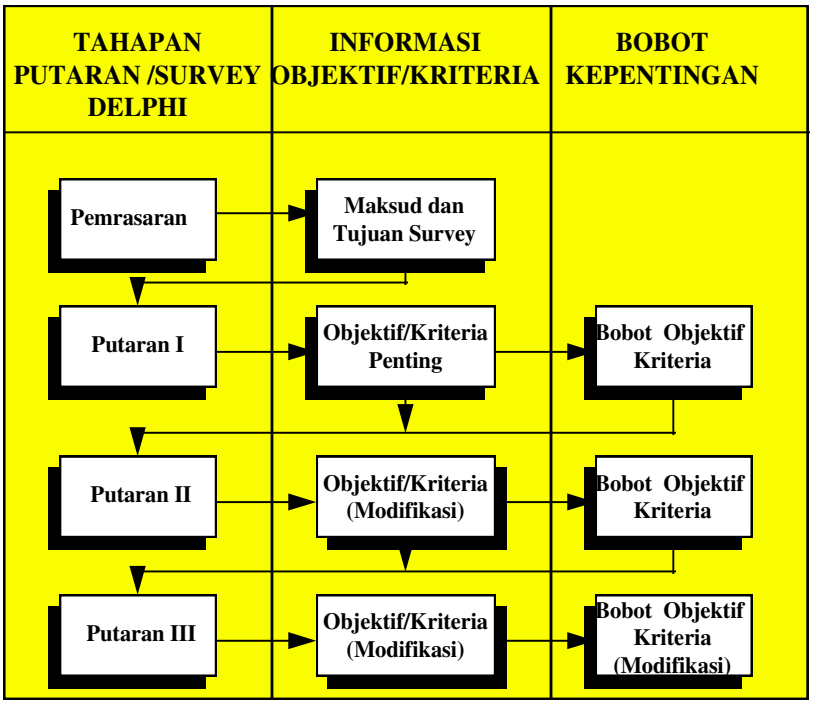


Figure 1 Delphi Method for Withdrawing Objectives Opinion /Criteria (Ciptomulyono, 2001)

There are some instructions for iteration/round of the questionnaire in the Delphi process (Hsu, 2007):

a. Round 1: it begins with an open-ended questionnaire. The questionnaire is used as a survey instrument in round 2.

b. Round 2: Delphi panelists receive a second questionnaire containing items of the information obtained in round 1. Usually, they will score or rank to set a list of priorities.

c. Round 3: Delphi panelists receive a questionnaire containing the list and rankings obtained from round 2 and revise their decisions or provide reasons if they remain out of consensus. In this round, the panelists can make further clarifications and decisions. However, there are usually little changes in consensus.

d. Round 4: is the final round, where the panelists receive the final list and ranking. Here, they have the last chance to change their decisions.

2.5 Analytical Hierarchy Process (AHP) Method

The Analytical Hierarchy Process (AHP) is a part of the Multi-Criteria Decision Making (MCDM) developed by Saaty. AHP is an analytical method to create a problem model that is structure-less and can be used to solve quantitative problems and others that demand specific judgments.

In the last ten years, the AHP approach has commonly been applied as a decision support tool for many problems (saaty, 1995). Integration of the AHP with other optimization approaches such as multi-objective and goal programming is useful for broader practical technical and management applications such as environmental, energy, and information system problems (Ciptomulyono, 1998). In solving the problems, some basic principles must be understood, namely:

a. Decomposition is the main principle in the AHP method that describes or solves a problem into its simplest elements manifested in a hierarchical form after defining the problem.

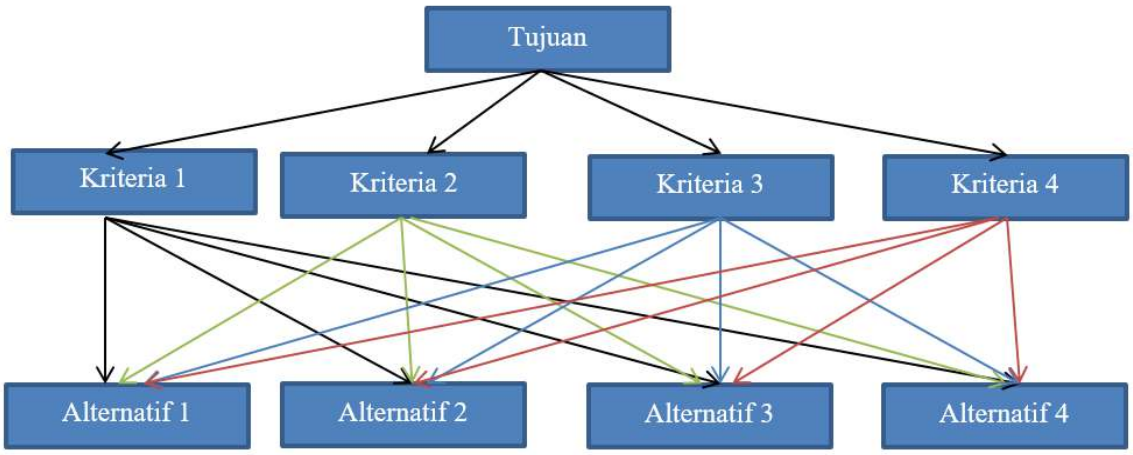


Figure 2 Decision-Making Hierarchical Structure

b. Comparative Judgment aims to assess the relative importance of two elements at a certain level based on their higher level. The assessment results are displayed in a pairwise comparison matrix. It is a matrix that contains the preference levels of some alternatives for each criterion. The preference scale is 1 to 9.

Table 2 Saaty Scale

Level of Importance	Definition
1	Just as important as the others

3	Having moderate importance to others
5	Having stronger importance than others
7	Having very strong importance over others
9	Having extreme importance over others
2,4,6,8	The value between two adjacent ratings

c. Synthesis of Priority is done by using the eigenvector method to obtain the relative weights for the elements of decision-making.
d. Consistency has two meanings. The first is that similar objects can be grouped according to their uniformity and relevance. The second one is the level of relationship among the objects based on specific criteria

2.6 Integration of Delphi Method with Analytical Hierarchy Process (AHP)

The Delphi method before the AHP approach aims to generate criteria and sub-criteria. A pairwise comparison matrix is prepared using the AHP method (Ciptomulyono, 2000):

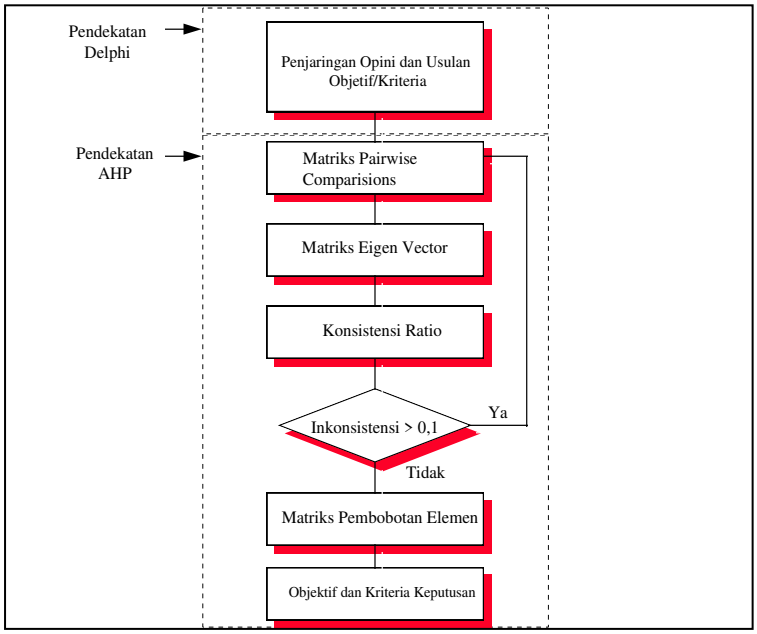


Figure 3 Integration of Delphi Method with AHP Approach (Ciptomulyono, 2001)

The Delphi method is based on the respondents' subjective opinions. It can formulate the overall objectives or criteria disclosed more flexibly. The results of the polling or opinions from the Delphi approach have not been tested for the consistency of their answers. Therefore, the AHP method can complement the proposed procedure for testing the consistency of individual and group opinions, and priority weighting of the interests of each criterion/objective.

3. METHODS

3.1 Setting Criteria and Sub-criteria

The Delphi method consists of three rounds of the survey. Each round has a specific target explained as follows:

a. Round 1: This round aims to get significant criteria for selecting alternative shipyard repairs for ferry ships. The proposed criteria are based on field observations and literature reviews, and they should be further corrected. The opinions are recorded using a Likert scale with the following options:
   - SS: Strongly Agree (score 5)
   - S: Agree (score 4)
   - N: Doubtful (score 3)
   - TS: Disagree (score 2)
   - STS: Strongly Disagree (score 1)

b. Round 2: it aims to obtain important sub-criteria for selecting alternative shipyard repairs using the same Likert scale as Round 1.

c. Round 3: determining the weights of the approved important sub-criteria using a Likert scale

The initial alternative was a shipyard located in the East Java province having repair facilities. There were two state-owned shipyards and nine private ones placed in Gresik, Madura, Lamongan, and Surabaya. After determining the alternative, the most important thing is to set the criteria proposed in the Delphi method. The following table describes the proposed criteria.

Table 4 Proposed Criteria

Nu	Proposed criteria	Code
1	Ship Delivery Time	K1
2	Shipyard Experience	K2
3	Shipyard Facilities	K3
4	Shipyard quality or certificate	K4
5	Price and payment system	K5
6	Shipyard Type	K6

To set the criteria and sub-criteria, the Delphi method is implemented and helped by 8 (eight) expert respondents.

3.2 Criteria and sub-criteria weighting

After setting the criteria and sub-criteria, the next step is weighting them using the AHP pairwise comparison. Before, a hierarchical structure is made by setting a general goal, namely the selection of repair shipyards. Then, a pairwise comparison matrix is also drawn to describe the relative contribution or influence of each element on the set goals or criteria. The next step is to check the consistency of the hierarchy and find out Consistency Index (CI) value using the following formula:

$$CI = \frac{\lambda max - n}{n-1} \qquad (1)$$

Where CI is the Consistency Index, n is the number of elements, and λ_{max} is the sum divided by the number of existing criteria.

The next step is calculating the Consistency Ratio (CR) using the following formula:

$$CR = CI / IR \quad (2)$$

CR is the consistency ratio, CI is the Consistency Index, and RI is the Random Index. The random index (RI) is obtained by using the random consistency index in the table below.

Table 4 random table consistency index

N	1	2	3	4	5	6	7	8	9	10	N
IR	0,00	0,00	0,58	0,90	1,12	1,24	1,32	1,41	1,45	1,49	IR

The sensitivity analysis in the multi-criteria decision-making process is crucial to ensure the robustness of the final decision. In this research, the sensitivity analysis is conducted by changing the weights of the dominant sub-criteria.

4. RESULTS

4.1 Delphi data analysis

The first round shows that in Table 5, the respondents strongly agree with the proposed criteria. Also, some respondents propose others like Geographical Conditions, Application of Occupational Health and Safety (K3), Trust & Services, Certified Subcontractors, and Crews' Service Facilities (mess/dormitory). The proposed additional criteria from expert respondents are grouped into the existing criteria so that some are classified as sub-criteria in the second round. Meanwhile, the "Geographical Conditions" acts as the new one in the next step.

Table 5 Result of Criteria Selection

Nu.	Criteria	Score	Note
A	Ship delivery time	98%	Strongly agree
B	Experience	85%	Strongly agree
C	Facility	95%	Strongly agree
D	Quality & Certificates	85%	Strongly agree
E	Price and Payment	95%	Strongly agree
F	Dock type	80%	Strongly agree

The results of round 1 are given to all respondents, and the researchers submit a questionnaire containing the proposed sub-criteria. The proposed criteria still use a Likert scale with descriptive responses. Of the 27 proposed sub-criteria, 20 show Strongly Agree, 3 show Agree, and 4 show Neutral or Fair. Then, 23 of the 27 proposed sub-criteria are selected for the shipyard repairs, and the rest criteria are excluded from the sub-criteria.

The sub-criteria that state Neutral or Fair position and are excluded are B-2 (Less Experience), E-1 (Expensive), E-3 (Cash), and G-2 (Shallow). Sub-criteria B-2 (less experienced) and G-2 (Shallow) are less important because they are not comparable to others. According to the

respondents, the sub-criteria E-1 (Expensive) and E-3 (Cash) are combined with others in the "Price and Payment" criteria to become sub-criteria E-2 (offered price) and E-4 (Payment system).

4.2 Data Analysis using Analytical Hierarchy Process (AHP)

Using the Delphi method, the data analysis shows generates 7 (seven) criteria and 23 (twenty-three) sub-criteria for selecting the shipyard repairs. The hierarchical structure for selecting repair shipyards with alternatives is explained in the picture below.

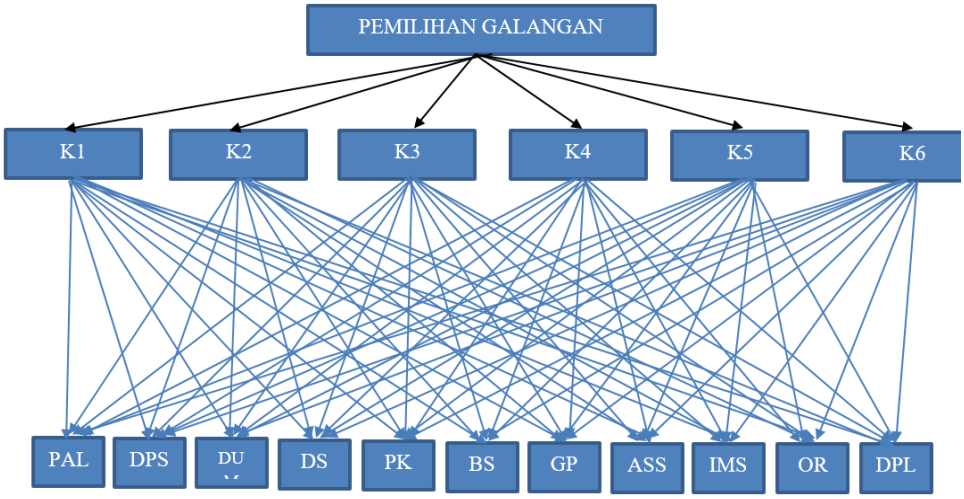


Figure 1 An example of a figure

The assessment for weighting the criteria of the best shipyard repairs uses the Saaty scale. The results are then processed using the AHP method with pairwise comparison, and the final values are presented in the following table:

Table 6 Summary of the weighting values of the repair shipyards selection criteria

No.	Criteria	weight	Ranking
A	Ship delivery time	0.343	I
B	Experience	0.119	IV
C	Facility	0.066	V
D	Quality & Certificates	0.133	III
E	Price and Payment	0.269	II
F	Dock type	0.029	VII
G	Geographical condition	0.041	VI

The table above shows that "Time of delivery" occupies the priority with a weight value of 0.343 followed by the "Financial" as the priority II with a weight value of 0.269, and "Quality & Certificates held" in the third priority with a weight value of 0.133, and "Dock Type" occupies priority VII with a weight value of 0.029.

The assessment results are processed using the AHP method with pairwise comparison. The weighting values are presented in the following table:

Table 7 Summary of the weight calculation for shipyard repair selection sub-criteria

Nu.	Sub-criteria	Partial Weight	Global Weight	Ranking
1	Completion of Additional Jobs	0.105	0.036	V
2	Fast	0.637	0.218	I
3	On-time delivery	0.258	0.088	III
4	Experience	0.167	0.020	X
5	Trust & Services	0.833	0.099	II
6	Crew' Service Facilities (mess/dormitory)	0.081	0.005	XX
7	Lifting Equipment	0.398	0.026	VIII
8	Workshop	0.348	0.023	IX
9	Warehouse	0.173	0.011	XV
10	Application of Occupational Health and Safety (K3)	0.416	0.055	IV
11	Welding Shop Approval from Class	0.064	0.009	XVI
12	Welder Certificate from Class	0.145	0.019	XI
13	Material certificate	0.23	0.031	VII
14	ISO Certificate	0.098	0.013	XIII
15	Certified subcontractor	0.047	0.006	XVIII
16	Price offered	0.333	0.013	XIV
17	Payment system	0.667	0.006	XIX
18	Graving dock	0.483	0.014	XII
19	Floating dock	0.276	0.008	XVII
20	Slipway	0.141	0.004	XXII
21	Balloon System	0.101	0.003	XXIII
22	Tidal Effect	0.125	0.005	XXI
23	Depth	0.875	0.036	VI

The table shows that the "Fast" sub-criteria on the "Delivery time" criterion places the priority with a weight value of 0.218. The "Trust & Services" sub-criteria on the "Experience" criteria becomes priority II with a weight value of 0.099. The "On Time" sub-criteria with a weight value of 0.088, and the "Balloon System" sub-criteria on the "docking type" criteria as the priority XXIII with a weight value of 0.003.

4.3 Analysis of the selection of repair shipyards for ferry ships

After having the respondents' values, they are multiplied by the weight of each sub-criteria and then added up with all the values in each sub-criteria. The final scores are presented in the table below.

Table 8 Final weight of alternative shipyard repairs

Nu.	Alternative Shipyard	Weight	Ranking
1	A	27.39	VII
2	B	21.88	XI

3	C	29.09	III
4	D	29.13	II
5	E	28.03	V
6	F	25.05	X
7	G	29.13	II
8	H	25.57	IX
9	I	30.07	I
10	J	27.97	VI
11	K	28.88	IV
12	L	27.02	VIII

Based on table 4.16 above, it can be seen that shipyard I has the first rank with a weight value of 30.07, D and G have the same score (second) with a value of 29.13, and C is number three with a value of 29.09. Meanwhile, B has the lowest score of 21.88.

6. CONCLUSIONS

The Delphi analysis procedure results in 7 (seven) criteria; Ship delivery time (delivery), Experience, Facilities, Quality & Certificates, Financial, Dock type, and Geographical Condition. The analysis also generates 23 (twenty-three) sub-criteria, namely: Completion of Additional Jobs, Fast, Timely, Experienced, Trust & Services, Crews' Service Facilities (mess/dormitory), Lifting Equipment, Workshop, Warehouse, Application of Occupational Health and Safety (K3), Welding Shop Approval from Class, Welder Certificate of Class, Certificate of material, Certificate of ISO, Certified subcontractor, Offered Price, Payment system, Graving dock, Floating dock, Slipway, Balloon System, Tidal Affected, and Depth.

The analysis using the Weight Sum Method results in shipyard repair priorities with the following rating: Shipyard A is 27,388, Shipyard B is 21,882, Shipyard C is 29,093, Shipyard D is 29,130, Shipyard E is 28,034, Shipyard F is 25,046, Shipyard G is 29,130, Shipyard H is 25,566, Shipyard I is 30,068, Shipyard J is 27,967, Shipyard K is 28,882, and Shipyard L is 27,021. From these findings, Shipyard I occupies the first position, shipyard D the second, and shipyard G in the third place.

The sensitivity analysis test shows that the criterion of "delivery time" has the greatest influence on the selection of repair shipyards for the ferry ships.

REFERENCES

Benjamin, C., 2009. *Engineering for Business Theory and Cases.* Maryland: University Press of America, Inc.

Celik, M., 2009. Fuzzy Axiomatic Design-based Performance Evaluation Model for Docking Facilities in Shipbuilding Industry: The Case of Turkish Shipyards. p. Applications 36:599–615.

Ciptomulyono, U., 1998. *Integration of Analytic Hierarchy Process and Goal Programming Approach For Waste Management Strategy.* Quebec City-Canada, (A paper presented) in "The Third International Conference on Multi-Objective Programming and Goal Programming"

Ciptomulyono, U., 2000. The Delphi Method and AHP Model for Determining Priority Energy Policy Objective. *Indonesian Science Communication,* 3(1).

Ciptomulyono, U., 2001. Integrasi Metode Delphi dan Prosedur Analisis Hierarkis (AHP) Untuk Identifikasi dan Penetapan Prioritas Objektif/Kriteria Keputusan. *Jurnal Iptek,* Volume 12, pp. 37 - 47.

INDONESIA, M. P. R., 2017. PENYELENGGARAAN ANGKUTAN PENYEBERANGAN. Volume NOMOR PM 104, p. 4.

Heger, R., 2005. *Dock master Training Manual, Preparation of a Pumping Plan.* Heger Dry Dock ed. s.l.:Inc.@.

Nurwanti, R., 2016. Analisa Peningkatan Kualitas Layanan Jasa. *JURNAL TEKNIK ITS Vol. 5,* 2337-3539(1), pp. 2301-9271.

Siallagan, M., 2005. Studi Peningkatan Kualitas Layanan Jasa Reparasi di Industri Perkapalan. *JURNAL TEKNIK ITS Vol. 1.*

Storch, R., 1995. *Ship Production.* s.l.: The Society of Naval Architects and Marine Engineers.

Saaty, T., 1995. How To Make A Decision: The Analytic Hierarchy Process. *Interfaces,* Volume 24, p. 6.

WATER CONSERVATION ALTERNATIVES FOR GREEN OFFICE BUILDING IN INDONESIA

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ABSTRACT

The issue of sustainability is currently a focus as global warming continues to increase, and ecological conditions are getting worse. One of them is related to the clean water crisis which is accompanied by the increasing demand for water and the population. Around 18 million Indonesians lack of clean water and 20 million do not have access to better sanitation facilities. Green building is a building with a sustainable concept, which can be an effective solution to provide benefits for the environment as well as for the building users themselves. The application of water conservation in the design of green buildings can be a solution to meet the increasing water needs and the current clean water crisis. This paper proposes some alternatives that can be implemented in office buildings with the green building concept, as an effort to save clean water and recycle water. The alternatives includes designing and planning a rainwater recycling system, designing and planning a gray water recycling system for flushing, and use of water-saving features in the building. In addition, irrigation systems and use of water-saving features for landscape watering can also be implemented for efficient water use so that water conservation can be done.

Keywords:Green building, Indonesia, Office building, Water Conservation.

1. INTRODUCTION

United Nations Environment Programme (2020) reported that the building sector is a sector that is very influential on energy consumption and production of CO2 emissions. In 2019, it was recorded that the building sector used 35% of total global energy, it is the largest percentage compared to other sectors, and became the largest contributor to CO2 emissions, at 38%. According to GBC Indonesia (2014) buildings are one of the environmental components that have a significant ecological footprint. MacNaughton, et al (2018) states that buildings have an impact on humans in two ways, a direct effect on human health inside the building, and also indirectly on human health through the use of resources and their contribution to environmental pollution.

Indonesia's Ministry of Environment and Forestry (2020) indicated that the threat of climate change disaster has become a major concern of the international community, including in Indonesia. As an archipelagic country that has a diversity of natural resources, high biodiversity, and a very high population, Indonesia is very vulnerable to the negative impacts of increasing concentrations of greenhouse gases (GHG) in the atmosphere.

World Resources Institute (2022) concluded that clean water is important for human health, agriculture, industry, and energy production. However, due to unsustainable management and climate change, the world's water system face some serious threats. 3.5 billion people are

predicted lack of water by 2025, while the water demand is projected to grow to 30% by 2050. Water-related conflicts and political instability are on the rise, and exacerbated by the problem about climate change, intensifying floods and droughts, change of precipitations patterns and fueling sea level rise.

Water.org (2022) concluded that Indonesia is the fourth most densely populated country in the world with a population of 273 million people. Jakarta, the capital city of Indonesia continues to grow, but most people still face the problem such as far, contaminated or expensive water source, and unaffordable household sanitation. Also 18 million people in Indonesia lack access to safe water. Jakarta faces several challenges related to water management and efficiency, despite having sufficient sources through rivers and rainfall. DKI Jakarta Provincial Government (2012) said that these challenges include insufficient clean water supply, flooding and land subsidence due to overexploitation of groundwater. Das, et al (2015) found that all the fresh water resources will be exhausted, and the world in the future will experience water scarcity. So the activities to conserve water and prevent water pollution need to be carried to over come the water crisis problem.

U.S. Environmental Protection Agency (2016) stated that one solution to overcome these environmental problems is to apply the concept of sustainable development. Green building is also known as sustainable building or high performance building. According to GREENSHIP, the assessment tool for green building by GBCI (Green Building Council Indonesia), six criteria for green building are include Appropriate Site Development (ASD), Energy Efficiency and Conservation (EEC), Water Conservation (WAC), Material Resources and Cycle (MRC), Indoor Health and Comfort (IHC), and Building Environment Management (BEM). In this paper focuses on the water conservation (WAC) aspect of green buildings and identifying what alternative can be done to fulfill it.

GBC Indonesia (2014) indicated that water conservation is one of the categories that assessed in green building. This category is intended to promote the importance of saving water and also as a water saving measure for water use in buildings. Things that can be pursued for this category are to design and plan water systems in the form of installation of meters and installation of high-efficiency water features, installation of water recycling units, installation for rainwater and alternative water system, and selection of efficient landscape irrigation system. According to GREENSHIP, water conservation is the criterion with the 2nd largest point being considered after energy efficiency and conservation (EEC).

2. LITERATURE REVIEW

Based on the Regulation of the Minister of Public Works and Public Housing of the Republic of Indonesia Number 21 (2021) concerning Performance Assessment of Green Buildings, the definition of a building is a physical form resulting from a construction work that is integrated with its domicile, partially or wholly located above and/or in the land and/or water, which functions as a place for humans to carry out their activities, either for housing or residence, religious activities. , business activities, social activities, culture, and special activities.

The definition of green building stated by World Green Building Council (2016) is a building which, in its design, construction or operation, reduces or eliminates negative impacts, and can create positive impacts, on the climate and natural environment. And based on the Regulation of the Minister of Public Works and Public Housing of the Republic of Indonesia Number 21 of 2021 concerning Performance Assessment of Green Buildings, The definition of a Green Building, as known as BGH (in Indonesia), is a Building that meets the Technical Standards for Buildings and has a significantly measurable performance in saving energy, water, and other

resources through the application of BGH principles in accordance with the functions and classifications in each stage of its implementation.

The concept of sustainability, based on research by Mahdavinejad, et al (2014), is something that is comprehensive, because the subject is complex. Sustainability is very important for all living things, because it is directly related to survival. Therefore, at this time the principle of sustainability is increasingly becoming a major consideration in building practitioners, policy makers, and industry, because the world is currently moving towards green construction. When buildings have a green concept, the impact of the energy contained and greenhouse gas emissions becomes very important. The ASTM standard (2005) states that sustainability is an ideal practice that has an impact on balance, with efforts to protect and enhance the health, safety and well-being of building occupants, neighbors and communities, which contributes to a positive quality of life for present and future generations, reduce negative impacts on the environment, and increase positive impacts on ecosystems, biodiversity, and balance the use of renewable, non-renewable and enduring energy, optimizing the direct economic impact, which is related to the material, land and labor life cycle costs/benefits directly related to the building, and the indirect economic impact, which is related to the external costs/benefits felt by those who are indirectly affected by the building.

Kats & E (2003) concluded that green building or sustainable building is closely related to the environment, consumption of energy & resources, impacts on humans (quality and health of the work environment), financial impacts (cost effectiveness from the point of view of financial returns), and the world in general or wider problems (such as groundwater renewal and global warming which until now has been a concern of the government). General components of green building from research from Ragheb, et al (201) are namely a focus on energy efficiency (in some cases using renewable energy), efficient use of water, use of environmentally friendly building materials and specifications, minimization of waste and toxic chemicals produced in building construction. as well as when the building is in operation, good indoor air quality, and pay attention to "smart growth" and sustainable development.

Based on the International Energy Agency (2008), green buildings or sustainable buildings in addition to improving health and the environment, also have the characteristics of increasing energy and water efficiency, reducing consumption of materials and natural resources. DKI Jakarta Governor Regulation Number 38 (2012) stated that water conservation is an effort to streamline the use of water for a need so that water waste can be avoided. One of the goals of green buildings is to reduce water use and maintain water quality. To achieve the goal of water conservation, things that can be done are the installation of double pipes for water recycling in toilets and used car wash water, the use of water-saving bathroom appliances and fixtures. In addition, from Das, et al (2015) it can also use a rainwater harvesting system (PAH) or often referred to as rainwater harvesting, water recycling systems, and others.

Water conservation based on GBC Indonesia (2014) is one of the main focuses of building management. Things that need to be done to meet the water conservation category include the design and planning of water systems in the form of metering, installing high-efficiency water features, procuring water recycling units, utilizing rainwater and using alternative water sources, and using an efficient landscape irrigation system. These alternatives are carried out as an effort to save and reduce the use of clean water from the ground and PDAM. In the Jakarta green building user guide, volume 5 related to water efficiency (2012), there are several ways to reduce water consumption from primary sources (PDAMs and wells) in buildings, namely the use of efficient equipment, sub-metering from all main water consumption systems, recycling used water, cooling tower water efficiency, utilizing air conditioning condensate water, and utilizing rainwater.

Table 1 are alternatives to meet the water conservation category, some of which are requirements that must be met based on DKI Jakarta Governor Regulation No. 38 of 2012 and the GREENSHIP assessment tool for New Buildings version 1.2.

Table 1. Alternatives for Water Conservation Based on DKI Jakarta Governor Regulation No. 38/2012 and GREENSHIP New Building v1.2

Criterias	DKI Jakarta Governor Regulation No. 38/2012	GREENSHIP New Building v1.2
Water metering	required	required
Water calculation		required
Water fixtures	required	
Alternatives water resource	required	
Rainwater harvesting	required	

3. METHODS

This study uses a qualitative method using a case study of office building in Jakarta, Indonesia. The qualitative methods are used to analyze the green building potential of the object. Data were collected through interviews and literature studies. Interviews were conducted with green professionals from GBCI and the project manager of the building. Then the literature study was reviewed from the guidelines for green building assessment tools, GREENSHIP New Building Version 1.2, from GBCI, the guidelines for green buildings in Jakarta based on the governor's regulation no. 38/2012, and from studies related to water conservation aspect of green building.

4. RESULTS

Based on the GREENSHIP by GBCI (2014) in water conservation (WAC) category, there are two criteria that must be met, it is water sub-metering and water calculations. The purpose of sub-metering installation is to monitor water use so that it can be the basis for implementing better water management. Installation of sub-metering needs to be placed at certain locations in the water distribution system, to measure the output of clean water sources (PDAM or ground water), monitoring the output of the recycled water system, measure the additional output of clean water if the recycling system is not sufficient. Then the aim of water calculations are to determine the simulation of water use when the building is operating. The other criteria that will be assessed in GREENSHIP by GBCI are water use reduction, water fixtures, water recycling, alternative water resource, rainwater harvesting, and water efficiency landscaping.

Meanwhile refers to the Jakarta green building user manual based on governor's regulation No. 38/2012, main requirements for water conservation are using of water efficient tools, alternative water source on site, rainwater harvesting system, and the installation of water sub-metering. Some of the most effective ways to reduce clean water consumption in building are use of water efficient fixtures, water sub-metering, recycling used water, efficiency water of cooling tower, reuse water from AC condensate, and reuse water from rain.

So that below are scenarios that combine alternatives that can be planned and carried out to fulfill water conservation categories in green office building.

Table 1. Alternative Scenarios for Water Conservation (WAC)

Alternative	Scenario 1	Scenario 2	Scenario 3	Scenario4
Water metering (WAC P1)				
- Installation sub-water metering	√	√	√	√
Water calculation (WAC P2)	√	√	√	√
Water reduction (WAC 1)	√	√	√	√
Water fixtures (WAC 2)	√	√	√	√
Water recycling (WAC 3)				
- Installation of recycle water tank		√		√
- Installation of WTP (Water Treatment Plant)		√		√
- Installation of STP (Sewage Treatment Plant)		√		√
Alternative water resources & Rainwater Harvesting (WAC 4 & 5)				
- Installation raw/rain water tank	√	√	√	√
- Installation clean water tank	√	√	√	√
- Installation clean water roof tank	√	√	√	√
Water efficiency landscaping (WAC 6)				
- Installation sprinkler			√	√
- Installation digital timer			√	√
- Installation solenoid valve			√	√

In the first scenario, the alternative that is fulfilled is an alternative that is a mandatory requirement from the aspect of water conservation, it is water sub-metering, water calculations, the addition of efficient use of water features, the installation of raw/rain water tank, clean water tank, and clean water roof tank. According to Alwisy, et al (2018) Water sub-metering can contribute to water conservation aspect, because it can be used to detect and trace in the case of significant water loss. Water features used in the form of faucets/sanitary equipment must not exceed the maximum discharge and flushing capacity according to the specified standards. Then the volume of the rainwater tank must be 0,05 meters x ground floor area. Infiltration wells and infiltration ponds must be provided according to governor regulation no. 20/2013 concerning "infiltration wells" which depend on the basic area of the building. Based on research by Campisano & Modica (2014) the effect of rainwater harvesting tanks on water use were simulated, and show potential savings between 25% to 50%.

Then in the second scenario, completing the first scenario with an additional installation for a water recycling system. This water recycling system consists of a recycle water tank, installation water treatment plant (WTP), and installation sewage treatment plant (STP).

Water recycling installation is not a mandatory requirement in the water conservation aspect, so that in the third scenario, the water recycling category is assumed not to be fulfilled, and is replaced by meeting the water efficiency landscaping category. In this category, several things that can be done are the installation of sprinklers, digital timers, and solenoid valves. In the use of a sprinkler system, water is flowed in the form of a spray using overhead sprinkler. Based on research by Koech & Langat (2018) Pressurized irrigation method, i.e. use of sprinkler system, is generally less labor intensive and have more efficient use of water.

The forth scenario is a combination of second and third scenario, what can be done other than installation of sub-water metering, water calculation, water reduction, and installation of water fixtures, are combination between installation for water recycling, use of water resources & rain water harvesting, and water efficiency landscaping.

6. CONCLUSIONS

Based on the study, it can be concluded that tsome efforts should be paid to meet water conservation aspects based on governor regulations and GBCI standards are: water metering, water calculation, water reduction, water fixtures, and installation of rain/raw water tank (included in the alternative water resources & rainwater harvesting category). Another alternatives that can be done to fulfill water recycling criteria is installation of recycle water tank, WTP, and STP. While installation of sprinkler, digital timer, and solenoid valve can be done to fulfill water efficiency landscaping criteria. Quantitative alternatives need to be conducted to witness the proposed alternatives.

REFERENCES

Alwisy, A., BuHamdan, S., & Gül, M. (2018). Criteria-based ranking of green building design factors according to leading rating systems,. *Energy and Buildings, 178*, 347-359. doi:https://doi.org/10.1016/j.enbuild.2018.08.043

ASTM. (2005). *Standard Guide for General Principles of Sustainability Relative to Buildings.* West Conshohocken: ASTM International.

Campisano, A., & Modica, C. (2014). Selecting Time Scale Resolution to Evaluate Water Saving and Retention Potential of Rainwater Harvesting Tanks. *Procedia Engineering*, (pp. 218-227).

Das, O., Bera, P., & Moulick, S. (2015). Water Conservation Aspects of Green Building. *IJRET: International Journal of Research in Engineering and Technology, 04*(13), 75-79.

GBC Indonesia. (2014). *Perangkat Penilaian Bangunan Hijau untuk Bangunan Baru Versi 1.2.* Jakarta: Green Building Council Indonesia.

Kats, G., & E, C. (2003). *The Cost and Financial Benefits of Green Buildings.* A Report to California's Sustainable Building Task Forces.

Kementrian Lingkungan Hidup dan Kehutanan. (2020). *Laporan Inventarisasi Gas Rumah Kaca (GRK) dan Monitoring, Pelaporan, Verifikasi (MPV).* Jakarta: Kementerian Lingkungan Hidup dan Kehutanan, Direktorat Jenderal Pengendalian Perubahan Iklim.

Koech, R., & Langat, P. (2018). Improving IrrigationWater Use Efficiency: A Review of Advances, Challenges, and Opportunities in the Australian Context. *Water, 10*(12).

MacNaughton, P., Xiaodong, C., Buonocore, J., Cedeno-Laurent, J., Spengler, J., Bernstein, A., & Allen, J. (2018). Energy Savings, Emission Reductions, and Health Co-benefits of The Green Building Movement. *Journal of Exposure Science & Environmental Epidemiology*, 307-318.

Mahdavinejad, M., Zia, A., Larki, A. N., Ghanavati, S., & Elmi, N. (2014). Dilemma of green and pseudo green architecture based on LEED norms in case of developing countries. *International Journal of Sustainable Built Environment*, 235-246.

Menteri Pekerjaan Umum dan Perumahan Rakyat Republik Indonesia. (2021). *Peraturan Menteri Pekerjaan Umum dan Perumahan Rakyat Republik Indonesia Nomor 9 Tahun 2021 Tentang Pedoman Penyelenggaraan Konstruksi Berkelanjutan.* Jakarta: Menteri Pekerjaan Umum dan Perumahan Rakyat Republik Indonesia.

Pemerintah Provinsi DKI Jakarta. (2012). *Panduan Pengguna Bangunan Gedung Hijau Jakarta.* Jakarta: Pemerintah Provinsi DKI Jakarta.

Ragheb, A., El-Shimy, H., & Ragheb, G. (2016). Green Architecture: A Concept of Sustainability. *Procedia-Social and Behavioral Sciences* (pp. 778-787). Elsevier.

U.S. Environmental Protection Agency. (2016). Retrieved from https://archive.epa.gov/greenbuilding/web/html/about.html

United Nations Environment Programme. (2020). *2020 Global Status Report for Buildings and Construction: Towards a Zero-emission, Efficient and Resilient Buildings and Construction Sector.* Nairobi: GlobalABC.

Water.org. (2022). *Our Impact*. Retrieved from Water.org: https://water.org/our-impact/where-we-work/indonesia/

World Green Building Council. (2016). Retrieved September 1, 2021, from https://www.worldgbc.org/what-green-building

World Resources Institute. (2022). *Ensuring Prosperity in a Water-stressed World*. Retrieved from wri.org: https://www.wri.org/water

ANALYSIS OF THE JAKARTA-BANDUNG HIGH SPEED TRAIN PROJECT IN A STATE-OWNED CONSTRUCTION COMPANY PT XYZ

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ABSTRACT

The development of Indonesian infrastructure projects has increased very rapidly over the last decade. This increase is related to the number of projects, the magnitude of the project value, and the complexity of the value of the infrastructure project. One of the government's megaprojects is the Jakarta-Bandon High Speed Rail Infrastructure Project, a national strategic project. The value of this project is very large at 70 trillion rupiah, and the construction period is 3 years. The larger and more complex the project, the greater the risks it poses. Project risks arise from the feasibility study phase to planning and construction. PTXYZ, the only state-owned construction company involved in the implementation of the Jakarta-Bandung high-speed rail project, also bears enormous risks in its implementation. These risks impact increased completion times and project costs. This study uses failure mode and effects analysis (FMEA) and analytic hierarchy process (AHP) methods to identify risks and develop prioritized risk mitigation measures to avoid project risks. increase. Risk mitigation is also needed to predict the risks that occur during a project. By analyzing the risks that arise and how you mitigate them, you can manage your projects to achieve your project and your company's goals with implication managerial.

Keywords: High Speed Train, Risk Management, Construction Project, Risk Mitigation.

1. INTRODUCTION

Projects are a dynamic and risky area. Risks can affect project productivity, performance, quality, and cost constraints. The lower the potential risk, the more profitable the cost will be from both a development and implementation perspective. The wider the scope of a project, the greater the potential risk of impeding the implementation of the project if not properly managed (Ssempebwa, 2013).

(Wikarsa, 2014) defines risk as a factor that causes loss, damage, or an unexpected condition that can cause loss. All parties involved in a construction project need to prioritize the key risks that affect the profits of the project (Labombang, 2011). Risk management is a systematic approach to risk management that includes all parts of an organizational project. This includes understanding, understanding, action, and communication of risk-related matters (Wikarsa, 2014).

Infrastructure development in Indonesia has increased rapidly over the last decade. Construction of all transportation, harbors, highways and toll roads is widespread in all states and all islands. The PUPR Ministry's budget is also the largest, except for grants and loans from

private organizations and other countries.The phenomenon of the implementation of construction projects at PT XYZ still often occurs in conditions of completion of work that are not as expected.

Based on corporate evaluation data, it shows that there are several things that are delayed in completing work and resulting in late fees, which have an impact on increasing the cost of completing work, as well as increasing the time for completion of work, resulting in an extension of completion time which causes costs at the end of completion of work increased. So to be able to anticipate the risks that will occur, it is necessary to evaluate the application of risk management, through risk mitigation efforts. In this research, the method used is Failure Mode and Effect Analysis (FMEA). The selection is based on the respective functions in which FMEA works to assess potential failures measured from the aspects of impact, chance of occurrence and prevention (Pasaribu, 2021).

One of the trusted projects is the Jakarta-Bandung High Speed Rail Project. This is also a national strategic project. The project is 142km long and is worth up to 70 trillion. One of the contractors for this implementation, PT XYZ, is also one of the representatives of Indonesia working on the construction of the Jakarta-Bandung high-speed railway. During the implementation of this project, there are some risks ranging from small to large. These risks need to be mitigated and identified so that they can be controlled and modified so that they do not affect the completion of the project.

In its implementation, it is divided into several areas: the main line (truck) and the building. With these two types, the station building has a higher risk of delay than the main line. This is due to an increasing number of authorities, delays in payments, financial problems, land acquisition, and many conditions that impede construction. The stations operated by PT XYZ are Halim Station, Karawang Station, and Walini Station. The three stations are at greatest risk and can lead to cost and time overruns. These risks are highly influential, both internal and external, and occur from the design stage to the execution of work in the field. Many of these risks need to be implemented and then mitigated in relation to them. Communication and consultation with the teams involved in the project is required regarding the risks themselves. This requires good planning, qualitative and quantitative risk analysis, and response to potential risk planning. Develop. Make sure the project runs according to its completion goal.

2. LITERATURE REVIEW

Flanagan (2003) states that project management is the planning, organization, direction, and control of corporate resources to achieve specific short-term goals. One of them is FMEA to analyze and identify risks.

FMEA (Failure Mode and Effects Analysis) is a structured process for identifying and avoiding many possible failures. Pasaribu et al. According to (2021), Failure Mode and Effects Analysis (FMEA) is a cyclical risk analysis used to determine how a piece of equipment, equipment / system fails and what the consequences are. It is a method.

Flanagan (2003) states that project management is the planning, organization, direction, and control of corporate resources to achieve specific short-term goals. One of them is FMEA to analyze and identify risks.

The FMEA output is a numerical value of risk priority and can also be defined as a measure of relative risk by multiplying the severity, occurrence, and detection scores (McDermmot et al., 2002). Therefore, to formulate failure mode priorities, you need to calculate severity, occurrence, and detection. Here, the highest RPN value can reflect the cause of the highest risk.

Risk management is a systematic process or step in managing and minimizing or preventing the occurrence of risk. These phases consist of the following elements:

1. Risk identification: All project teams should always be involved in the risk identification process to gain insights into risk mitigation and who is responsible for the risks incurred in implementing the project (PMBOK6).
2. Risk assessment: The result of calculating or grouping the respondents' estimates of the frequency (probability) and magnitude of the impact (result) resulting from the risk.
3. Risk acceptance: Based on the result of frequency mode multiplied by result mode.

Based on (ISO 31000: 2009 – Risk Management Principles and Guidelines), risk management is a coordinated activity carried out to direct and manage an organization to address risk. PT XYZ has developed a comprehensive enterprise risk management framework called Enterprise Risk Management (ERM) to minimize potential losses and optimize profitability to achieve set goals. Did. The Analytic Hierarchy Process (AHP) is one of the decision support methods developed by Thomas L. Saaty (2012). Complex problems can be divided into groups, and the groups are arranged hierarchically, so the problems are more structured and systematically displayed (Efrizon, 2014). The previous surveys that were used as the basis for the survey and were considered relevant to the survey conducted are:

Table 1. Previous Research

Authors 1	Years 2	Titles 3	Result 4	Equality 5	Difference 6
Jonathan	2017	Indonesia-China High Speed Rail Issue Management Strategy Facing Rejection Issues	The issue management strategy carried out by KCIC is to lead to a reactive strategy: deliberate action where PTKCIC uses a strategy to be silent in responding to an issue.	1) Issues faced related to community refusal are included in the current risks.	1) Study at PTKCIC as owner, not contractor. 2) the issue is limited to rejection only
Mehdi Tavakolan	2017	Risk management workshop application: a case study of Ahwaz Urban Railway project	Research examination shows identify critical risks. In addition, it helps organizational staff to have a better understanding of the project environment and provides opportunities to improve teamwork. The two main limitations of the analyzed research were time constraints, and the lack of experience in risk monitoring and control. In addition, this study did not investigate the association between risk.	1) Railway Project.	1) Scope is very limited only time and cost.
Toni Yuri Prastowo, Humiras Hardi Purba	2020	RISK MANAGEMENT ON RAILWAY PROJECTS: A LITERATURE VIEW	Risk identification is carried out through a literature study of international journals by taking data from 30 journals from 100 related journals. Risk analysis based on literature review is divided into: Internal and External Factors. Internal Factors: (1). Technical and (2) Non-technical, External Factors (1). Technical, (2) Non-technical and (3) Legal. From the results of the Pareto chart and pie chart analysis, it can be concluded that the Internal Technical Factor is the most involved in the identification of this risk.	1)Railway project. 2) Mitigation of risks to the project based on Internal and External factors	1) Case studies from planning to maintenance, not just construction.
Krzysztof Kaczorek1,*, Michał Krzemiński1, and Nabi Ibadov1	2020	The problem of choosing risk management methodology at the example of railway construction.	The high cost and specificity of implementation involve high risks during the investment and construction process. Over the years, project management methodologies have been developed that facilitate, inter alia, the management of risk factors. This article reviews the recommendations for risk management across each methodology. In addition, its usefulness has been evaluated in railway construction.	1) Railway Project. 2) Risk management	1) Limited selection of Risk Management Methodology
Yutong Xue	2020	Risk Assessment of High-Speed Rail Projects: A Risk Coupling Model Based on System Dynamics	Based on the system dynamics method, this paper develops a risk coupling model for risk assessment of HSR projects. A list of risk factors was created from a literature review, and relationships were analyzed using case studies. studies and expert interviews. System dynamics equations are built and their parameter obtained by expert evaluation of risk factors. The proposed model is applied to real world HSR project to demonstrate it in detail. This model can evaluate the risk level of an HSR project over the simulation period. In particular, it can identify the key coupling effects that constitute the main risk increase.	1. HSR Project. 2) Risk analysis and selected the most dominant risk.	1) The project site is in China. 2). Overall aspect of all risky work

3. METHODS

In the implementation of this research, it was made based on 4 stages, namely the preparation stage, the collection stage, data processing and analysis and the final stage. The following is a flow chart of the research methods carried out:



Figure 1. Research Flowchart

3.1. Risk Data Collection

Risk data is obtained by checking based on the risk register that has been made and a questionnaire with the related risk PIC (Person in Charge). The risk data obtained are as follows:

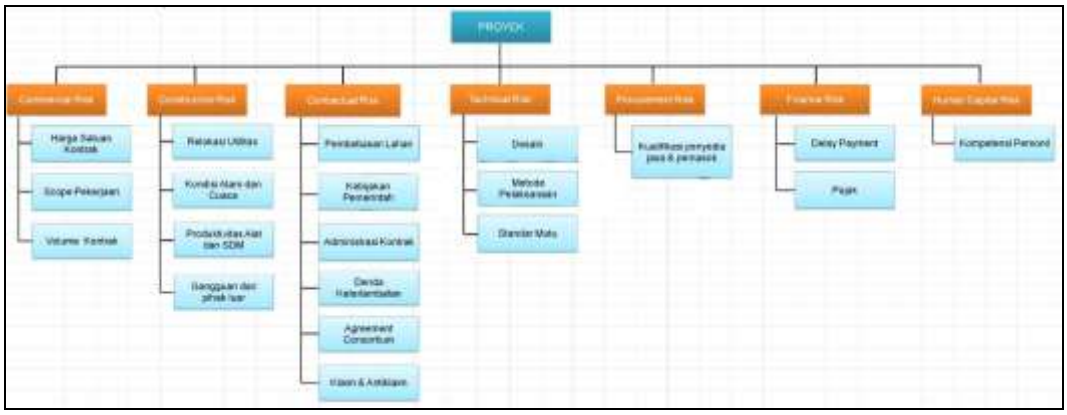


Figure 2. Risk Register High Speed Train Project PTXYZ

3.1.1. Probability and Impact Assessment Data

Risk assessment is carried out using the Qualitative Risk Assessment method through observations from researchers and also assisted by interviews with respondents to provide a broader view when conducting risk assessments. The key persons in question are: Project Manager, Deputy Project Manager, Construction Manager, Commercial Manager, Finance and HC Manager. Multiple probability assessments by mutual agreement.

3.1.2. Risk Assesment

This assessment method qualitatively assesses risk based on the severity (severity) that may occur at the location and probability. The risk level is based on the product of severity and probability (severity x probability).

The risk assessment for the Jakarta-Bandung high-speed rail project is shown in the following table:

Table 2. Risk Assesment Table : Severity x Likelihood

Likelihood of Hazards	Severity of Hazards				
	Insignificant (1)	Minor (2)	Moderate (3)	Major (4)	Fatal (5)
Rare (1)	19	10		9	
Unlikely (2)			1,2,11,12, 13,17,20	15	
Possible (3)		6	3,8,14	16	
Likely (4)		4		5,7,18	
Almost Certain (5)					

3.2 Risk Data Analysis

Data analysis using AHP and FMEA methods. The data used by researchers in preparing risk mitigation planning for the Jakarta – Bandung High-speed train was formulated based on the results of interviews and filling out questionnaires by the project key person.

3.2.1. Data Analysis Using AHP Method

The AHP method is a technique that objectively selects alternative strategies in priority from various alternative strategies that have been formulated. Based on the results of the questionnaire and analysis using Expert Choice version 11, a hierarchy with priority values was generated. This assessment is carried out for 7 risks that occur in the Jakarta – Bandung high-speed rail project.

3.2.2. Data Analysis Using FMEA Method

FMEA is a qualitative bottom-up risk analysis technique used in quality management and risk management to identify, prioritize, and eliminate potential failures/risks from systems, designs or processes with continuous improvement. There are different areas that FMEA uses. Failure mode and effects analysis examines the FMEA methodology, the first of which is improved and implemented.

They learn to calculate risk using the FMEA method, where risk has three components: Severity (S), Occurrence (O) and Detection (D). These components are multiplied to produce a risk priority number (RPN), which is a way of prioritizing failure modes. The FMEA technique aims to determine and prioritize deficiencies in the production process. After determining the risk that has a high risk priority number (RPN), the necessary actions can be taken.

Construction risks are more likely to occur during the construction and post-construction stages, where there is a lack of proper planning in the pre-construction and design stages of the project. This situation makes FMEA a powerful tool as the construction industry can apply during planning and construction as well as other stages.

The risk matrix consisting of occurrence, detection, severity, RPN (Risk Priority Number) indicated in different color scales (green - low, orange – medium, red - high) can be found in the following table:

Table 3. Risk Matrix

		RISK MATRIX									
		Detection (D)									
		1	2	3	4	5	6	7	8	9	10
Occurrence (O)	1	1	4	9	16	25	36	49	64	81	100
	2	2	8	18	32	50	72	98	128	162	200
	3	3	12	27	48	75	108	147	192	243	300
	4	4	16	36	64	100	144	196	256	324	400
	5	5	20	45	80	125	180	245	320	405	500
	6	6	24	54	96	150	216	294	384	486	600
	7	7	28	63	112	175	252	343	448	567	700
	8	8	32	72	128	200	288	392	512	648	800
	9	9	36	81	144	225	324	441	576	729	900
	10	10	40	90	160	250	360	490	640	810	1000
		1	2	3	4	5	6	7	8	9	10
		Severity (S)									

4. RESULTS

After analyzing the data based on several methods above, the results of the risk assessment are obtained.

4.1. Results of data analysis using the AHP method

The results of the synthesis of the overall analysis (overall) of the priority scale of criteria and alternative management objects for the implementation of the Jakarta-Bandung high-speed rail infrastructure development with AHP are as follows:

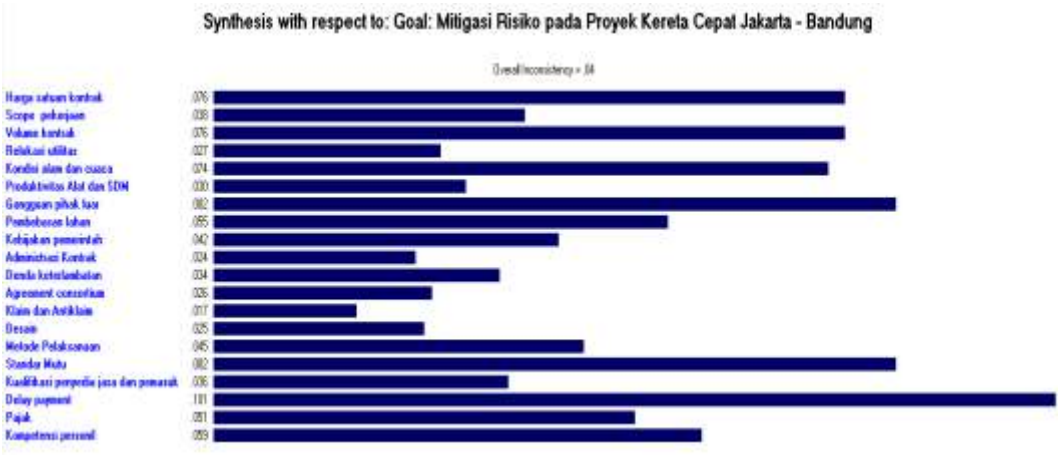


Figure 3. Risk Mitigation using AHP Method

From these data, it can be seen that the three main priorities in risk mitigation of the implementation of the Jakarta-Bandung high-speed rail infrastructure development are as follows:

a. Delay payment (weight 0.101)
b. External interference (weight 0.082)
c. Quality standard (weight 0.082)

4.2. Results of data analysis using the FMEA method.

In the risk matrix, critical risk factors are shown in red, which have an RPN value higher than 400. The determination of the threshold value may differ according to the user. The threshold value is determined as 400, subject to subjective considerations. Other RPN values are also shown in different color scales (green - low, orange - medium). The value of the Risk Priority Number for each risk factor is determined according to: the three parameters can be seen in the following table:

Table 4. RPN Result Table using FMEA

Failure 1		S 2	O 3	D 4	RPN 5
Change by owner	R1	7	6	2	84
The owner is not experienced in the project	R2	4	7	8	224
Slow decision by owner	R3	8	6	2	96
Lack of communication and coordination	R4	7	5	3	105
Financial difficulties	R5	10	9	7	630
Construction error	R6	9	8	5	360
Inappropriate construction method	R7	8	7	5	280
Weak contractor supervision and management skills	R8	9	4	2	72
Not enough contractor experience	R9	9	6	2	108
Bad sub contractor job	R10	8	7	2	112
Inadequate planning and scheduling	R11	8	8	6	384
Inaccurate cost estimates	R12	9	10	9	810
Low material quality	R13	7	5	2	70
Project quality is not good	R14	7	8	2	112
Slow response and bad inspection	R15	8	7	3	168
Imperfect tender documents	R16	8	8	2	128
Permissions	R17	10	1	1	10
Labor expertise is not enough	R18	8	7	3	168
Weak labor productivity	R19	8	5	3	120
Lack of workforce skills	R20	8	5	3	120
Lack of on-site materials	R21	8	6	4	192
Lack of on-site equipment availability	R22	8	7	4	224
Delay in preparing/receiving draft documents	R23	7	7	4	196
Design changes during implementation	R24	8	7	6	336
Unclear contract clause	R25	8	6	5	240
Lack of communication	R26	6	5	4	120
Weather, soil and environment in an invisible location	R27	9	9	7	567
Inflation/price fluctuation	R28	10	9	7	630
Other risks (conflict, country risk, deployment of force)	R29	8	9	4	288

The result with the highest value indicates a risk that must be watched out for and must be minimized immediately. From the results of the analysis of the highest risk are:

Table 5. Summary of Critical Risk

Critical Risk Factors 1	RPN 2
Financial difficulties	630
Inaccurate cost estimates	810
Weather, soil and environment in an invisible location	567
Inflation/price fluctuation	630

6. CONCLUSIONS

After analyzing the 7 main risks in the Jakarta - Bandung high-speed rail project, the following results were obtained:

1. Based on the AHP analysis, it is concluded that the three main priorities in mitigating the risk of implementing the Jakarta-Bandung high-speed rail infrastructure development are: (a) delay payment (weight 0.101), (2) external interference (weight 0.082), and (3) quality standards (weight 0.102). weight 0.082). The overall inconsistency ratio value (overall analysis) is 0.02 < 0.04 < 0.10, which means the results of the analysis are acceptable. Furthermore, the results of the AHP mentioned above are used as one of the considerations in formulating the strategy model.
2. Based on the FMEA analysis shown in the matrix, critical risk factors are depicted in red, which have an RPN value higher than 400. There are 4 things that need to be considered in minimizing risk, namely: (1) financial difficulties, (2) cost estimation inaccurate, (3) weather, soil and environment in locations that cannot be seen, (4) inflation/price fluctuations

Based on the above results, PT XYZ need to make managerial implication as follows :

1. The company pays more attention to improves risk control internally and a special team is formed to focus on obtaining risk data, analyzing and developing risk strategies to be carried out. Person in Charge of risk must be assisted by key persons namely Project Manager, Deputy Project Manager, Construction Manager, Commercial Manager, Finance and HC Manager to detail the risks that occur and take mitigation steps so that project and company goals can be achieved.
2. The company must create a strong and reliable contract administration team to back up the contractual aspects. Contractual checks starting from before the project runs, to eliminate or minimize burdensome clauses and include matters that may lead to disputes or major risks in the future. Such as inflation, late payments, weather and environmental factors are not known.
3. The company must make a policy not to take on projects that cause losses or have great risks.
4. The project management team must conduct studies on similar projects in other cities or countries in order to get an overview of the risks and their mitigation.

REFERENCES

Burghate, Mukul, (2018), Work Breakdown Structure: Simplifying Project Management, International Journal of Commerce and Management Studies (IJCAMS) Vol.3, No.2, June 2018

Chapman, C., Ward., S. 2003. Project Risk Management. West Sussex : John Willey & sons Ltd. [4]

Duffield, C & Trigunarsyah, B. 1999. Project Management Conception to Completion. Engineering Education Australia. (EEA). Australia.

Ervianto,A.U dan Joshua, M. (2001). Manajemen Proyek Konstruksi. Andi, Yogyakarta

Flanagan, R & Norman, G.1993, Risk Management and Construction. Blackwell Science, London.

Godfrey, P.S. 1996. Control of Risk. A Guide to the Systematic Management of Risk from Construction. Westminster London : CIRIA

Hum, D. P. S., Agus, B., & Iip, S. S. (2018). Team project ©2017 Dony Pratidana S. Hum | Bima Agus Setyawan S. IIP. Fti Umn, 53(9), 1–15.

Kangari, R. 1995. Risk Management Perceptions and Trends of U.S. Construction. Journal of Construction Engineering and Management. ASCE. December.

Kaczorek, K., Krzemiński, M., & Ibadov, N. (2017). The problem of choosing risk management methodology at the example of railway construction. MATEC Web of Conferences, 117. https://doi.org/10.1051/matecconf/201711700073

Kustiani, I., Siregar, A. M., & Fanhar, M. N. A. (2018). Analisis risiko reaktivasi jalur kereta api menuju Pelabuhan Panjang dengan Soft System Methodology (SSM). Prosiding Semnas SINTA FT UNILA, 1, 260–265. http://repository.lppm.unila.ac.id/id/eprint/11763

Kusumadewi, A., Listyani, V., & Risiko, A. (2017). Analisa Manajemen Risiko Tahap Konstruksi Pada Proyek Kereta Cepat Jakarta-Bandung. Jurnal Karya Teknik Sipil, 6(1), 157–164. http://ejournal-s1.undip.ac.id/index.php/jkts

Maddeppungeng, A., Wigati, R., & Faris, A. (2017). Manajemen risiko proyek pembangunan jalur kereta api yang berpengaruh terhadap kinerja waktu (Studi Kasus Double-Double Track Railway Jakarta, Zona Jatinegara-Bekasi). Jurnal Fondasi, 6(2). https://doi.org/10.36055/jft.v6i2.2474

Munang, A., RM, F., & Mansur, A. (2016). Evaluasi Dan Perencanaan Mitigasi Risiko Proyek Pembangunan Jalur Ganda Kereta Api Semarang - Bojonegoro. Teknoin, 22(2), 1–10. https://doi.org/10.20885/teknoin.vol22.iss2.art5

Pasaribu, Haryanto Pandapotan; Harijanto Setiawan; Wulfram I. Ervianto, (2021), Metode Failure Mode and Effect Analysis (FMEA) dan fault tree analysis (FTA) untuk mengidentifikasi potensi dan penyebab kecelakaan kerja pada proyek gedung," Core

Prastowo, T., & Purba, H. (2020). Risk management on railway projects: A literature view. Facta Universitatis - Series: Architecture and Civil Engineering, 18(3), 231–240. https://doi.org/10.2298/fuace191212017p

Soeharto, I. 1995. Manajemen Proyek dari konseptual sampai operasional. Erlangga. Jakarta.

Well-Stam, D Van, et.al., 2004. Project Risk Management: an essential tool for managing and controlling project, Kogan Page, London and Sterling VA.

Wideman, Max.R.1992. Project And Program Risk Management: A Guide To Managing Project Risk Opportunities. Project Management Institute. Amerika.

Xue, Y., Xiang, P., Jia, F., & Liu, Z. (2020). Risk assessment of high-speed rail projects: A risk coupling model based on system dynamics. International Journal of Environmental Research and Public Health, 17(15), 1–27. https://doi.org/10.3390/ijerph17155307

LEAN CONSTRUCTION USING VALUE STREAM MAPPING TO INCREASE EFFICIENCY IN THE BEAM AND SLAB CONSTRUCTION PROCESS

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ABSTRACT

The development of the construction sector in Indonesia requires construction players to keep growing in increasing the effectiveness and efficiency of the construction process. One of them is in the process of working on the beam and slab. There are obstacles that often interfere with activities that can reduce productivity in the beam and slab work process. One of the factors causing the occurrence of waste is poor planning resulting in the target not being achieved. Waste in the construction process can affect work productivity and efficiency in the implementation of construction. Waste in this process is non-value-added activity that really needs to be eliminated. This study aimed to categorize the activities into value-added (VA), non-value-added (NVA), and non-value-added but necessary (NVAN). Value stream mapping was conducted to identify these categories. as it helped to map or describe the process flow in detail. Data collection was obtained through observation using the purposive sampling technique. The results of this study were the value-added activity category has a percentage of 21%, the non-value-added activity category has a percentage of 11%, and the non-value-added but necessary category has a 69% percentage.

Keywords: waste, type activity, value stream mapping

1. INTRODUCTION

Construction is one of the keys to the development of a developing country (Herliandre and Suryani 2018). The development of the construction sector in Indonesia requires construction players to continue to develop in increasing the effectiveness and efficiency of the construction process. There are obstacles that often interfere with the activities they can interfere with the performance of the construction process. Problems in the construction world may lead to unachieved project targets such as quality, cost, and time (Syahri, et al. 2017). No exception applies to the work of beam and slab. So many waste activities that occur during the implementation of the beam and slab work require removal.

All activities that do not provide added value must be eliminated, otherwise, they will have side effects on construction implementation, for example behind schedule and over budget. Poor planning is one of the factors causing waste in the construction that can result in unachieved project targets. Waste in the construction process can affect work productivity and efficiency in

construction implementation. To maximize the construction process, good management and appropriate methods are needed. The construction sector must learn from the manufacturing sector in managing the production process so that it can reduce the amount of waste (Abduh 2005).

One of the theories that can be adopted from manufacturing theory is lean manufacturing for construction, which is called lean construction. The five principles contained in lean are: specify the value (creating value from the customer point of view), identify value stream, flow (smooth value flow), pull mechanism, and perfection (Womack and Jones 2003). Success in using the lean method must focus on all the causes of the occurrence of waste so that the value stream can run properly and more efficiently. Lean construction aims to avoid something that is considered to be wasteful during the construction process. One of the lean construction methods that can be used to analyze process waste is value stream mapping. Value stream mapping will focus on process waste (Kololu and Camerling 2017). One of the important steps in value stream mapping is making improvements. These improvements are mapped into the future state mapping. The difference in conditions between the current state mapping and future state mapping can be seen from the total value-added ratio (VAR) percentage. Current state mapping analysis will classify construction activities into 3 categories, namely: value-added (VA), non-value-added (NVA), and non-value-added but necessary (NVAN). That are will be presented with a diagram.

2. WASTE

Waste is all activities that require resources, costs, and time, but do not provide added value (L. Koskela 1992). Waste variables include waiting time for instructions, waiting time for materials arrival, waiting time for tools arrival, waste of raw materials, damage to on-site materials, unemployed workers, slow workers, and rework work (Mudzakir, et al. 2017). The factors that cause waste are divided into 6 groups, namely: human, management, design and documentation, implementation, material, and external (Alwi, Mohamed and Hampson 2002). Purnatha and Jaya (2013) mentioned that there are 5 factors, which may cause waste in construction projects, namely: design changes, lengthy revision and distribution of drawings, too much overtime, unclear working drawings, and poor site conditions. Ohno in Koskela (2000) said that waste is classified into 7 categories, namely overproduction, waiting period, transportation, Overprocessing, Inventory, motion, and defect

3. VALUE STREAM MAPPING

Stream mapping is a tool that can be used in implementing a lean construction approach. Value stream mapping is a method used to describe and analyze the production process (Langstrand 2016). Value stream mapping is a powerful tool that enables companies to understand and continuously improve their understanding of the lean (Salunke and Hebbar 2015). Value stream mapping identifies each action to design, order, and manufacture a particular product (Womack and Jones 2003). Value stream mapping groups activities into 3 categories, namely: non-value-added (NVA), non-value-added but necessary (NVAN), and value-added (VA) (Hines and Rich 1997). The purpose of grouping these activities is to find out which activities have added value and which do not have added value so that steps can be taken to minimize the potential waste. There are three main parts to value stream mapping, namely production process flow, information flow, and timelines (Nash and Poling 2008). With this concept, companies can build a sense of urgency that includes several members of an organization and is also used as a communication tool to facilitate the implementation of lean (Gaspersz dan Fontana 2011). The basis for understanding the activities and operations that are connected and form the basis for

analyzing a process is a value stream mapping that can provide a graphical depiction of material flow and information flow (Langstrand 2016).

4. ACTIVITY TYPE

Value is a fulfillment of customer needs (Zhao and Chua 2003). In generating value, it is necessary to carry out activities in the production process (Hines and Taylor 2000). The following are the activities in a production process, namely:

a. Value-Added Activity (VA)
   It is an activity in a process that adds value to the product (Hines and Taylor 2000). All activities that can generate added value in producing products can be categorized as value-added activities.
b. Non-Value-Added Activity (NVA)
   This activity includes waste that does not provide added value that must be eliminated or eliminated to increase productivity at work (Hines and Taylor 2000). Activities that do not add value must be identified so that they can be eliminated and performance can be improved through the production process (Zhao and Chua 2003). Value-added activities cannot affect the products that are processed directly, both in terms of quantity and quality (Hines and Taylor 2000). This activity needs to be reduced to achieve the efficiency of the production process because this activity is a waste. The ability to eliminate or eliminate activities that do not provide added value is the main strategy for improving the production process.
c. Non-Value-Added but Necessary Activity (NVAN)
   This activity is an activity that does not provide value, but this activity is very necessary for the production process, the unavailability of this activity will disrupt the production process (Hines and Taylor 2000).

5. METHODS

In this study, direct observation was conducted to determine the actual conditions in the construction process. This study uses a case study on the Malang Creative Center project. All activities in the process of beam and slab will be observed directly and thoroughly. The identification of activities on the beam and slab will then be described in the current state mapping. The next step is to group activities into 3 categories. This grouping is done based on a discussion between the researcher and the sample of respondents in this study. The technique for taking this sampling is purposive sampling. Purposive sampling is a data sampling technique based on certain considerations (Sugiyono 2017). The selected sample was deliberately determined based on the criteria determined by the author so that the sample in this study may become more representative. The criteria for the individuals who were sampled in this study were people who had experience or expertise in the construction field and were directly related to the work of beam and slab on the Malang Creative Center project.

6. RESULTS

The beam and slab construction process consist of 8 main processes, namely reinforcement fabrication, concrete deck manufacture, scaffolding installation, formwork installation, reinforcement assembly, wire mesh installation, casting, and formwork removal. Figure 1 describes the flow of the construction process and the construction of the beam and slab described

in the current state mapping. Value stream mapping was conducted to identify these categories, as it helped to map or describe the process flow in detail.

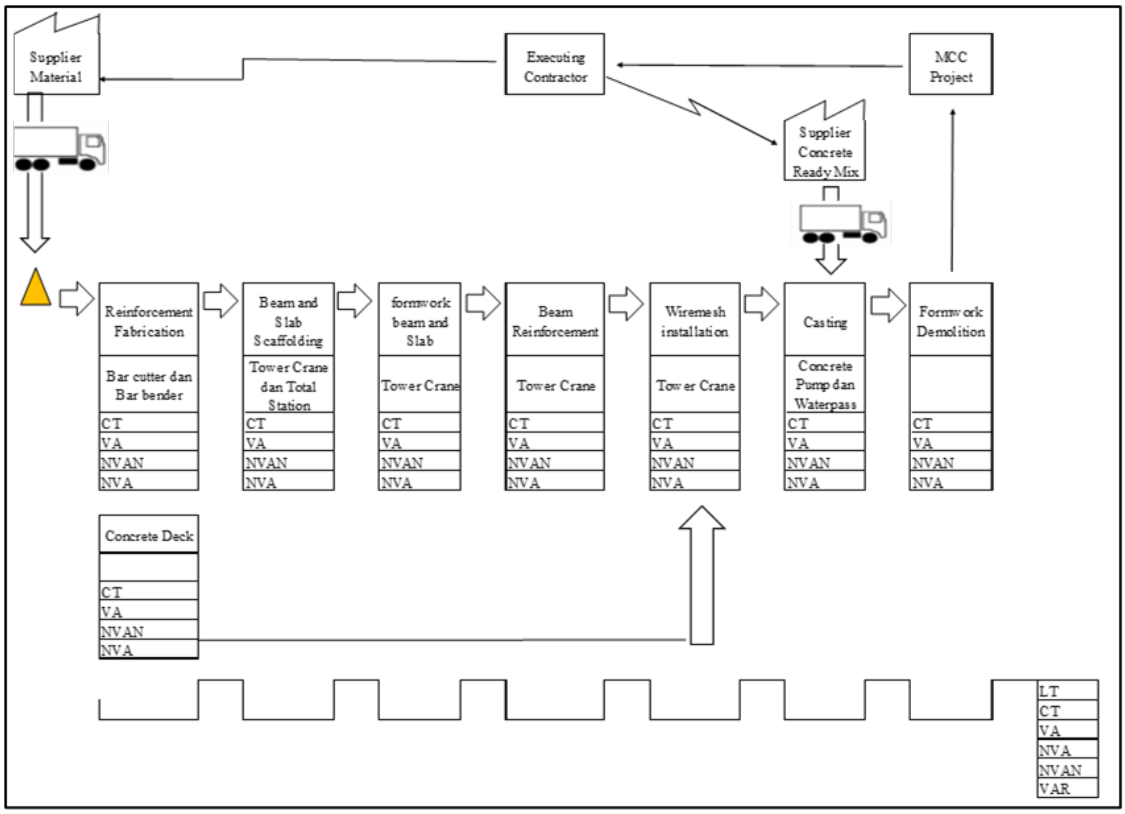


Figure 1. Current state mapping

After identifying the activity process on the beam and slab, afterward, it was grouped into 3 categories. The value-added activity (VA) category is an activity that can provide added value to the work of beam and slab, non-value-added activity (NVA) is an activity that does not provide added value or waste, and non-value-added but necessary activity (NVAN) is an activity that does not provide added value directly to the process of beam and slab, but this activity is very necessary. The table below is the result of grouping activities.

a. Beam Reinforcement Fabrication

Table 1. Identifying activity process on beam reinforcement fabrication

Description	VA	NVA	NVAN
Site engineer makes job request to quality control			✓
Quality control reviews DED first			✓
Quality control asked the site manager for approval			✓
Site engineer requested permission from HSE			✓
Quality control contacted logistics regarding the use of materials			✓
Waiting for the logistics issue the material issued		✓	
Site engineer provides instructions for fabricating reinforcement			✓
Review the DED first to find out the size of the reinforcement			✓
Workers prepare to measure tools and sockets		✓	
Set up bar cutter machine			✓

Description	VA	NVA	NVAN
Measuring one steel bar to make a mold	✓		
Cut the mold according to the size in the DED	✓		
Cut the reinforcement according to the mold at the same time	✓		
Transferring the cut reinforcement to the bar bender			✓
Review the DED to find out the dimensions of the reinforcement			✓
Bar bender machine setup			✓
Bending reinforcement using a bar bender	✓		
Checking			✓

b. Concrete Deck Manufacturing

Table 2. Identifying activity process on concrete deck manufacturing

Description	VA	NVA	NVAN
Site engineer makes job request to quality control			✓
Quality control asked the site manager for approval			✓
Quality control contacted logistics regarding the use of materials			✓
Waiting for the logistics issue the material issued			✓
Instruct workers to make a concrete deck		✓	
Workers take material from the warehouse to the concrete deck manufacturing site			✓
Prepare equipment (mold and water bucket)		✓	
Making a concrete deck	✓		
Molding the dough with a concrete deck mold	✓		

c. Installation of beam and slab scaffolding

Table 3. Identifying activity process on the installation scaffolding

Description	VA	NVA	NVAN
Site engineer reviews DED			✓
Site engineer makes job request at quality control			✓
Quality control reviews the DED			✓
Quality control asked the site manager for approval			✓
Site engineer requested permission from HSE			✓
Quality control contacted logistics regarding the use of scaffolding			✓
Site engineer gives instructions to workers for scaffolding installation			✓
Site engineer gives instructions to surveyors			✓
Workers surveyed scaffolding installation placement points	✓		
Site engineer gives instructions to the tower crane operator			✓
Waiting for tower crane tool setting			✓
Lifting the existing scaffolding on the ground to the floor where the scaffolding will be installed using a tower crane	✓		
Scaffolding Installation	✓		
Scaffolding check			✓

d. Installation of beam and slab formwork

Table 4. Identifying activity process on the installation of formwork

Description	VA	NVA	NVAN
Site engineer reviews DED			✓
Site engineer makes job request at quality control			✓
Quality control reviews DED			✓
Quality control asked the site manager for approval			✓
Site engineer requested permission from HSE			✓
Quality control contacted logistics regarding the use of plywood			✓
Waiting for the logistics party to issue a material issued		✓	
Site engineer gives instructions to workers for formwork installation			✓
Site engineer gives instructions to the tower crane operator			✓
Lifting the plywood to the floor where the formwork will be installed using a tower crane			✓
Reviewing the drawings to find out the dimensions of the beam formwork	✓		✓
cutting plywood according to formwork size	✓		
beam formwork installation	✓		
slab formwork installation	✓		
Formwork checking			✓

e. Beam Reinforcement Installation

Table 5. Identifying activity process on beam reinforcement installation

Description	VA	NVA	NVAN
Site engineer reviews DED			✓
Field executive makes job request at quality control			✓
Quality control reviews DED			✓
Quality control asked the site manager for approval			✓
Site engineer requested permission from HSE			✓
Quality control contacted logistics regarding the use of reinforcement			✓
Waiting for the logistics party to issue a material issued		✓	
Site engineer gives instructions to workers			✓
Site engineer contact the tower crane operator			✓
Review DED before the material is lifted			✓
Lifting the material to the floor where reinforcement will be installed using a tower crane			✓
Review the image to find out the size of the reinforcement that will be used			✓
Assembly of reinforcement by workers	✓		
Reinforcement check with the suitability of the drawing			✓

f. Wire mesh installation

Table 6. Identifying activity process on wire mesh installation

Description	VA	NVA	NVAN
Waiting for the material to come from the supplier		✓	
Site engineer reviews DED			✓
Field executive makes job request at quality control			✓
Quality control reviews DED			✓
Quality control asked the site manager for approval			✓
Site engineer requested HSE permission			✓
Quality control contacted logistics regarding the use of wire mesh			✓
Waiting for the logistics party to issue a material issued		✓	
Site engineer gives instructions to workers			✓
Site engineer gives instructions to the tower crane operator			✓
Lifting the wire mesh material to the floor where the wire mesh will be installed using a tower crane			✓
Installation of concrete deck	✓		
First layer wire mesh installation	✓		
Installation of chicken claw iron (between layers 1 and 2)	✓		
Second layer wire mesh installation	✓		
Checking			✓

g. Beam and Slab Casting

Table 7. Identifying activity process on casting

Description	VA	NVA	NVAN
Site engineer reviews DED			✓
Site engineer makes job request to quality control			✓
Quality control reviews DED			✓
Quality control asked the site manager for approval			✓
Quality control places an order for concrete from a ready mix concrete supplier			✓
Waiting for the material to come from the supplier		✓	
Quality control conducts inspections on newly arrived materials and provides a material inspection report which is then submitted to the HSE			✓
HSE issues a letter of receipt of the material which is submitted to the logistics party			✓
Waiting for logistics to issue material issued		✓	
Site engineer reviews DED			✓
Site engineer instruct surveyors			✓
Site engineer gives instructions to workers			✓
Preparation of tools (slump test equipment, compressive strength test equipment, vibrator, etc)		✓	
Slump test on ready mix concrete			✓
Making a concrete compressive strength test sample			✓

Description	VA	NVA	NVAN
Waiting for the installation of the concrete pump		✓	
Casting Process	✓		
Checking			✓

h. Formwork Demolition

Table 8. Identifying activity process on formwork demolition

Description	VA	NVA	NVAN
Site engineer checks the concrete			✓
Site engineer makes job request to quality control			✓
Quality control asked the site manager for approval			✓
Site engineer requested permission from HSE			✓
Site engineer instructs the foreman to release			✓
Scaffolding formwork demolition	✓		
Check after formwork removal			✓
Instructing maintenance on defective concrete	✓		

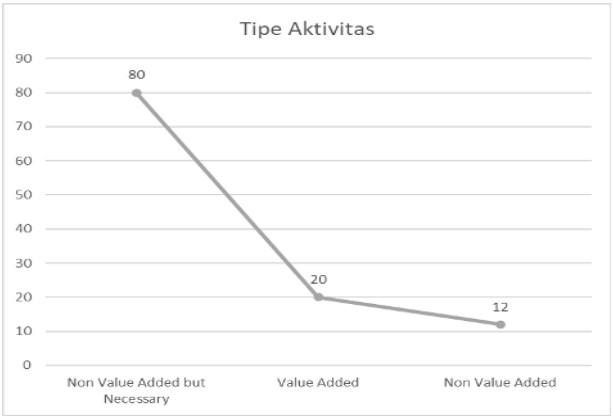


Figure 2. diagram of recapitulation of three types of activity

The results of the analysis of value stream mapping in this study indicate that the application of value stream mapping can be implemented in the construction industry. The research of Syahri, et al. (2017) also shows that the value stream mapping method can identify waste in the construction process. This is indicated by the identification of waste in the beam and slab work. In figure 2 of the diagram for three types of activity, it can be seen that the activities included in the value-added category has 20 activities. These activities can cause physical changes in the implementation of beams and slabs. Without these activities, there will be no physical results from the beam and slab. The non-value-added but necessary activities category has 80 activities. These activities do not provide added value, but these activities are very necessary during the work process and usually, activities belonging to this category will be difficult to eliminate.

While those belonging to non-value-added activities have 12. These activities can cause waste and do not provide added value at all during the beam and slab work process, for example in the activity of waiting for the material's arrival, which resulted in delays in the schedule that led to additional costs. This activity is called waste, which must be eliminated immediately. This non-

value-added activity is an activity that does not affect the results directly in terms of quantity and quality (Hines and Taylor 2000).

The existence of non-value-added activities indicates that there is a waste that can affect the level of efficiency or productivity in the work process in construction, especially on beams and slabs. This proves that even though a construction work has been planned properly and carefully, in reality, when the work is in progress, there is still a waste. The identification of waste in every construction work is needed to make the process easier to improve, namely by eliminating waste. Zhao and Chua (2003) stated that waste or activities do not provide added value. Therefore, an elimination action is needed to improve the performance of a process. All activities that are classified as waste or non-value-added activities must be eliminated so that the beam and slab work process is more productive and efficient.

7. CONCLUSIONS

Based on the results of the above analysis, the conclusions that can be drawn in accordance with the objectives of this study were: The grouping of all process activities into 3 categories results that the activities included in the value-added category have 20 activities, the non-value-added category has 12 activities, while the category of non-value-added but necessary has 80 activities. This shows that using the value stream mapping method can identify value-added, non-value-added, and non-value-added but necessary activities. so that, later improvements can be made to the process of beam and slab. Some of the strategies should be formulated to reduce the non-value-added activities

REFERENCES

Abduh, M. 2005. *Konstruksi Ramping: Memaksimalkan Value dan. Meminimalkan Waste.* Bandung: Institute Teknologi Bandung.

Alwi, Sugiharto, Sherif Mohamed, and Keith Hampson. 2002. "Waste in the Indonesian construction projects." *Proceedings of the 1st International Conferences of CIB W107 – Creating a Sustainable Construction Industry in Developing Countries.* South Africa: Worcester Polytechnic Institute. 305-315.

Gaspersz, Vincent , and Avanti Fontana. 2011. *Lean six sigma for manufacturing and service industries waste elimination and continuous cost reduction.* Bogor: Vinchristo Publication.

Herliandre, Agus, and Fitri Suryani. 2018. *Penerapan Konstruksi Ramping (Lean Construction) pada Pembangunan Gedung di Bintaro.* Jakarta: Universitas Persada Indonesia Y.A.I.

Hines, Peter, and David Taylor. 2000. *Going lean.* Cardiff University: Lean Enterprise Research Centre.

Hines, Peter, and Nick Rich. 1997. "The seven value stream mapping tools." *International Journal of Operations & Production Management* 46-64.

Kololu, Welmy, and B. J. Camerling. 2017. *Tinjauan Penggunaan Metode Lean Contruction pada Proyek Konstruksi (Studi Kasus: Pada Pesona Alam Estate).* Ambon: Universitas Pattimura.

Koskela, Lauri. 1992. *Application of the New Production Philosophy to Construction.* California: Stanford University.

Koskela, Lauri J. 2000. "An Exploration Towards a Production Theory and its Application to Construction." *Technical Research Centre of Finland, VTT Publications* (VTT Building Technology) 298-408.

Langstrand, Jostein. 2016. *An introduction to value stream mapping and analysis.* Swedia: Linkoping University.

Mudzakir, Ahmad Chasan, Arif Setiawan, M. Agung Wibowo, and Riqi Radian Khasani. 2017. "Evaluasi Waste dan Implementasi Lean Construction (Studi Kasus: Proyek Pembangunan Gedung Serbaguna Taruna Politeknik Ilmu Pelayaran Semarang)." *Jurnal Karya Teknik Sipil* 145-158.

Nash, Mark A, and Sheila R Poling. 2008. *Mapping the Total Value Stream.* New York: Taylor & Francis Group.

Purnatha, and I Putu Gede Jaya. 2013. *Studi Mengenai Construction Waste Pada Proyek Konstruksi di Kabupaten Badung.* Yogyakarta: Universitas Atma Jaya Yogyakarta.

Salunke, Shweta S, and Sunith Hebbar. 2015. "Value Stream Mapping: A Continuous Improvement tool for Reduction in Total Lead Time." *International Journal of Current Engineering and Technology* 931-934.

Sugiyono. 2017. *Metode Penelitian Kuantitatif, Kualitatif, dan R&D.* Bandung: PT. Alfabeta.

Syahri, Ramadhana Fajar, Heryanto, M. Agung Wibowo, and Jati Utomo Dwi Hatmoko. 2017. "Analisa Waste dengan Value Stream Mapping pada Pekerjaan Kolom Gedung Bertingkat." *Jurnal Karya Teknik Sipil* 192-200.

Womack, James P, and Daniel T Jones . 2003. *Lean Thinking: Banish Waste and Create Wealth in Your Corportion.* New York: FREE PRESS.

Zhao, Ying, and David K. H Chua. 2003. *Relationship Between Productivity and Non Value Adding Activities.* Singapore: National University of Singapore, Singapore.

DEFECT ANALYSIS OF COSMETIC PRODUCTS USING FAULT TREE ANALYSIS

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ABSTRACT

PT. XYZ is a company engaged in the cosmetic industry. This company produces cosmetics according to customer orders, with specific specifications. Job order patterns like this, resulted in many products being rejected in the production process. This study aims to identify the factors that cause production defects. Defect problems are minimized by using a Plan-Do-Check-Act (PDCA) approach. Fault Tree Analysis (FTA) is used to determine the source of the causes of product defects, then quality control was proposed to reduce product defects. The result shows that the dominant cause of rejection of the product is the color mismatch. Pareto diagram also shows that the acceptability of products caused by color mismatches is only 52.25% (reject 47.75%). To overcome this problem, quality improvement is carried out by improving work processes such as adding a standard specification test data check sheet for the Quality Control (QC) Team, providing Standard Operating Procedure (SOP) to the Production Team, and performing maintenance on existing machines. The proposed corrective action succeeded in increasing the achievement of product acceptance by 82% (reject 18%).

Keywords: Quality Control, Fault Tree Analysis (FTA), Cosmetics Industry

Keywords: Quality Control, FTA, Cosmetics Industry

1. INTRODUCTION

The cosmetic industry is one of the industries in Indonesia with fairly rapid growth. To maintain and improve the company's position, the company needs to maintain and improve the system in its factory. Good product quality in the market can increase the company's competitive ability. However, in every production process, errors often occur which result in defective products. So in the production process, intensive supervision is needed so that defects that occur in the product can be minimized. Quality control activities can help reduce production errors thereby reducing defective products. This study aims to identify the source of the causes of cosmetic product defects in PT. XYZ. The results of this identification will then be used to improve the quality of production. It is hoped that by reducing the sources of product defects, in the future the quality of cosmetic production at PT. XYZ will be better and can seize the market share of cosmetics in its class.

2. LITERATURE REVIEW

2.1 Product Defect

In manufacturing, the production quality is the main goal in every company, defects from production will of course harm the company, production defects must be reduced/emphasized so that companies are more efficient and can compete. To be able to compete in the business world, especially in the cosmetic industry, defective products must be minimized to avoid losses within the company. As a result of this problem in production, there will be losses from the company due to the number of production defects that occur. (Satriyo, 2014)

Meanwhile, according to (Don R. Hansen & Maryanne M. Mowen, 2009), the product must be by its specifications in meeting its needs, to function properly the product is made. The product is declared defective if the product does not meet its specifications.

2.3 Quality Control

Quality control is a structured technique and activity carried out to produce, maintain, improve, and improve the quality of a product and service to comply with established standards and meet customer satisfaction. (Fitriyenti, 2016)

2.4 Factors Causing Product Defect

Product quality is the main focus of an industrial company so the quality needs to be maintained to maintain customer buying interest. Quality control of cosmetic products needs to involve the testing of physical and chemical parameters.

Table 1. Types of Raw Specifications for Cosmetic Products

No.	Author	Research Title	Variable Quality Control of Cosmetics
1.	(Singh, 2016)	Quality Assurance Of Cosmetics	Color
2.	(Singh, 2016)	Quality Assurance Of Cosmetics	Specific Gravity
3.	(Singh, 2016)	Quality Assurance Of Cosmetics	Viscosity
4.	(Singh, 2016)	Quality Assurance Of Cosmetics	Hardness-Soft
5.	(Singh, 2016)	Quality Assurance Of Cosmetics	Foam
6.	(Singh, 2016)	Quality Assurance Of Cosmetics	Stability Test accelerated
7.	(Singh, 2016)	Quality Assurance Of Cosmetics	Chemical Test (pH)

The occurrence of defective products can be caused by many things. In an industry, several studies have succeeded in identifying the causes of defects. The following is a summary of the factors causing product defects from several studies:

Tabel 2. Source of Product Defect

No.	Source of Product	Defect Reference Source
1.	Human Resources (Operator)	(Firman Prayogi, 2016) & (Fakhri Gusti, 2019) & (Satriyo, 2014) & (Widyasari, 2021)
2.	Machine	(Firman Prayogi, 2016) dan (Rafsanjani, 2018) & (Widyasari, 2021)
3.	Job Information	(Firman Prayogi, 2016)
4.	Work environment	(Fakhri Gusti,2019) & (Satriyo, 2014) & (Fitrananda, 2021)
5.	Material	(Fitrananda, 2021) & (Widyasari, 2021)
6.	Production Method	(Fitrananda, 2021) & (Widyasari, 2021)

2.5 Fault Tree Analysis (FTA)

Fault Tree Analysis (FTA) is a fault tree analysis that can simply be described as an analytical technique. A fault tree is a graphical model involving various parallels and pilot combinations of errors that will result in the occurrence of a previously defined undesirable event, or it can also be interpreted as a logical reciprocal description of the basic events that drive an event.

2.6 PDCA (Plan-Do-Check-Action)

PDCA (Plan, Do, Check, Action) is a step to improve the problems in this study. The research was conducted with the Plan stage (problem identification, problem specification, and data collection), the Do stage (data analysis, making tentative conclusions, and examining statistical conclusions), the Check stage (conducting experiments), and the Action stage (taking corrective actions and maintaining the results). repair). PDCA is a useful way to make continuous improvements without stopping. Following are the stages of PDCA:

a. Plan (Planning) This means planning the goals (Goal = Goals) and what processes are needed to determine the results by the specified goals.
b. Do (Implement) It means to plan a predetermined process
c. Check (Evaluation / Checking) This means evaluating and analyzing the goals and processes and reporting the results.
d. Action (Follow Up/ Adjustments) This means conducting a total evaluation of the results of targets and processes and following up with improvements.

3. METHODS

This study uses the Plan-Do-Check-Action (PDCA) method, where Plan (planning), is the first action in the improvement plan at PT. XYZ is to collect sample data in the form of the total number of production, the number of defects, and the type of the number of defects from the check sheet recording conducted by PT. XYZ. From the data that has been collected, the source of the problem is identified using the Fault Tree Analysis (FTA) method. Next is the Do (implementation) stage, after making a repair plan for product defects that occurred at PT. XYZ, then the next step is to implement the solution at PT. XYZ. The 5W+1H (What, Why, Where, When, Who, Ho) method aims to determine improvement solutions for the company. Check (inspection), and re-examine whether the corrective action is running as intended or not at PT. XYZ by creating a repair checklist. Action (adjustment) maintains the quality control results that have been

achieved to prevent the recurrence of the same problem by setting standards for the company after making suggestions for improvement.

4. RESULTS

In this study using the PDCA Plan-Do-Check-Action method, the following are the stages of the PDCA method in controlling quality.

4.1 Plan

The results of the FGD and field observations found several factors causing bulk rejects of production, namely color, viscosity, texture, aroma, and pH. A Pareto diagram is used to determine the priority cause of the problem. The following is a Pareto diagram of the number of rejects in cosmetic production at PT. XYZ in January to May 2021 at PT. XYZ. The highest ranking of the Pareto diagram is the color type is the most dominant type of defect with the highest frequency of 58 (52.25%) during the production process from January to May 2021. To analyze the source of the problems that occur, an FTA approach is needed to avoid company losses.

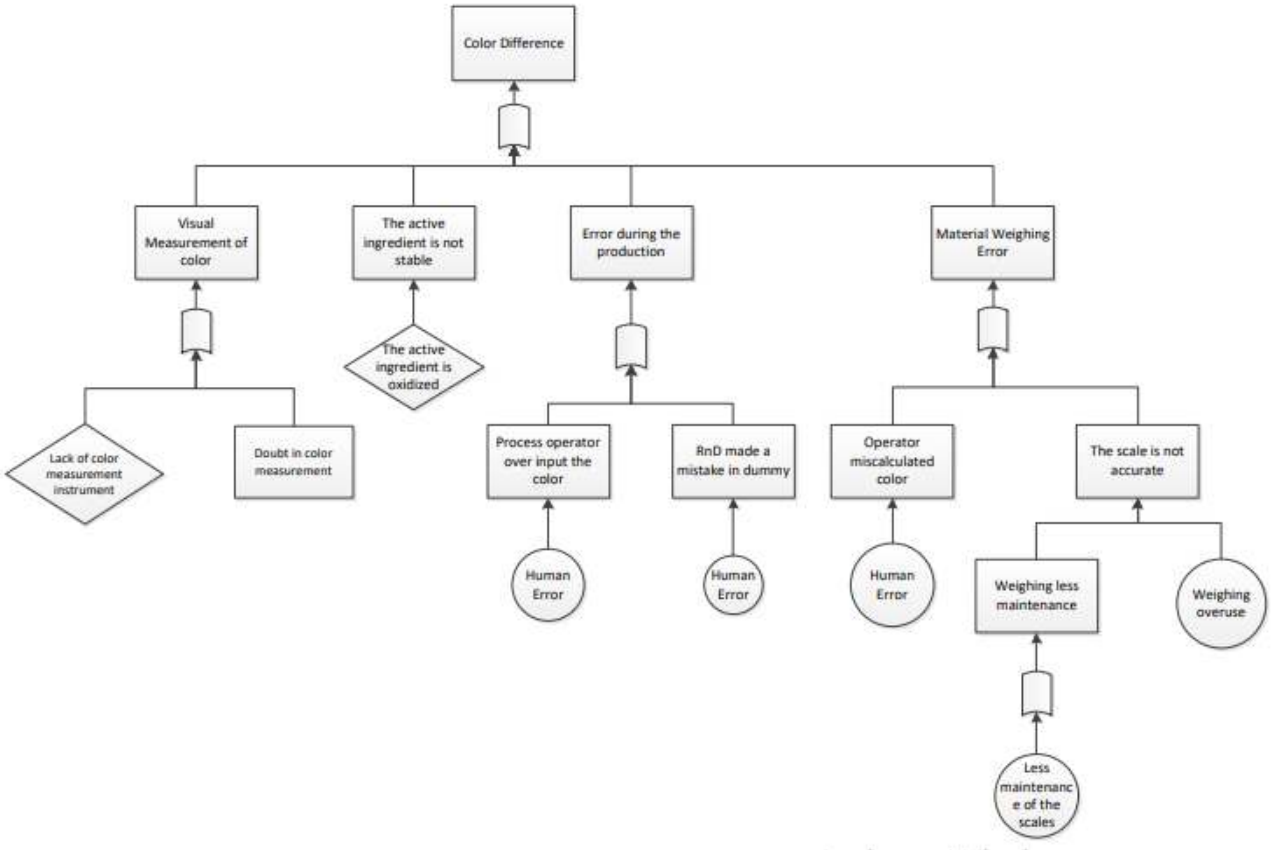


Figure 1. FTA Tree Diagram by Type of Color Defect

Table 3. FTA Tree Description Based on Color Defect Type

Number.	**Source Cause of Problem**	**Problem Description**
1.	Lack of QC Instruments	In the field, there is no equipment to check the color of the product. The QC team checks the color only by matching the color of the product with the dummy and Pantone references
2.	The occurrence of discrepancies in QC	The field is still using visual color checking of the production results.
3.	Oxidized Active Ingredients	Active ingredients have different characteristics. In the field, oxidation often occurs in the bulk of the product which causes discoloration. This is due to the lack of active ingredient analysis before production.
4.	Human Error Production Operator	Operator inputting too much color during production
5.	Human Error RnD	The dummy reference made by the formulator which is used as a reference for the operator in the production process is not representative. This is due to the inaccuracy of the formulator in making the dummy.
6.	Weighing Operator Human Error	A weighing error occurred that did not comply with the SOP
7.	Lack of Maintenance Tool	Scales that lack maintenance become inaccurate when in use
8.	Overuse Excessive	Use of scales makes the scales inaccurate.

4.2 Do

Table 5. Corrective Action with 5W+1H Method

Factor	What	Why	Where	When	Who	How
Machine/ Equipment	The absence of color-checking equipment and the occurrence of color-checking discrepancies To minimize QC errors in color checking	To minimize QC errors in color-checking	Lab *Quality Control*	2-16 February 2022	QC Team	Provide equipment for color-checking
Ingredient	Oxidized Active Ingredients	To minimize bulk discoloration	Lab RnD	2-16 February 2022	RnD Team	Provide RnD in charge of material stability test analysis before production
Human Resource	Human Error Weighing Process	To prevent operator error in weighing materials	Weighing Room	2-16 February 2022	Weighing Team	Weighing officers take turns to anticipate accuracy
Human Resource	Human Error Production Operator	To prevent operator errors during the production process	Production Room	2-16 February 2022	Production Team	Conducting job evaluation and job training for the production team
Human Resource	Human Error RnD	To prevent dummy errors	Lab RnD	2-16 February 2022	RnD Team	Evaluating the RnD. team
Maintenance	Lack of maintenance of production machines and scales	To increase the accuracy of the scale	Maintenance	2-16 February 2022	Maintenance Team	Perform regular machine maintenance
Maintenance	Overuse	To provide a means of knowledge about scales	Weighing Room	2-16 February 2022	Team weighing	Provision of operator training in the use of tools

4.3 Check

At this stage a re-examination is carried out whether the corrective actions proposed at the implementation stage are running according to the objectives or not at PT. XYZ. This inspection action is carried out by observing production results during the period 2-16 February 2022.

4.4 Action

The act of maintaining quality control is carried out by setting standards for the company. For this reason, several control measures are needed as follows:

1. Completion of the standard specification test data check sheet for the Quality Control Team by providing a column for the reasons for rejection if there are products that do not comply with the dummy.
2. Purchase color instrumentation to test and measure color more easily and accurately.
3. Training of several Production Process Teams:
   a. ISO 9001 training for 2 Quality Control Teams
   b. Production work training according to SOP for 15 people from the Production Operator Team.
4. Completion of the Standard Operating Procedure carried out by the RnD Team so that the implementation of production can be maximized and minimize production errors.
5. Provide 2 people to be the RnD Analyst Team for testing raw materials to be used before production.
6. Provide 2 people to be RnD Team in Factory to do small-scale production before large-scale production.
7. Performing maintenance on machines at the factory including:
   a. Inspection: Scheduled for machine inspection that is every weekend so that the machine used is always in good condition.
   b. Cleaning: Cleaning activities are carried out every day before production activities so that the machines used are guaranteed to be clean.
   c. Replacement of spare parts: Procurement of spare parts for machines in preparation for when a machine is being repaired or cannot be used. Spare parts that need to be prepared are 2 homogenizer machines 15 kg.

5. OUTCOME AND DISCUSSION

Initially, products rejected due to color differences in the January-May 2021 period were 52.25%, while after repairs with the PDCA method there was a decrease in the color rejects rate, which was to 18%. So it can be concluded that the proposed corrective action provides achievement of 82% for the color type. Company PT. XYZ can use the proposed improvement to prevent product reject problems and improve the quality of production.

6. CONCLUSIONS

The results of the proposed PDCA succeeded in providing an improvement with the achievement of 82% color aspect (reject 18%). So that the proposed corrective actions that can be given are:

REFERENCES

Blanchard, B. (2004). *Blanchard Logistics Engineering And Management*, 6th Edition, Pearson Education, New Jersey

Bustami, B., Nurlela. (2006). Akuntansi biaya : *Kajian Teori Dan Aplikasi*, 1st Edition, Graha Ilmu, Yogyakarta

R. Hansen, Don., M. Mowen, Maryanne. (2009). *Managerial Accounting; Akuntansi Manajerial (Buku 1)*, 8th Edition, Salemba Empat, Jakarta

Ferdiana, T., & Priadythama, I. (2016). Analisis Defect Menggunakan Metode Fault Tree Analysis (FTA) Berdasarkan Data Ground Finding Sheet (GFS) PT. GMF AEROASIA

- Pdf Free Download. Https://Docplayer.Info/31428758-Analisis-Defect-Menggunakan-Metode-Fault-Tree-Analysis-Fta-Berdasarkan-Data-Ground-Finding-Sheet-Gfs-Pt-Gmf-Aeroasia.Html

Firman Prayogi, M., Puspita Sari, D., & Arvianto, A. (2016). Analisis Penyebab Cacat Produk Furniture Dengan Menggunakan Metode Failure Mode And Effect Analysis (Fmea) Dan Fault Tree Analysis (Fta) (Studi Kasus Pada Pt. Ebako Nusantara).

Fitrananda, S., Moektiwibowo, H., & Indramawan, I. (2021). Analisis Pengendalian Kualitas Produk Kosmetik Eyeshadow Dengan Metode Six Sigma Di Pt Cedefindo. Jurnal Teknik Industri, 10(1). Https://Doi.Org/10.35968/Jtin.V10i1.705

Fitriyenti, A. (2016). Analisis Pengendalian Kualitas Produk Dengan Menggunakan Fault Tree Analysis (Fta) Dan Failure Mode And Effect Analysis (Fmea) Pada Minute Maid Nutriboost Di Pt Coca Cola Amatil Indonesia. Http://Repository.Unpad.Ac.Id/Frontdoor/Index/Index/Docid/23013

Gusti, M. F., & Budiawan, W. (2019). Analisis Penyebab Cacat Menggunakan Metode Fta Dan Fmea Pada Departemen Final Sanding (Studi Kasus : Pt. Abc, Semarang) | Gusti | Industrial Engineering Online Journal.

Hakim, A. R. (2019). Industri Kosmetik Dan Manfaat Bagi Konsumen Kosmetik Di Indonesia (No. 12761885). 17. Https://Doi.Org/None

Hidayat, N. A. (2016). Identifikasi Penyebab Kecelakaan Kerja Pada Kegiatan Bongkar Muat Petikemas Di Terminal Berlian Tanjung Perak Surabaya.

I Gusti Made Oka Virgiawan, 041511223027. (2017). Analisis Defect Dengan Menggunakan Metode Six Sigma Pada Giyomi.Id Surabaya. Http://Lib.Unair.Ac.Id

Juran, J. M. (Joseph M. ., & Godfrey, A. B. (1999). Juran's Quality Handbook. Https://Books.Google.Com/Books/About/Juran_S_Quality_Handbook.Html?Hl=Id&Id=Mourdqaaqbaj

Pratomo, S. (2016). Evaluasi Rantai Pasokan Komoditas Bambu Di Kecamatan Minggir Sleman .

Prayogi, D. P. (2016). Analisis Penyebab Cacat Produk Furniture Dengan Menggunakan Metode Failure Mode And Effect Analysisis (Fmea) Dan Fault Tree Analysisi (Fta). 2.

Priyanta, D. (2000). Keandalan Dan Perawatan. Surabaya: Institut Teknologi Sepuluh November.

Pt. Nose. (2021). Quality Control.

Rafsanjani, S. (2018). Pengendalian Dan Perbaikan Kualitas Proses Printing Kemasan Produk Menggunakan Integrasi Fmea-Triz.

Satriyo, B. (2014). Analisis Pengendalian Kualitas Dengan Menggunakan Metode Fault Tree Analysis Untuk Meminimumkan Cacat Pada Crank Bed Di Lini Painting Pt. Sarandi Karya Nugraha | Satriyo | Industrial Engineering Online Journal. Https://Ejournal3.Undip.Ac.Id/Index.Php/Ieoj/Article/View/15936

Singh, V. K. (2016). Quality Assurance Of Cosmetics | Pharmatutor. Https://Www.Pharmatutor.Org/Articles/Quality-Assurance-Of-Cosmetics

Sriwidadi, T., & Agustina, E. (2013). Analisis Optimalisasi Produksi Dengan Linear Programming Melalui Metode Simpleks. Binus Business Review, 4(2), 725–741. Https://Doi.Org/10.21512/Bbr.V4i2.1386

Sunarto & Santoso, H. (2021). (Pdf) Buku Saku Analisis Pareto. Https://Www.Researchgate.Net/Publication/342586675_Buku_Saku_Analisis_Pareto

(Tannady H. , Pengendalian Kualitas, 2015)

Walujo, D. A., & Dkk. (2020). Pengendalian Kualitas - Djoko Adi Walujo, Titiek Koesdijati, Yitno Utomo - Google Buku. Https://Books.Google.Co.Id/Books?Id=Govudwaaqbaj&Printsec=Frontcover#V=Onepage &Q&F=False

Widyasari, D. R. (2018). Metode Six Sigma Untuk Mengurangi Jumlah Defect Pada Produksi Kaca Fl5.

OPTIMIZATION OF RAW MATERIAL SUPPLY TO CONSUMER DEMAND ARGOINDUSTRY LUWAK COFFEE (CIVET COFFEE) AT PT. KLC, WEST JAVA

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ABSTRACT

The supply chain in agro-industry activities at PT.KLC includes suppliers of main raw materials to consumers, seasonal raw materials. the fluctuating sales of Kopi Luwak cause conditions when demand conditions are low, the stock of Kopi Luwak high and conditions of high demand for low civet coffee stock causing losses for the civet coffee product to be unable to fulfill consumer demand. The purpose of the study was to analyze the pattern of consumer demand for Kopi Luwak in the previous 3 periods at PT. KLC with ARIMA analysis to be a reference for forecasting in the next period as well as analysis from the operational and sales side with the Sales and Operational Planning methodology and Material Requirement Planning to control the supply of raw materials with reference forecasting. The results of the ARIMA consumer forecasting methodology research are an alternative solution for fluctuating demand and the analysis of Sales and Operations Planning can optimize the supply chain where the research results prove that it does not need all of its civet to produce coffee beans, meaning that PT. KLC can meet market demand without the problem of lack of mongoose. Final analysis Planning material requirements to determine weekly supply of coffee cherries according to the latest forecast.

Keywords: Supply Chain, Luwak Coffee, Material requirement Planning, Agroindustry, ARIMA, Material requirement planning

1. INTRODUCTION

One of the Civet Coffee producing companies in Indonesia is PT. Cikole Luwak Coffee. This company has been running a business as a Kopi Luwak producer since 2012 and running its business as a Kopi Luwak producer from upstream to downstream from the coffee making process to the delivery of raw materials to the consumer. Civets cultivated at PT. KLC reach 250 for adult civet

PT. KLC cooperates with several travel companies so that foreign nationals visiting Indonesia, especially in the Greater Jakarta area, can enjoy Kopi Luwak directly from the producer. 80% of PT.KLC's biggest income or profit comes from foreign consumers. then it makes consumer demand fluctuate, this affects a lot of Luwak Coffee stock that is not sold in the warehouse (decrease profit), **Table 1.1** shows that in February there was a gap of 81 kg of unsold coffee products, or condition Kopi Luwak products run out of stock to be able to meet consumer demand (lost profit), **Table 1.1** shows that in March there was a gap of 25 kg of coffee products that could not fulfill consumer demand

Tabel 1. 1 Estimated gap in coffee beans sales 2018

Production 2018		
	Februari	Maret
Raw material	375	500
product	281	375
actual purchase 2018	200	400
Gap (kg)	81 kg	25 kg

explains the difference/gap between the production of civet seeds and the actual purchase, which is taken in 2 months March (peak season) and February (normal season). This gap occurs when the projection of Luwak Coffee supply and demand is not correct and causes losses to the company.

2. LITERATURE REVIEW

In previous studies on batik producers where the demand for finished products fluctuates every month. The problem of controlling the inventory of raw materials in batik producers is that there is no scientific calculation method that can be used as a reference for the procurement of raw materials, so there are often shortages and excesses of raw materials. The Material Requirement Planning methodology is used, which is a method of inventory control with a heuristic approach that can provide solutions that are close to optimal quickly and easily. Based on this background, the researchers conducted research on the analysis of the application of the Material Requirement Planning method for optimizing the supply of raw materials in the batik industry (Damayanti, 2018)

Conducting this study investigates the effect of Sales and Operations Planning on supply chain performance using the perspective of coordination and contingency theory. shows that Strategic Alignment of each division and Information is the most significant mechanism enabling good Sales and Operations Planning results. This paper makes a new contribution to the Sales and Operations Planning literature by providing evidence of a theoretical construct (organizational bricolage), which can trigger a re-evaluation of the efficacy of prescriptive Sales and Operations Planning procedures that have been advocated by several researchers and practitioners in Singapore. Through this research, there is information that can be adopted for this research regarding planning in terms of sales and operation of agribusiness distribution channels and

determining cost production strategies in current Luwak Coffee supply chain research, (Shao Hung Goh et al, 2019).

Conducting research on agribusiness in Brazil, shows that the supply chain of agribusiness is very complex. Not limited to crop and livestock management, but includes all equipment, services, and product processing and commercialization. Social and environmental problems, strict regulations, labor shortages and increased competition. These subtleties make planning and decision making difficult. A well-executed Sales and Operations Planning process can help organizations control some of these complexities. However, supporting the Sales and Operations Planning process with advanced analytics is much better, contributing to higher levels of productivity and profitability. Therefore, the previous research will be used as a reference in the preparation of Sales and Operations Planning analysis in accordance with the forecasting reference in the current Kopi Luwak research (Quintanilla Gloria, 2017).

3. METHODS

3.1 Forecasting Method (ARIMA)

In this study, the data of Kopi Luwak which was obtained from PT. KLC will be analyzed, first a forecast calculation or forecasting of civet coffee production will be carried out based on coffee bean sales data for the last 3 years, because data on sales of coffee beans fluctuates using the Arima Forecast method.

Table 3. 1 Civet coffee sales data for the previous 3 periods (2018-2020)

		Januari	Februari	Maret	April	Mei	Juni	Juli	Agustus	September	Oktober	November	Desember
2018	banyak biji Kopi luwak yang di hasilkan perbulan(Kg)	281	281	375	375	375	375	281	281	281	281	281	281
	banyak biji kopi luwak terjual (kg)	220	340	365	306	370	386	330	235	170	233	272	377
	Selisih biji kopi luwak perbulan	61	-59	10	69	5	-11	-49	46	111	48	9	-96
		Januari	Februari	Maret	April	Mei	Juni	Juli	Agustus	September	Oktober	November	Desember
2019	banyak biji Kopi luwak yang di hasilkan perbulan(Kg)	281	281	375	375	375	375	281	281	281	281	281	281
	banyak biji kopi luwak terjual (kg)	195	205	250	300	272	400	245	195	150	282	340	380
	Selisih biji kopi luwak perbulan	86	76	125	75	103	-25	36	86	131	-1	-59	-99
		Januari	Februari	Maret	April	Mei	Juni	Juli	Agustus	September	Oktober	November	Desember	
2020	banyak biji Kopi luwak yang di hasilkan perbulan(Kg)	281	281	375	375	375	375	281	281	281	281	281	281	
	banyak biji kopi luwak terjual (kg)	344	246	323	154	123	102	87	63	72	81	64	71	AWAL COVID
	Selisih biji kopi luwak perbulan	-63	35	52	221	252	273	194	218	209	200	217	210	

The ARIMA (Autogresive Integrated Moving Average) method is a forecasting technique by utilizing past data or previous periods to produce accurate short-term forecasts. Forecasting is an activity to predict what will happen in the future. Forecasting is needed to determine when an event will occur or arise, so that appropriate action can be taken. This applies if the lead time is the main reason for strategic planning in an effective and efficient company. In this study, civet coffee sales forecasting was analyzed using ARIMA so that sales forecasts in the coming year were known, ARIMA forecasting analysis would be used as a production reference.

3.2 Sales and Operational Planning

Sales and operations planning (SNOP) is a process for designing strategic business plans and coordinating plans from various departments. SNOP are cross-functional business plans that involve sales and marketing, product development, operations, and management. Different Supply Chain functions that operate separately can lead to non-optimal results, for example the case where the sales/marketing party lacked coordination with the factory which resulted in changes to the previously planned production schedule being uncontrolled and the wrong stock placement. also results in the distribution of goods to consumers being delayed or inconsistent and not in accordance with the sales needs that have been made by the sales/marketing party. In this study, the analysis of coffee sales, the number of civets needed to produce civet coffee according to the forecast reference and how much production cost is needed by PT. KLC which has just been issued to produce according to the forecast reference.

Table 3. 2 The ability Luwak to produce coffee beans per month

Luwak PT. KLC	250	ekor			
Maksimal Pakan luwak dalam sebulan	2	Kg/ekor			
Minimal Pakan luwak dalam sebulan	1,5	Kg/ekor			
Hasil Kotoran;		Produksi per bulan	**Kemampuan Produksi/bulan**	**Buah kopi yang dibutuhkan**	
Max. produksi biji kopi luwak	1,5	Kg/ekor	375	500	kg
Avg.	1,3125	Kg/ekor			
Min. produksi biji kopi luwak	1,125	Kg/ekor	281,25	375	kg

Table 3. 3 Civet treatment cost details

Rincian biaya perawatan 1 ekor luwak (perbulan)				
Pisang	800 gr x 15 hari	12 kg x 10.000	Rp	120.000,00
Pepaya	800 gr x 15 hari	12 kg x 10.000	Rp	120.000
Ceri Kopi	**200 gr x 8 hari**	**2 kg x 45.000**	**Rp**	**90.000**
Susu segar	100 cc x 12 hari	1,2 lt x 6.000	Rp	7.200
Telur ayam	5 butir x 8 hari	2,5 kg x 21.000	Rp	52.500
Madu	5cc x 12 hari	600 cc x (185.000:650 cc)	Rp	17.000
Daging ayam	200 gr x 4 hari	800 gr x 7.500	Rp	30.000
Vitamin dll	4 hari	4 x 15.000	Rp	60.000
Total biaya Per ekor/Per bulan			Rp	496.700,00

3.3 Supply raw materials method

Analysis of material requirements planning in this thesis, was carried out after knowing the forecast results for civet coffee bean production using time series regression to determine the demand for luwak coffee every month in the future and SNOP (Sales and Operation Planning) analysis was carried out to identify the maximum supply of raw materials and the lowest cost. needed to produce civet coffee products at PT. KLC based on forecast results, then analyzed the supply needs of coffee cherry raw materials at PT. KLC where coffee cherries are experiencing a seasonal harvest period, in planning the supply needs of coffee cherries, the needs of coffee cherries are analyzed using material requirement planning, the supply of raw materials that is not optimal makes the supply of raw materials and demand at PT. KLC unbalanced resulting in many products that settle in the warehouse and also run out of products to meet consumer demand.

Table 3. 4 previous period raw material supply data

	Keterangan	Januari	Februari	Maret	April	Mei	Juni	Juli	Agustus	September	Oktober	November	Desember	
2020	banyak supply buah Kopi (Kg)	340	361	506	530	500	499	360	398	400	405	422	401	Musim panen
	banyak buah kopi yang di konsumsi luwak (kg)	400	400	400	400	400	400	400	400	400	400	400	400	
	banyak buah kopi yang tdk terpakai *kadaluarsa buah kopi 1,5 hari (kg)	50	50	50	50	50	50	50	50	50	50	50	50	

4. RESULTS

Forecasting data on Luwak coffee sales for the next 12 months are shown in **Table 4.1**, Based on the results of ARIMA forecast analysis, demand frequency tends to increase. It can be seen that in the first month the forecast value was 105,904 kg until month 12, the forecast value was 212,729 kg.

Table 4. 1 Forecast ARIMA sales kopi luwak next period

HASIL FORECAST	
Bulan Prediksi	**FORECAST**
1	105,904
2	131,987
3	151,644

In **Table 3.3** previously it was known the cost needed to care for 1 civet in a month, then the Sales and operations planning production cost for forecast shown in **Table 4.2** identifies the total cost that must be spent by PT. KLC for care and food for PT. KLC civet during produce civet coffee products according to the forecast reference.

Table 4. 2

Set A	Operation		
	January	February	March
Sales			
Forecast (In Rp)	Rp 370.664.484,52	Rp 461.953.849,46	Rp 530.752.278,55
(In kg)	105,9	132,0	151,6
Actual (In kg)			
Difference Month			
Difference Cumulative			
Operations			
Plan (In kg)	105,9	132,0	151,6
(In Luwak)	85	106	121
Number working days /month	25	25	25
Actual (In 1,000 units)			
Difference month			
Difference cumulative			
Inventory			
Plan (In 1,000 units)	0,0	0,0	0,0
(In 1,000 $)			
Cost of :	January	February	March
Hiring	0	21	16
Layoffs	165	0	0
Waste Cost (No Inventory Cost)	-Rp 0,00	-Rp 0,00	-Rp 0,00
Production Cost	Rp 42.082.068,45	Rp 52.446.280,46	Rp 60.257.064,40

Sales and operations planning from shown in **Table 4.2**, the largest production cost was in the 3rd month, namely Rp. 60,257,064 maintenance costs for 121 civets that work to produce civet

coffee products according to the forecast with coffee bean production of 151.6 kg, earning a gross profit of Rp. 530,752,278 which was obtained by PT. KLC, then the production cost that must be issued by PT. KLC every month is 11%.

Table 4. 3 Material requirement planning for cerry coffee (raw material)

Part Number		1	2	3	4	5	6	7	8	9	10	11	12
Biji Kopi	gross requirements	35	35	35	35	44	44	44	44	51	51	51	51
	scheduled receipts												
	projected available												
	net requirements												
	planned order receipt	35	35	35	35	44	44	44	44	51	51	51	51
	planned order release	35	35	35	35	44	44	44	44	51	51	51	51

PT. KLC has a separate warehouse to store its products, starting from the raw material warehouse, the green bean warehouse and the civet coffee bean finished product warehouse. The supply of coffee cherries for the next 3 months forecast is shown in **Table 4.3**, where there is a supply of coffee cherries that must be provided and ordered every week by the company.

5. CONCLUSION

- **Demands**, ARIMA forecast time series regression technique is an alternative solution for the case experienced by PT. KLC for fluctuating demand, it can avoid the lost profit condition experienced by the company where Kopi Luwak stock does not meet demand because previously the company did not implement a strategy in terms of sales management and forecasts. and reduce the decrease in profit condition where 70% of the product is sold to coffee collectors due to the coffee beans being deposited in the warehouse which causes a decrease in the quality of the coffee beans, so this condition can be minimized by using Forecast analysis. Material requirement planning and Sales and operational planning (SNOP) can maximize seasonal coffee cherries, meaning that to make coffee bean products with a forecast reference, it does not require all the civets to produce according to the target, so when the supply of coffee cherries decreases or the civet is in a state of breeding / lust, from There are 260 tails, so the production needs can still run according to the forecast
- **Supply,** In this study, it is known that the expiration date of coffee cherries based on a real case experienced by PT KLC, the lifetime of coffee cherries is only limited to 1.5 days where coffee cherries sent in the morning must be fed with civets, if there are coffee cherries left the next day the fruit it's rotten. PT. KCL needs coffee cherries that are ready if the demand for civet coffee increases every month. Based on interviews and analysis in this thesis, so that coffee cherries can last longer than their previous expiration date, the company must prepare a Cold Storage or Chiller room with low temperature conditions between 10C to 100C which is usually used to store fresh food such as fruit. This cold storage can also extend the shelf life of the fruit up to 60 days (2 months), so when the demand for civet coffee is high and the condition of the coffee cherries is not during the harvest season, PT. KLC can get coffee cherries ready to use at any time. This suggestion is expected to be an input for companies related to the problem of seasonal coffee fruit supply

REFERENCES

Aksan Ilham, Khalilah nurfadilah, (2020). Aplikasi Metode Arima Box-Jenkins Untuk Meramalkan Penggunaan Harian Data Seluler. Program Studi Matematika, Universitas Islam Negeri Alauddin Makassar, Indonesia

AMOSOV (2014). A Forecast of the Situation in the Agro-Industrial Complex to the Year 2003

Bachtiar, Setiadevi (2019). Forecasting Analysis of Organic Red Rice's Demand Using Artificial Neural Networks**.**

Box, George; Jenkins, Gwilym (1970). Time Series Analysis: Forecasting and Control

Chopra, Sunil., and Meindl, Peter. (2016). *Supply Chain Management: Strategy, Planning and Operation* (Sixth ed.). United States of America: Pearson Education, Inc.

Damayanti, (2018). ANALISIS PENERAPAN METODE SILVER MEAL UNTUK OPTIMALISASI PERSEDIAAN BAHAN BAKU DI INDUSTRI BATIK

Gimenez, C. dan Ventura, E. (2003). Supply Chain Management as a Competitive Advantage in the Spanish Grocery Sector. The International Journal of Logistics Management, Vol 14, No 1.

Ibrahim dan Zailani. (2010). A Review on the Competitiveness of Global Supply Chain in a Coffee Industry in Indonesia. Universitiy of Sains Malaysia. International Business Management 4 (3): 105-115, 2010

Ikhwan. (2013). Genetic diversity and correlation of bean caffeine content with cup quality and green bean physical characteristics in coffee (Coffea arabica L.). *Journal Sci Food Agric* [online], 88 (5), 1726–1730.

N Pujawan, MM Arief, B Tjahjono, D Kritchanchai. (2015). An integrated shipment planning and storage capacity decision under uncertainty: A simulation study, International Journal of Physical Distribution

Pujawan, (2005). Supply Chain Management, Surabaya.

Pujawan, (2008). Schedule instability in a supply chain: an experimental study Scholar articles, International Journal of Inventory Research.

Pujawan, (2010). Supply Chain Management | vol: | issue: | 0000

Pujawan, Kurniati, Wessiani. (2009). Supply chain management for Disaster Relief Operations: principles and case studies International Journal of Logistics Systems.

Pujawan, Mahendrawathi. (2017). Supply Chain Management. Edisi 3 | vol: | issue: | 0000

Putra, Pujawan, Arvitrida. (2011). Peramalan Permintaan dan Perencanaan Produksi dengan Mempertimbangkan Special Event di PT. Coca Cola Bottling Indonesia.

Quintanilla Gloria (2017). *Sales and Operations Planning* in Agribusiness: How to Harvest the Benefits with Advanced Analytics

Shao Hung Goh (2019). Sales and Operations Planning: The effect of coordination mechanisms on supply chain performance.

Sinaga, Fernando, (2020), Material Requirement Planning (MRP) dalam proses perencanaan dan pengendalian produksi pembuatan ragum

Wei Chiang Hong, (2006). Short-Term Load Forecasting by Artificial Intelligent Technologies

Wei Chiang Hong, (2006). Hybrid Intelligent Technologies in Energy Demand Forecasting

RISK MANAGEMENT ANALYSIS FOR INFORMATION TECHNOLOGY BASED ON COBIT FRAMEWORK IN E-PROCUREMENT SYSTEM (A CASE STUDY OF PT.XYZ)

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ABSTRACT

PT XYZ is a company engaged in the field of electricity generation, the main objective of its business operations is to provide a sustainable electricity supply efficiently. Suppliers have become strategic business partners who play an important role in ensuring the availability of supplies of goods and services. E-Procurement systems allow greater flexibility to control every aspect of the purchasing process, and offer advantages such as increased competitiveness, reduced procurement costs, improved user satisfaction, and provided long-term relationships with potential suppliers. The implementation of E-Procurement is required substantial changes to the organization's internal business processes. The likelihood of cyber-attacks against E-Procurement systems has increased. Based on these conditions, IT risk management plays a crucial role in minimizing potential losses COBIT 2019 helps the company to create an optimal IT value by maintaining a balance between realizing benefits, optimizing risk levels, and utilizing the resource. In this research, the author conducted a risk management analysis in the E-Procurement system based on the COBIT 2019 framework of risk management domains, EDM03 (Ensured Risk Optimization) and APO 12 (Managed Risk). The gap between actual and expected capability levels is used to formulate risk mitigation recommendations to improve the capability level to meet stakeholder expectations.

Keywords: E-Procurement, COBIT 2019, IT Risk Management, Capability Level, Risk Assessment, Risk Mitigation.

1. INTRODUCTION

The availability of electrical energy supply has played an important role in human life. It has a major influence on the development of a country in the social and economic aspects. PT XYZ is a company engaged in power generation that contributes to the development of the national economy by supplying reliable electrical energy. Within its business activities, the suppliers have become important business partners to ensure the availability of goods and services needed by the company. The implementation of E-Procurement is one of the company's strategic actions to ensure the availability of the goods and services needed.

According to David Caffey (2009), E-Procurement is procurement activities that are integrated using an electronic system for all aspects of purchasing/procurement process using internet technology. E-Procurement is a form of e-commerce for the intermediary of goods and

services used for tendering of goods and services that automates all activities in the procurement process such as storing requests, management approvals, authorizations, and interfaces with the company's financial system. Many benefits can be realized by applying E-Procurement (Caffey, 2009) including the potential to reduce direct costs, which is achieved by increasing efficiency in the procurement process. Process efficiency is defined as less time used by employees to search for goods and services, authorization, approval, and order. This makes it possible to reduce the number of staff processing each order by automatic validation of pre-approved budgets for each person and each department and by lowering the printing and paper costs of order forms and invoices.

Technology-based applications have the potential to improve the quality and speed of service in the logistics industry. However, the adoption of internet-based technologies has increased cyber attacks in the logistics environment. The attacks can have a negative impact on logistics and overall supply chain performance (Cheung & Michael G.H. Bell, 2021). As digitalization continues to develop, supply chains also benefit from digitalization to be able to compete globally. Cyber risk is one of the biggest potential obstacles in the digital supply chain process, this causes every element in the supply chain to be at risk starting from company data, process flows, and information from relevant stakeholders (Filho, et al., 2021).

Risk management is a method for dealing with future risks that may affect the company's activities. This process begins with identifying possible future events, assessing the risks they pose, determining responses to them, and monitoring the progress of those responses. COBIT 2019 is used as a basis or framework for assessing IT governance in an organization. Based on ISACA, the core COBIT model related to specific IT risk management is the domain EDM03 Ensured Risk Optimized and APO12 Managed Risk (ISACA, 2018).

2. LITERATURE REVIEW

In their paper, Kishor Vaidya (2006) introduce the concept of critical success factors (CSF) for e-procurement initiative success and documented the variables that could determine the success or failure of an e-procurement project. There are not only Information and Technology-related variables such as system integration and data security, but also human factors including user training, business process, and change management. The top management support is crucial for the success of the e-procurement project.

Due to reducing the risks, the IT governance process is needed for companies to decide what and how to use their IT resources to achieve the expected business benefits. The concept of IT governance process capability is defined as the company's ability to identify, design, implement and utilize the following IT governance processes including IT decision making, IT planning, IT infrastructure modernization, IT service delivery, and IT management (Joshi et al., 2021).

According to Joshi, et al., (2021), for many organizations, the implementation of IT governance is challenging, not only about changing the organizational internal business processes and IT infrastructures but also the need to change human behavior.

This statement was also identified by Masudin, et al., (2021). To be more beneficial the effectiveness of the e-procurement process is influenced by senior management support and data quality.

In previous research about the Control Objectives for Information and Related Technology (COBIT) as a risk assessment framework, COBIT is capable to provide comprehensive information security governance. Wolden, et al., (2015) conducted a study on the effectiveness of the implementation of information security framework governance using COBIT in reducing the risk of cyber attacks in supply chain management. The results show that the COBIT framework

provides a new dimension for IT security governance through strict policies and rules that further strengthen the security of IT applications within the enterprise. Overall the organization benefits from implementing security measures with the COBIT 2019 framework in supply chain management systems and ERP systems.

Research performed by Sari Agustin Wulandari (2019) is based on COBIT 5 for Risk and COBIT 5 Enabling Process conducted a risk assessment in helpdesk activity. The research focused on the DSS01 domain for operational procedures and APO12 for managing risks. The result is that COBIT 5 could minimize the impact of the risks by identifying the risk factors of staff operation, IT expertise and skill, information, ineffective business ownership of IT, regulatory compliance, program/project lifecycle management, and IT investment decision.

3. METHODS

The subject of the research is the implementation of an E-Procurement system in a power generation company in Indonesia. The main goal of the research is to develop a comprehensive risk analysis using the COBIT 2019 framework. The research was focused on COBIT practices domain APO12 and EDM03.

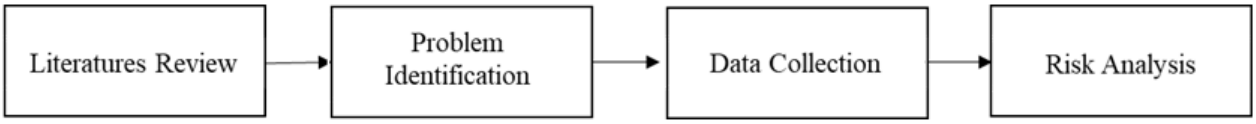


Figure 1. Methodology

The methodology for this research consists 4 of steps :

1. *Literature review phase*
   Literature study by looking for previous research with a similar topic related to COBIT for Risk that was carried out from various types of books, journals, and theories regarding COBIT 2019.
2. *Problem identification phase*
   Finding problems related to IT risk management in the E-Procurement system used by the Purchasing department of PT. XYZ is based on the COBIT 2019 domain EDM03 *Ensured Risk Optimization* and APO12 *Managed Risk*.
3. *Data collection phase*
   Data is identified, labeled, and recorded during the collection phase from potentially relevant sources. RACI chart was determined to involve a matrix of the roles and responsibilities of the respondent. The related forms and quizionair are made for data collection and observation. In this phase, the main goal was to transform the data collected into something useable to measure the level of capability of COBIT 2019 in the E-Procurement system.
4. *Risk analysis phase*
   The systematic risk management analysis started with the risk identification stage. The Risk will be analyzed by the probability and consequence, risk impact, and prioritization. A gap analysis was measured by comparing as-is conditions and expected capability levels in domain EDM03 and APO12. The recommendations of risk mitigation strategies are taken to minimize the potential impact.

4. RESULTS

4.1 Capability Level

Based on the assessment of Design Factor 1 (Enterprise Strategy) to Design Factor 10 (Technology Adoption Strategy) the result was that there were 40 processes in the Cobit 2019 domain. The main priorities of IT governance are domains with an importance weight of more than 75% to be objective that require a level of capability/capability at level 4. This research concluded that there are with recommendation level is 4 :

- EDM03 - Ensured Risk Optimization (Importance 75%)
- APO12 - Managed Risk (Importance 100%)

Table 1. Selected COBIT domains

Core Model	**Priority**	***Target Level***
EDM03—Ensured Risk Optimization	75 %	4
APO12—Managed Risk	100 %	4

Through observation, documentation, and interviews with the respondents in the company, several things can be concluded.

Table 2. Capability level domain EDM03

Capability Level	Participant 1	Participant 2	Participant 3	Participant 4	Participant 5	Final Capability
Level 1	F	F	F	L	F	**Level 2**
Level 2	L	F	F	F	F	
Level 3	L	L	L	L	F	

The final capability level achieved in the domain EDM03 is level 2. That indicates the IT risk management activities have been carried out and supported by the top management, but still need some improvements to meet the expected level of capability.

Table 3. Capability level domain APO12

Capability Level	Participant 1	Participant 2	Participant 3	Participant 4	Participant 5	Final Capability
Level 1	F	F	F	F	F	***Level 3***
Level 2	F	F	L	F	F	
Level 3	L	F	F	F	F	

Level 4	L	L	L	L	L	

The final capability level achieved in the APO12 domain is 3 (Defined), a risk management system has been built and implemented to identify, measure, analyze and report IT risks using defined processes to achieve the expected results.

Table 4. Capability Level Scale

Scale	Description	Achievement (%)
N	Not Achieved	0% - 15%
P	Partially Achieved	>15% - 50%
L	Largely Achieved	> 50% - 85%
F	Fully Achieved	> 85% - 100%

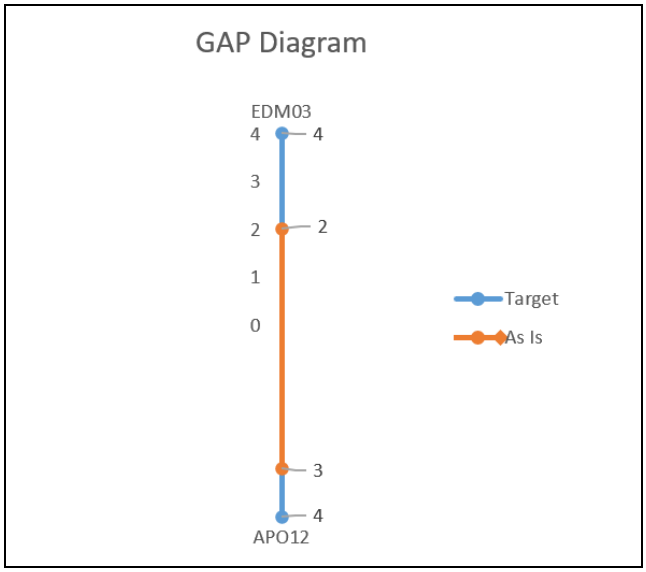


Figure 2. COBIT gap diagram EDM03 & APO12

After analyzing the level of IT process capability, there is a difference between the current level of capability (as is) and expected (to be). The gap between the current capability and the expected target in domain EDM03 and APO12 will be used to define improvement recommendations.

Table 5. Gap capability level

Goal	COBIT Domain	Current Level	Target Level	Gap
Governance	EDM03—Ensured Risk Optimization	2	4	2
Management	APO12—Managed Risk	3	4	1

4.2 Risk Analysis

Referring to Kishor Vaidya (2006), there are Critical Success Factors (CSFs) that may have an impact on the successful implementation of the E-Procurement system. The provided CSF variables will help identify risk scenarios associated with the successful implementation of E-Procurement. CSF variable mapped with related IT assets is described in the table below.

Table 6. E-procurement Critical Success Factor

IT Asset	**E-procurement CSF (variable)** *(Kishor Vaidya, 2006)*
Information	Integration between Systems
	Performance Measurement (KPI)
Infrastructure	Document Security and Authenticity
	Technology Standard
Process	Alignment with the best practices of business processes
	Restructuring the procurement process
	Support from top management
	Change management
	E-Procurement implementation strategy
Human Resources	Understanding and training for users
	Adoption by supplier

This research found there are 48 risks grouped into 11 risk scenarios and 6 asset categories, that affected the implementation of an e-procurement system. Based on the IT asset category, the Human Resource factor has the biggest risk contribution followed by the IT Infrastructure factor.

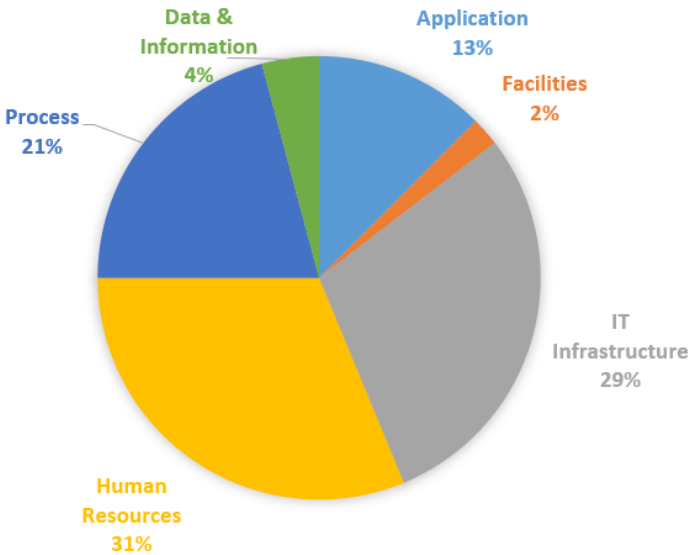


Figure 3. Risks categorized by IT Assets

Based on the evaluation result of information system risk management in the form of mitigation measures undertaken can be summarized by risk scenario. The top 3 categories are Software adoption/usage problems, IT expertise skills & behavior, and Third-party/supplier incidents.

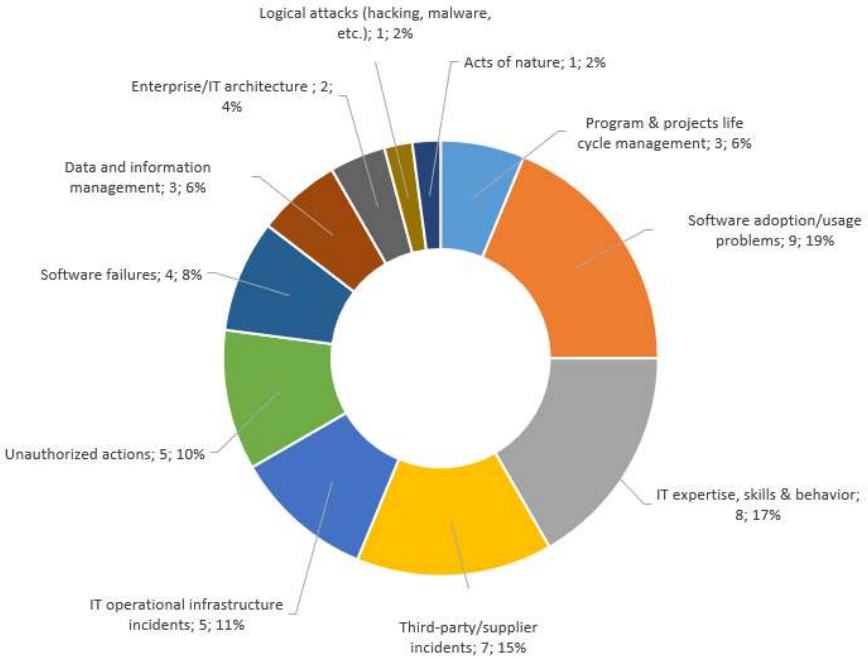


Figure 4. Risks summarized by risk scenario

Table 7. Risk Scenarios

No	Risk Scenario	Risks Total	Percentage (%)
1	Program & projects life cycle management	3	6,3
2	Software adoption/usage problems	9	18,8
3	IT expertise, skills & behavior	8	16,7
4	Third-party/supplier incidents	7	14,6
5	IT operational infrastructure incidents	5	10,4
6	Unauthorized actions	5	10,4
7	Software failures	4	8,3
8	Data and information management	3	6,3
9	Enterprise/IT architecture	2	4,2
10	Logical attacks (hacking, malware, etc.)	1	2,1
11	Acts of nature	1	2,1
Total		48	100

4.3 Risk Response

IT-related risk must not exceed risk appetite and risk tolerance. Risk appetite helps the management of a company to make risk-informed decisions. Risk appetite is the basis for determining risk tolerance. The determination of PT XYZ's Risk Appetite is as follows:

- Low and very low levels of risk are acceptable and no risk mitigation process must be carried out,
- Risks with moderate, high, and very high categories must be handled to reduce the level and impact of the risk.

Table 8. Risk Level

Risk Level	**Risk Range**	**Action**
Very High	20-25	Immediate action is needed to manage the risk that occurs
High	11 – 19	Action is needed to manage risk
Medium	5 - 10	Action is taken when resources are available
Low	1 – 4	Action is taken if needed

Risk tolerance is the level of variation in relative risk events that can be accepted for the achievement of the company's/organization's strategic goals or the level where the risk events that occur will not interfere with the achievement of the company's/organizational goals. After determining the Risk Appetite and Risk Tolerance, a matrix table can be made containing the possibility, impact, and the multiplication of impacts and risks.

		Impact				
		1 Trivial	2 Minor	3 Moderate	4 Major	5 Extreme
Probability	5 Very Likely	R14, R23, R34,				
	4 Likely	R43, R45, R47				
	3 Moderate	R7	R10, R37, R41, R11, R15, R40, R8, R9	R17, R19, R30, R31, R35, R4, R5, R21	R24	
	2 Unlikely	R1, R2	R18, R22, R26, R27, R3, R32, R38, R6	R20, R25, R39	R12, R13, R16, R36, R33	R21, R46, R48
	1 Rare	R28	R29, R42, R44			

Figure 5. E-Procurement Risk Map

There are found 4 risks with a High-risk level including IT security issues, human resource factors, and system integration. Data security risks are increasing in the ever-growing cyber threat landscape. All of these risks are recommended to be mitigated. COBIT 2019 process mapping for mitigation are APO03 (Managed Enterprise Architecture), APO13 (Managed Security), and APO07 (Managed Human Resource).

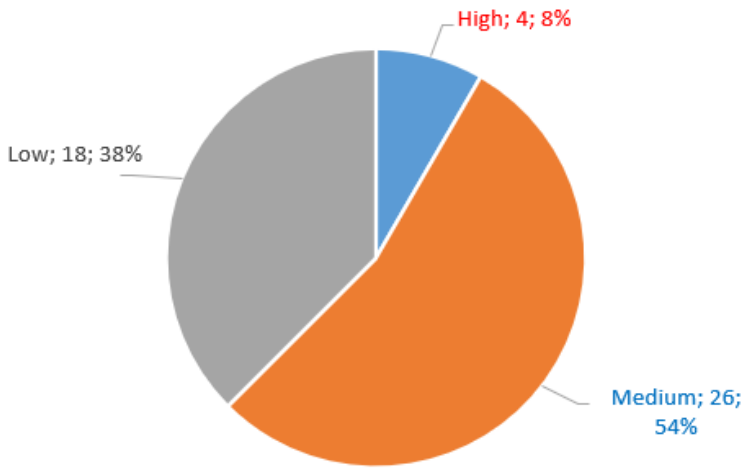


Figure 6. Risks by Priority

Table 9. High Priority Risk Response

ID	Risk	Risk Response	COBIT 2019 Process Mapping	Recommendation Action
R24	Integrate Failure with the ERP system, which causes the procurement process to be hampered	Mitigate	APO03 — Managed Enterprise Architecture	Provide contract support between ERP system consultants and E-Procurement system vendors to ensure smooth integration with the ERP system
R21	Data theft by hackers	Mitigate	APO13 — Managed Security	Improve security protection mitigation from the technology side by updating infrastructure and network. As well as awareness of human resources to prevent social engineering
R46	Leakage of sensitive commercial reports due to employee negligence	Mitigate	APO07 Managed Human Resource	Conduct awareness regularly to improve safe behavior in using the E-Procurement system
R48	Leakage of sensitive information by unauthorized persons due to inefficient storage/archiving/disposing of information	Mitigate	APO13 — Managed Security	Monitor and evaluate IT data storage infrastructure and update governance standards for document confidentiality classification

Weighting the recommendations by considering the Business Impact Analysis (BIA) can help decision-making in ensuring the recommendations can be implemented properly. Prioritization is not only by the size of the impact and the likelihood, but also by other factors such as costs, resources, and time available for risk response (Ward, 1999).

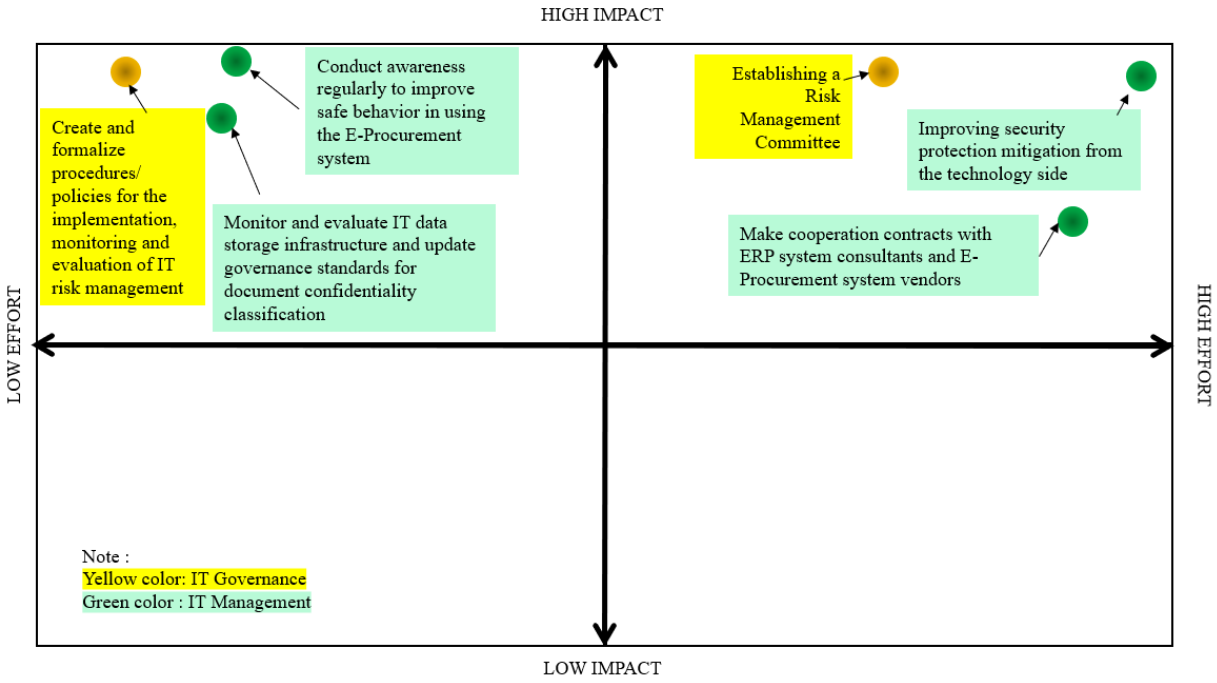


Figure 7. Recommendation map based on BIA

6. CONCLUSIONS

Based on the analysis of the risk that has been carried out on the E-Procurement system at PT XYZ using the COBIT 2019 framework, concluded:

1. *IT Governance*

The achieved capability level domain EDM03 (Ensured Risk Optimization) is 2 (Managed). IT risk management activities have been carried out, however, requires continuous improvement. For a successful risk management program, the company needs to involve aligning risk initiatives with existing company values, and policies convincing everyone involved that risk management is worthwhile. Continuous improvement of IT governance is required top management support by providing a Risk Management Committee to act as an extension of the Board of Directors regarding the implementation of IT risk management.

2. IT *Management*

Based on the analysis, the achievement of the capability level domain APO12 (Managed Risk) is 3 (Defined), which indicates that IT risk management is implemented to identify, measure, analyze and report by using a defined process to achieve the expected results. There are 48 IT risks identified in the e-procurement system used in the online procurement of goods and services. The risk of human resources (HR) readiness is a dominant factor to achieve the goal, followed by adequate IT infrastructure and security factors to support the defined business processes. IT security risks need to be mitigated by IT infrastructure security standards and it is necessary to increase IT security awareness for the use of the e-procurement system, both by company employees, as well as partners who use this system. Integration of the e-procurement system with the Enterprise Resource Planning (ERP) software is one of the determinants of successful implementation so that the tender process is faster and more efficient.

REFERENCES

Caffey, D., 2009. *E-Business and E-Commerce Management.* s.l.:s.n.

Cheung, K.-F. & Michael G.H. Bell, J. B., 2021. Cybersecurity in logistics and supply chain management: An overview and future research directions. *Transportation Research Part E: Logistics and Transportation Review,* Volume 146.

Filho, N. G., Rego, N. & Claro, J., 2021. Supply chain flows and stocks as entry points for cyber-risks. *Procedia Computer Science,* Volume 181, pp. 261-268.

ISACA, 2018. *COBIT 2019 : Framework Introduction and methodology.* 2018 ed. United States of America: ISACA.

ISACA, 2018. *Designing an Information and Technology Governance Solution.* Illinois: ISACA.

ISACA, 2018. *Self-assessment Guide: Using COBIT® 5.* Illinois: ISACA.

Joshi, A. et al., 2021. Impact of IT governance process capability on business performance: Theory and empirical evidence. *Decision Support Systems,* Issue 113668.

Kishor Vaidya, A. S. M. S., G. C., 2006. CRITICAL FACTORS THAT INFLUENCE E-PROCUREMENT IMPLEMENTATION SUCCESS IN THE PUBLIC SECTOR. *JOURNAL OF PUBLIC PROCUREMENT,* 6(1 & 3), pp. 70-99.

M.R.Fazlida & Said, J., 2015. Information Security: Risk, Governance and Implementation Setback. *Procedia Economics and Finance,* Volume 28, pp. 243-248.

Masudin, I., Aprilia, G. D., Nugraha, A. & Restuputri, D. P., 2021. Impact of E-Procurement Adoption on Company Performance: Evidence from Indonesian Manufacturing Industry. *MDPI Logistics.*

Sari Agustin Wulandari, A. P. D. M. R. P. D. I. S. M. M. S., 2019. Risk Assessment and Recommendation Strategy Based on COBIT 5 for Risk: Case Study SIKN JIKN Helpdesk Service. *Procedia Computer Science,* Volume 16, pp. 168-177.

Supriyadi, Y. & Hardani, C. W., 2018. Information System Risk Scenario Using COBIT 5 for Risk And NIST SP 800-30 Rev. 1 A Case Study. *IEEE.*

Wolden, M., Valverde, R. & Talla, M., 2015. The effectiveness of COBIT 5 Information Security Framework for reducing Cyber Attacks on Supply Chain Management System. *IFAC-PapersOnLine,* 48(3), pp. 1846-1852.

SUPPLY CHAIN PERFORMANCE AND MANAGEMENT ANALYSIS USING SUPPLY CHAIN OPERATIONAL REFERENCE (SCOR) 11.0 IN AGRICULTURE SECTOR: CASE STUDY OF PT RAJATANI AGRO NUSANTARA

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ABSTRACT

The main objective of this research is to evaluate PT Rajatani Agro Nusantara's supply chain process with the commodity of fresh vegetables to the catering industry by using Supply Chain Operational Reference (SCOR) 11.0. This study will identify the process using SCOR Level 1, 2, and 3, to obtain the root of the problem in the company's supply chain process which is then analyzed for causes and mitigations. Sales data specifically on supply chain activities related to the catering industry were used. As supporting material, interviews were conducted with the company's internal to evaluate the identified causal factors. The results of this study show that there are gaps in 3 metrics that are not yet optimal. Order Fulfillment Cycle Time (OFCT) and Supply Chain Response Time (Source Leadtime) each with a gap of 1 day. Cash-to-cash cycle time (C2C) with a gap of 2-4 days. Meanwhile, the Perfect Order Fulfillment (POF) has exceeded the company's target of 99.77%. It was identified in SCOR Level 3 that the root cause of the problem was the delay in payment from the buyer and the delay in the goods preparations due to several factors which are obtained through an interview with company's internal.

Keywords: Performance Analysis, Supply Chain Operational Reference, SCOR, Revision 11.0, Rajatani, Fresh Vegetables Supply Chain, industry catering.

1. INTRODUCTION

Globalization makes markets more competitive, thus adding value to a product or service is well-advised. As a country gets more populated, food demand gets higher, agriculture sector production needs to be increased, with it is attracted a lot of attention, competitive is fiercer as a lot of new competitors also joined in. A higher competitive market means that increasing competitiveness in terms of production effectivity and efficiency is important while increasing product quality and service toward clients/buyer is another important thing to be considered as well (Worldbank, 2005). Supply chain is a process that transfers information and materials from and to the process of manufacturing/service in a company (Jacobs and Chase, 2014). Because agricultural products are perishable, they have risk in distributing from farmers to end customers. In addition horticulture commodities (vegetables, fruits, ornamental plants and medicinal plants) price is fluctuated overtime. For example, in January 2020, monthly average price of Big Red Chili (TW) per kilogram in Kramat Jati Central Market (DKI Jakarta) was Rp. 60,032,- in

February was Rp. 64,345,- and in March was Rp. 45,000,- (Pasar Jaya, 2020). Many factors cause fluctuating commodity prices phenomenon, including the length of the food supply chain, the difficulties in distribution, low efficiency in the distribution process, especially across island food distribution, and the presence of speculators and cartels in certain commodities is also a classic problem that can affect the selling value in the market (Satya, 2016). Improving efficiency can be integrated in the company's supply chain. Supply chain management (SCM) could integrate operational management functions in relation to the company to form a complete system and support each other. The key to effective SCM is having the supplier as a partner in the company's strategy to fulfill fluctuating market (Heizer & Render, 2005). Suppliers that are not well-managed could possibly lead to delayed raw materials to the company, due to decreased supplier performance and no transparency over the price. One of the agricultural companies that already applied the SCM concept in their business model is PT. Rajatani Agro Nusantara (Rajatani). In their company profile, they stated that they handled from cultivation until it is served to buyer/client. Focusing on their main business in supplying several catering industries, they have unique SCM in which buyer/client could buy their product for years with a fixed price, while the price of agriculture's raw materials mostly fluctuated, hence if not handled carefully it can lead to massive loss.

PT. Rajatani Agro Nusantara is an agriculture company that supplies retail, wholesale markets, wet markets, and their specialty in supplying for the catering industry. They have been sustained in the market for more than ten years. Especially in the catering industry supply, they claim that they can give a contract within a certain period with a flat price. By analyzing their supply chain, it can be known regarding the performance and management of their supply chain model. Analyzing the supply chain model will be conducted by using the Supply Chain Operational Reference (SCOR) 11.0. The first step to increase the effectiveness and efficiency of the business is by assessing the business performance. By knowing the performance, then management could take a more precise step to increase their business productivity. In addition, there are many sectors in the past research with a case study of several companies such as cement industry, coal industry, et cetera regarding supply chain management and performance, but still in few numbers in the agriculture sector. Another purpose of this study is to advance understanding of the supply chain management and performance in the agricultural sector by using PT Rajatani as a case study and also to initiate another research in the agricultural supply chain.

2. LITERATURE REVIEW

Supply Chain Management (SCM) is the dynamic organization of supply chain activities to maximize client esteem and achieve a sustainable upper hand. It represents an insightful effort by the supply chain firms to create and run supply chains in the best and most effective manners possible. Supply chain activities spread everything from creation, logistics, item improvement, and sourcing, just as the data frameworks organize these activities (SCRC, 2017). Supply chain management is defined as all activities that include the delivery of goods from raw materials to consumers, including the procurement of raw materials and parts, manufacturing and assembly, inventory tracking and warehousing, order management and order entry, distribution through channels, delivery to customers, and the information systems needed to monitor the entire activitiy. Meanwhile, according to Simchi-Levi et al. (2004), supply chain management is a set of approaches that are used to efficiently integrate suppliers, manufacturing companies, warehouses, and stores, until the goods are produced and distributed, at the right quantity, time and place with the goal of minimizing costs while meeting the service level.

According to Furqon (2014), agricultural commodity supply chain management is not the same as non-agricultural commodity supply chain management since it identifies with the idea of transitory agrarian items, additionally, the way toward planting, growth, and harvest relies upon climate and season, and yields have varying shapes and sizes. These variables must be considered in the plan of agricultural commodity supply chain management to acquire a thorough, powerful, effective, responsive, and sustainable supply chain system. According to Maye, *et al*. (2018) due to relatively fast and cash in payment, wholesale markets, wet markets, and retails are typically markets that will be supplied by many farmers, but oppositely there are uncertainties in these markets. Farmers or suppliers that supply these market is very dependent on the end-consumer thus the risk is relatively high. The market potential of agricultural commodities is not only limited to the sale on free markets such as wholesale markets, wet markets, and retails. Another potential market is captive markets such as supply activities for the foodservice industry. One of the requirements to be a supplier of the catering industries is the ability to maintain price and quantity in a based-time contract. In order to sustain the upper hand in these turbulent business conditions, it is broadly perceived that agri-food company needs to take an interest in the demand-driven supply chain that can adjust deftly to changes in the commercial center. To increase the upper hand in the long haul, improvements in the market should be recognized, seen, and converted into strategy, and afterward into assets that make customer value (Hult et al., 2007).

Measurement of the supply chain performance by the SCOR model is the most comprehensive, well recognized in various industries and has been used by many companies to improve supply chain management (Kocaoğlu et al., 2013). The SCOR model provides a systematic approach to explaining, classifiying, and evaluating complex supply chain process (Erkan and Baç, 2011). According to Pujawan (2005), the SCOR model coordinates three principal components in management, namely business process reengineering, benchmarking, and process measurement into the supply chain. Respectively the functions are business process reengineering, benchmarking, and process measurement. The last version of the SCOR model, published by Supply Chain Council describes the following processes of the first-level supply chain for each organization: Plan, Source, Make, Deliver, Return and Enable. According to SCC (2012), Plan is a procedure that adjusts demand and supply to decide the best game plan in meeting procurement, production, and delivery needs. Source is the way toward getting products and services to fulfill needs. Make is a procedure for changing crude materials into items that clients need. Deliver is a procedure to fulfill the need for goods and services. Return is the way toward returning or getting an item returned for different reasons. Activities included incorporating distinguishing proof of item conditions, mentioning approval for imperfect returns, booking returns, and making returns. Besides having the five core processes, SCOR has a performance attribute. A performance attribute is a set of attributes used to assess supply chain processes from a variety of different perspectives. There are five attributes used in evaluating the performance of the supply chain by using the SCOR method. Reliability, Responsiveness and Agility are considered customer-focused. Cost and Asset Management Efficiency are considered internal-focused. All SCOR metrics are grouped within one of the performance attributes.

3. METHODS

The design used in this study was non-experimental. Non-experimental research is a systematic empirical study in which the researcher cannot directly control the independent variables because their manifestations have emerged, or because the nature of the variables does not allow them to be manipulated (Kerlinger, 2006). This study utilizes a quantitative approach. All data taken from PT Rajatani Agro Nusantara. The data is the performance of the vegetable

supply chain limited to catering industry customers and continued to measure with SCOR Level 1, Level 2, and Level 3. Primary and secondary data are used in this study. The primary data information is gotten through observation in the organization which straightforwardly handles the acquirement procedure for raw materials, and by interviewing informants that legitimately deal with and directly manage all the supply chain activities. The secondary data information, are the sales data to get an idea of overall demand, the logistic data to capture the historical activities for raw material procurement, the warehouse data to understand the inventory policy, as well as the financial data to capture the company has experienced. All secondary data is recorded from 2017 until 2019 and supported by interview with Director of Operations of PT Rajatani.

This study uses several stages in identifying the company's operational performance. The main approach used is the Supply Chain Operational Reference (SCOR). This approach aims to analyze the company's operational performance from the secondary data that has been obtained. The SCOR hierarchically defines the processes and activities of SCs and is organized around five primary processes: plan (sP); source (sS); make (sM); delivery (sD); and return (sR) (Ramos, Manotas & Osorio, 2019). The data proceed with an assessment of the supply chain performance by using SCOR 11.0 which comprises of the levels as follows:

3.1. *SCOR Level 1*

The objective of level 1 is to portray the main scope and configuration of the supply chain, also assess strategic metrics against the organization’s objectives or benchmark data. The performance target of the supply chain is determined as the basis for contending in the market. The extent of discussion of SCOR Level 1 includes six primary management processes, namely plan, source, make, deliver, return, and enable.

The performance attributes along with the strategic metric to be evaluated are determined. Concerning the client-centered performance attribute, reliability is utilized as one of the attributes, with Perfect Order Fulfillment (POF) as its strategic metric. Another attribute is responsiveness, with the Order Fulfillment Cycle Time (OFCT) as its strategic metric. Regarding internal-focused performance, asset management efficiency is utilized as the last attribute., with the Cash-to-Cash cycle time (C2C) and Return on Working Capital (RWC) specifically for inventory, as its strategic metrics. The calculation formula that is utilized for the predefined strategic metrics, both refer to the SCOR guidelines just as their adjustments for PT Rajatani Agro Nusantara.

3.2. *SCOR Level 2*

At this level, the objective is to describe the entirety of the organization’s supply chain activities and identify potentially problematic activities for the overall supply chain management. An increasing point-by-point detailed configuration of SCOR Level 1 is made, and a capability assessment of the supply chain is made in the Make-to-Stock or Make-to-Order. SCOR Level 2 mapping is conducted using a thread diagram (Wulandari & Kusumastuti, 2019).

3.3. *SCOR Level 3*

The objective of this level is to describe the details of the potentially problematic activity identified at SCOR Level 2, focusing on source activity and asset management efficiency, as well as to analyze the factors that cause the problem by using a fishbone diagram.

4. RESULTS

PT. Rajatani Agro Nusantara is an Indonesian agriculture company that supplies retail, wholesale markets, wet markets, and the catering industry. They have been sustained in the market

for more than ten years. Especially in the catering industry supply, they claim that they can give a contract within a certain period with a flat price. Focusing on their main business in supplying several catering industries, they have unique SCM which is buyer/client could buy their product for years with a fixed price, while agriculture's raw materials mostly fluctuated if not handled carefully it can lead to massive loss.

To conduct an assessment using SCOR in this study, sales performance data for 2017-2019 will be used. The data used is limited to the supply chain of vegetables for sales to industrial catering clients. Delivery is made to the central kitchen of each client's factory. There are 17 types of vegetables sent to factory's central kitchen. Top three commodities with the highest shipments are Kentang Besar/Large Potatoes (56.717 kg - 61,898 kg), Cabe Merah Besar/Big Red Chilli (49,231 kg - 53,297), Kol/Cabbage (46.626 kg - 48,191 kg), and Wortel/Carrots (42,367 kg - 47,590 kg). Although the sales trend from 2017-2018 to 2018-2019 has increased, with the number of orders ordered from the client factory being 687,164 kg and the number of completed deliveries being 685,560 kg, there is a decent difference in the quantity of about 1,604 kg. The difference in the amount can be caused by various factors, one of which is an unoptimized supply chain.

4.1. *SCOR Level 1*

PT Rajatani Agro Nusantara's supply chain generally starts from Purchasing Order (PO) generated from their customer which is an industry catering company. The PO will be published every Friday for next week's orders. Every week orders will be sent about 3-4 times. In other words, the estimated PO generated for one week orders but the exact PO will be sent 2 days before due date. Then the holding company will forward to branch regarding the PO. The branch will manage the needs and calculate with how much goods will be taken from company's farmer partner (small plasma) and company's own farm. Every transaction with small plasma farmer will be paid cash in advance. At the PO due date, Branch will send the goods to customer. After the goods delivered, Goods Receipt will be generated by the customer, and thus it will be sent to the holding company. The payment from the customer will be sent to Rajatani holding company in about 5 – 7 days. Any goods that are damaged and thus not fulfilling the customer PO at that time will be sent in advance on the due date of the next PO.

Data are collected from PT. Rajatani Agro Nusantara and arranged to be performances framework (Table 1). The SCOR metrics that will be conducted are reliability, responsiveness, asset management efficiency. Metric reliability contains perfect order fulfillment. Metric responsiveness contains order fulfillment cycle time. Metric Asset management efficiency contains Cash-to-Cash Cycle time and Return on Working Capital. The metrics that have been determined are then analyzed using the formulas founded by the Supply Chain Council in the SCOR revision 11. In the SCOR Level 1, gap analysis is performed for each selected strategic metrics. Gap analysis is performed to compare the actual historical conditions for the past years and the company's target or industry's benchmarks (if available). For Perfect Order Fulfillment (POF), this strategic measure the company's ability to fulfil the Purchasing Order (PO) from industry catering company, which can be met in a timely manner and an appropriate amount. Gap analysis is done by comparing to company's target, where for the actual performance is 99,77% and the company's target is 95%, hence its performance already passed the target by 2,77%. For the Order Fulfillment Cycle Time (OFCT), this strategic metric measures the time it takes from Industry Catering PO is issued until all goods received at the Industry Catering Central Kitchens (Cibitung and Gandaria). Since there are no items stored in the company warehouse (no inventory policy).

Table 1. PT Rajatani Agro Nusantara's SCOR Level 1

Performance Attributes	Metrics	Formula	Actual Performance	Company Target	Gap
Reliability	Perfect Order Fulfillment (POF)	([Total quantity of Goods received on-time]/[Total quantity shipment plan]) 100%	(685.560/687.164) kgs x 100% = 99,77%	97%	+2,77% (exceeded company target)
Responsiveness	Order Fulfillment Cycle Time (OFCT)	[Actual Received Date Goods]-[PO Goods Issue Date]	2 days	1 days	1 day
Agility (Flexibility)	Supply Chain Response Time (Source Leadtime)	Number of days to respond to an unplanned significant increase or decrease in demand without cost penalty	2 days	1 day	1 day
Asset Management Efficiency	Cash-to-Cash Cycle Time (C2C)	[Days of Procuring goods until goods received]+ [Days Sales Outstanding]	9 days	5-7 days	2-4 days

It takes 2 days at average to prepare all goods (17 types of vegetables) from the PO is issued, hence the gap is 1-day difference from the company's target. For the Supply Chain Response Time (Source Leadtime), this strategic measure is the time to respond to an unplanned demand from an Industry catering company without cost penalty. In the practice, the unplanned demand will be sent in the next delivery to cut the cost of transportation if the demand is below 1,5 tons. For the Cash-to-Cash Cycle Time (C2C), this strategy measure the time needed from PO issued, procuring, and delivering goods, until cash is received from the same PO. Since the farmers are getting paid on the same day as the goods received by the company, there is no Days Payables Outstanding (DPO). The average of C2C cycle time is in 9 days, while the company's target is in 5-7 days, hence the gap is 2-4 days difference. One of the factors that lead to high C2C cycles is late payments from catering industry companies, where this can only be resolved by internal discussions between Rajatani and the catering industry companies. In the other hand, there is also a gap that can be increased in 2 strategic values (Responsiveness and Agility) in supply activities from farmers/suppliers to Rajatani that need attention, where there are various kinds of risks in the supply process. In SCOR Level 2, this research will focus more on supply activities between farmers/suppliers to Rajatani.

4.2. *SCOR Level 2*

In SCOR Level 2, the mapping is conducted in the form of thread diagram.

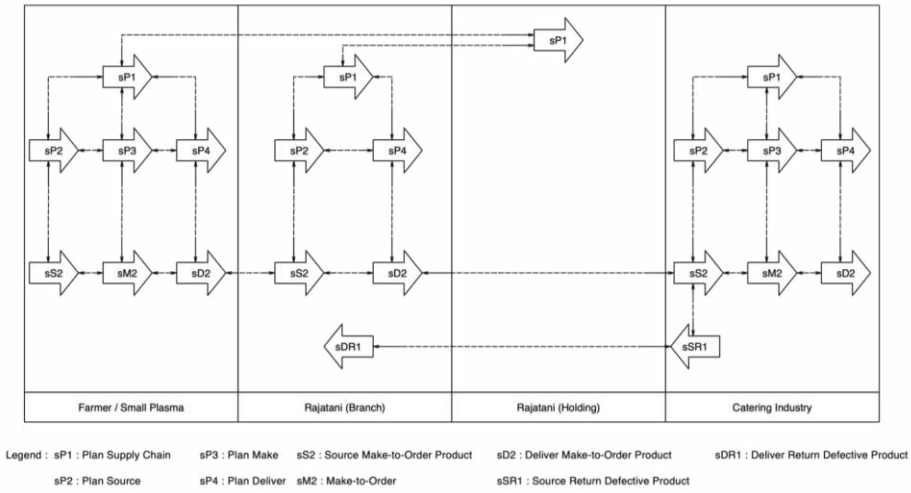


Figure 1. Thread Diagram

Figure 1. shows the overall activities carried out in the procurement and delivery process of vegetables as well as the relationship of each activity, the actual conditions, and the potential problems that may happen in the future. There are 3 main suppliers in charge of supplying Rajatani (Branch), located in Ciasmay, Bandung, and Pangalengan, with their own specialties. Since the contract with the farmers as suppliers is a plant-based contract (kontrak tanam), having a limited number of suppliers makes suppliers and company more dependent on each other and increases the risk for both parties. Supply chain risks can arise in various ways, such as the failure of suppliers to deliver goods due to the weather or pests, which will lead to higher materials prices and decreased qualities. Another risks are the big difference of days sales outstanding and days payable outstanding. Farmers as suppliers paid by Cash on Delivery on the same day as goods received by branch, while the industry catering company pays 5-7 days after goods are delivered. It can lead to insufficient funds to procure materials for the next orders, which will lead to higher OFCT and C2C metrics. Based on Figure 1, the most likely problem is the Delivery Make-to-Order Product (sD2) in the Farmers/Small Plasma/Suppliers side that is directly related to the Source Make-to-Order (sS2) activity in the Rajatani (Branch) area. Issues that are related to this activity are perfect order fulfillment, source lead time, and order fulfillment cycle time. While the cash-to-cash cycle time is most likely to arise in the Plan source activity (sP2) between the Rajatani (Branch) and industry catering company, it is also affecting the Source Make-to-Order (sS2) activities. To determine the root cause of the problem, the next mapping will focus on the activities of Source Make-to-Order (sS2) in the Rajatani (Branch) area.

4.2. *SCOR Level 3*

The SCOR Level 3 mapping is performed to identify the Source Make-to-Order (sS2) activities carried out by the supply chain. At this level, the causes of problems that occur can be identified, hence the remedial measures can be determined to overcome these from both within the company and externally. More details in Source Make-to-Order (sS2) activities can be seen in the following Figure 2:

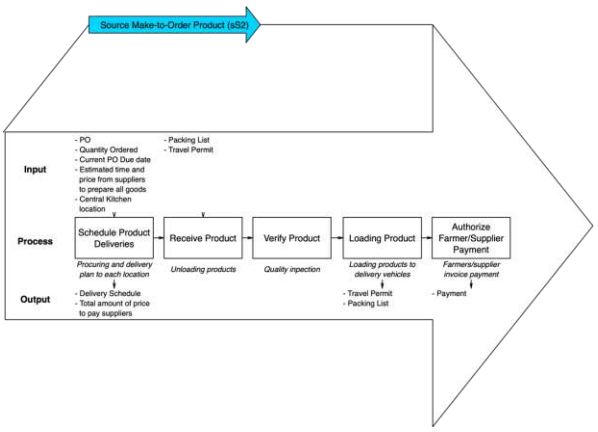


Figure 2. sS2 Source Make-to-Order product

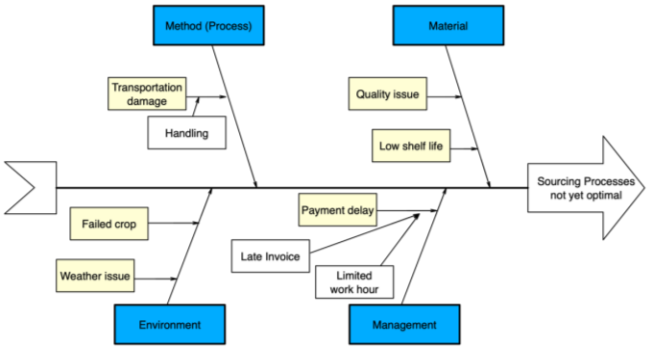


Figure 3. Fishbone Diagram

Figure 2. shows more details on activities carried out in the process of Source Make-to-Order (sS2) activity. Start with the process of scheduling product deliveries and end with authorizing farmers/suppliers payment. The most likely problem is the delayed time or lower quality product delivery from suppliers. The products are tightly related to the current weather. When the rainy season is applied, overall the quality of the products is lower, hence it will take a longer time to fulfill the products ordered not only from suppliers' own farms but sometimes they need to procure from other farmers or wet markets. Based on Figure 3, at one point in time even though scarcely happened, pests breakout also affected the time and quality of product deliverances. In the process of authorizing payment to farmers/suppliers sometimes the problems occur due to the delayed of payment from the industry catering company. When it has happened farmers have two options either to hold the products until payment from industry catering arrived or sell to another buyer/wet market, which will delay the product deliverance and hence the multiple effects occur, and the results are higher order fulfillment cycle time and higher cash-to-cash cycle time.

Based on the evaluated strategic metrics, it appears that the company needs to make improvements in 3 metrics, order fulfillment cycle time (ofct), supply chain response time, and cash-to-cash cycle time, which are interconnected with each others. Higher cash-to-cash cycle time will lead to higher order fulfillment cycle time (ofct) and supply chain response time, and vice versa. From a supply chain perspective, the risk is customarily viewed as “the probability of an incident associated with inbound supply from individual supplier failures or the supply market occurring, in which its outcomes result in the inability of the purchasing firm to meet customer demand or cause threats to customer life and safety” (Zsidisin, 2003). Herein, the objective of SCRM is to minimize the negative impact of such adverse events on the performance of distinct supply chain partners as well as the entire supply chain (SCC, 2012). The roots of the problems that have been identified in SCOR Level 3 can be registered as risks. Table 2 describes the events that occur in the product sourcing process. All of these events were analyzed for their causes based on the results of interviews conducted with the PIC who is responsible for handling the fulfillment of the PO. Based on the events that occurred, the researchers designed risk mitigation in accordance with the company's business processes so that it can help PT Rajatani Agro Nusantara in mitigating risks due to the sourcing process that is not optimal so as not to cause losses for PT Rajatani Agro Nusantara.

Table 2. Risk Register

Event	Cause	Consequence	Freq.	Sev.	Mitigation
Failed crop	- Bad weather - Pests breakout	- Damaged product - Delayed deliverance - High OFCT and C2C cycle - High Price	Moderate	High	- Increasing farmers/suppliers number, with different location from the major suppliers - Crops insurance to cover the damage - Lowering risk portfolio on procuring products, divide the quantities of PO into several farmers/suppliers
Delayed payment from buyer	- Work hour - Late invoice due to delivery delayed	- High cash-to-cash cycle - Could not authorize payment to farmers/suppliers - Delayed on material procurement - Low competitive power to procure the needed product	High	High	- Using financial third party, hasten the payment with a relative cost - Negotiate the term of payment on the current contract with buyer - Negotiate with farmers/supplier to extend the payment term - Increase working capital
Low quality product deliverance	- Poor handling on lower supply chain - Bad weather - Higher acceptance price on wet market (Good product goes to wet market)	- Delivery delayed - High products procuring cost - High order fulfilment cycle time	Rarely	Medium	- Extend quality inspection before delivery, by photo and video - Create crops harvest calendar based on several suppliers, and do a visit nearly 1-3 days before harvest time - Consider using closed contract with main suppliers to obligate that no listed products are able to go to outside farm site.

6. CONCLUSIONS

The main objective of this research is to evaluate the company's supply chain process of fresh vegetables with the catering industry by using SCOR Revision 11.0. As one that has a fairly large network of farmers in Indonesia, the company's sustainability should be maintained and protected in order to improve the welfare of Indonesian farmers. Due to the product's low shelf time characteristics, the supply chain process must be fast-paced, in contrast to other commodities that can be stored for months in inventory. A slight delay somewhere in the process, create multiple effects on the other processes. Also with the company’s nearly-full reliant for its sourcing from three main suppliers, the risk to its supply chain can arise in various way. It was founded that the root of the problem was the delay in payment from the buyer and the delay in the preparation of the goods due to several factors which is obtained through interview with internal company. To overcome the risk due to sourcing that has not been optimal, company need to develop strategies

to mitigate so that the contributing factors can be reduced and mitigated. Company can find out how to deal with these events based on the risk register.

REFERENCES

Erkan, T.E. & Baç, U. (2011). Supply Chain Performance Measurement: A Case Study About Applicability of Scor Model in a Manufacturing Industry Firm. International Journal of Business and Management Studies Vol 3, No 1, 2011 ISSN: 1309-8047.Askin, R. G., (1981). A procedure for production lot sizing with probabilistic dynamic demand. *AIIE Transactions* 13 (2), 132 – 137.

Furqon, C. (2014). Analisis Manajemen dan Kinerja Rantai Pasokan Agribisnis Buah Stroberi di Kabupaten Bandung. *IMAGE*, Vol. III No. 2, November 2014

Heizer, J., & Render, B. (2005). Operations Management (7th ed.), Pearson

Hult, G.T.M., Ketchen, D.J., & Arrfelt, M. (2007). Strategic Supply Chain Management: Improving Performance Through A Culture Of Competitiveness And Knowledge Development. Strategic Management Journal. Vol. 28 No. 10, Pp. 1035-1052.

Jacobs, F.R. & Chase, R. (2014). Operations and Supply Chain Management (14th ed.). New York: McGraw Hill Education.

Kocaoglu, B., Gulsun, B. & Mehmet, T. (2013). A SCOR Based Approach For Measuring A Benchmark-Able Supply Chain Performance. Journal Of Intelligent Manufacturing, 24, 113-132.

Maye, D., Kirwan, J., Chiswell, H., Vigani, M., Muñoz-Rojas, J., Mathijs, E., Bonjean, I., Thorsøe, M., Noe, E., von M, Susanne., G, Mikelis., A, Pierre-Marie., Nowak, P., & Minarelli, F. (2018). Farmer Strategies to Manage Market Uncertainty: Commodity-Level Analysis and Critique. Theme 5 – Sustainable agrifood systems, value chains and power structures. 13th European IFSA Symposium. Chania: Greece.

Pasar Jaya (2020). Monthly Report Commodity. https://infopangan.jakarta.go.id/publik/report_commodity

Pujawan, I.N. (2005) . Supply Chain Management. Surabaya : Guna Widya.

Rajatani (March, 2020). MAS The Future of Agrobusiness.Company Profile. Retrieved from : https://rajatani.id/wp-content/uploads/2021/07/Compro-BU-Aneu-Rajatani.pdf

Ramos R, J., Manotas D, D. F., & Osorio G, J. C. (2019). Operational supply chain risk identification and prioritization from SCOR model. Editorial Pontificia Universidad Javeriana. https://doi.org/10.11144/javeriana.iyu23-1.oscr

Satya, V. E (2016). Anomali Fluktuasi Harga Bahan Pangan di Indonesia. Info Singkat Pusat Penelitian Badan Keahlian DPR RI. Vol. VIII – pp. 15.

SCRC. (2017). The SCOR Model for Supply Chain Strategic Decisions. Supply Chain Resource Cooperative. NC: State University. Retrieved from : http://scm.ncsu.edu/scm-articles/article/what-is-supply-chain-management-scm.

Simchi-Levi, D., Kaminsky, P. & Simchi-Levi, E. (2004). Managing Supply Chain-The Definitive Guide for The Business Professional. New York: McGraw-Hill.

Supply Chain Council (SCC). (2012). Supply Chain Operations Reference Model. Version 10.0. United States Of America Supply Chain Council, Inc.

World Bank. (2005). Indonesia Policy Briefs-Ideas for The Future, Priorities Issues for Indonesian Agriculture.http://siteresources.worldbank.org/INTINDONESIA/Resources/Publication/280016-1106130305439/6173311110769011447/8102961110769045002/Agricultural.pdf.

Wulandari, R.D. & Kusumastuti, R.D. (2019). Performance Analysis of Tinplate's Main Raw Material Procurement Process Using the SCOR (Supply Chain Operations Reference) model. Business Innovation and Development in Emerging Economics – Trinugroho & Lau Eds. London : Taylor & Francis.

Zsidisin, G.A. (2003). A Grounded Definition of Supply Risk. Journal of Purchasing and Supply Management, Vol. 9 No. 56, pp. 217-224.

EVALUATION AND RISK MITIGATION OF SUPPLY CHAIN MANAGEMENT IN HEAVY EQUIPMENT MANUFACTURE

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ABSTRACT

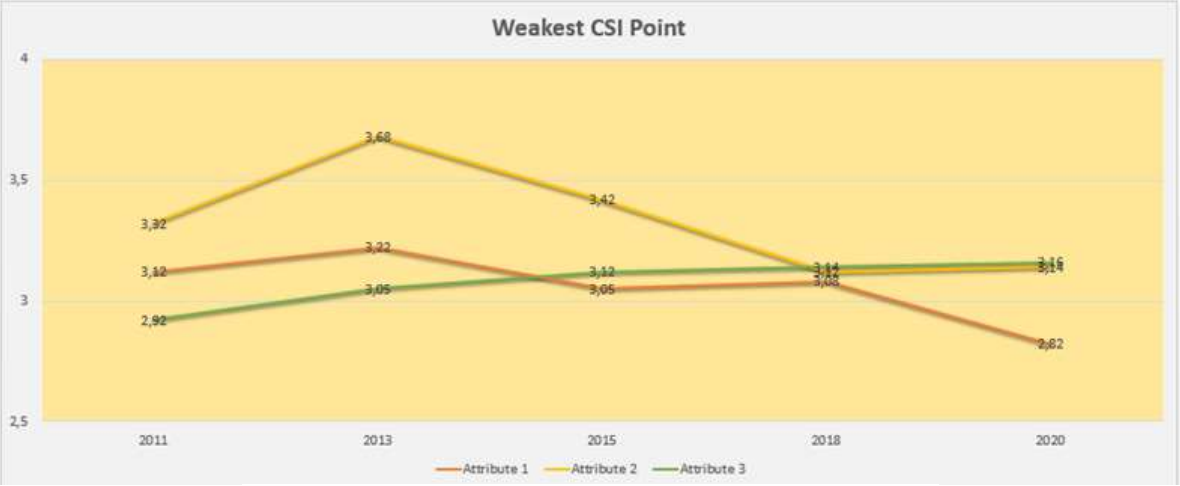
Customized heavy equipment, indicated there are modification from original design, and will impact to the several risk in the supply chain management, even if the modifications are minor. The production achievement on 2020-2021 are 74,58% and 65,13% from 100% that already planned in the beginning of the year, it's mean the differences between percentage are delayed delivery. Methodology Fuzzy FMEA are used to analyze the factors causing production delays, the importance of the factors, and formulating the recommendation as risk mitigation of supply chain management in the heavy equipment manufacturing. The value of severity, occurrence, and detection are obtained from focus group discussion with experts. Can be analyzed 68 potentials risk factors that cause production delays and there are 11 risks as the potential factors that have most impact on production delays. Drawing completeness and the bill of material completeness is the most importance factors. Eleven recommendations are formulated, centralized database design, and review standard operational procedure of design process, is the most importance recommendation. And the recommendation will be implemented in 5 department; design department, process engineering department, purchasing department, warehouse department, and production department.

Keywords: Supply chain management, manufacturing, delay production, fuzzy, FMEA.

1. INTRODUCTION

The trend of coal demand affected to the demand of heavy equipment, especially for mining sector. When demand coal is high, the demand of heavy equipment will increase and otherwise. When demand of heavy equipment increases, every company will find the order as much as possible. But the order will come to company depend on the customer satisfaction. Kotler and Keller (2016) suggested the customer satisfaction is the priority to make sure the customer satisfied with the company's products and services, to strengthen the reason, they must repurchase. Riaz (2014) suggested, factors that affect customer satisfaction are important to knowing, in order to branding sustainability in the market.

PT ABC is one of customized heavy equipment manufacturing in Indonesia. Data of customer satisfaction index from PT ABC marketing strategic, giving information that accuracy delivery is the lowest point of index with 2,82 point from 4. It indicate, the customer unsatisfied to purchase product at PT ABC, because due date delivery promised are missed. Figure 1 give information about the attribute of customer satisfaction index from 2011 until 2020.



CSI	ATTRIBUTE	REMARKS
2,82	DELIVERY ACCURACY	ATTRIBUTE 1
3,14	SERVICES VISITED FREQUENCY	ATTRIBUTE 2
3,16	PRODUCT PRICE	ATTRIBUTE 3

Figure 1. PT ABC Customer Satisfaction Index

Source: Marketing Strategic PT ABC (2020)

Shakya and Chauhan (2019) said, a production system can be defined as a procedure, methodology, or arrangement that includes all the functions required to collect inputs, process or reprocess inputs, and deliver finished outputs. Russel and Taylor (2011) suggested, the production process is a collection of stages to produce goods or services. Tsany et al (2017) suggested every step in the production process have risk that impacted to the next process. The production process in the PT ABC depend on the supply chain management indeed, its mean the production scheduling depending by the schedule every department. The production process, or flow of supply chain are started from design until delivery process.

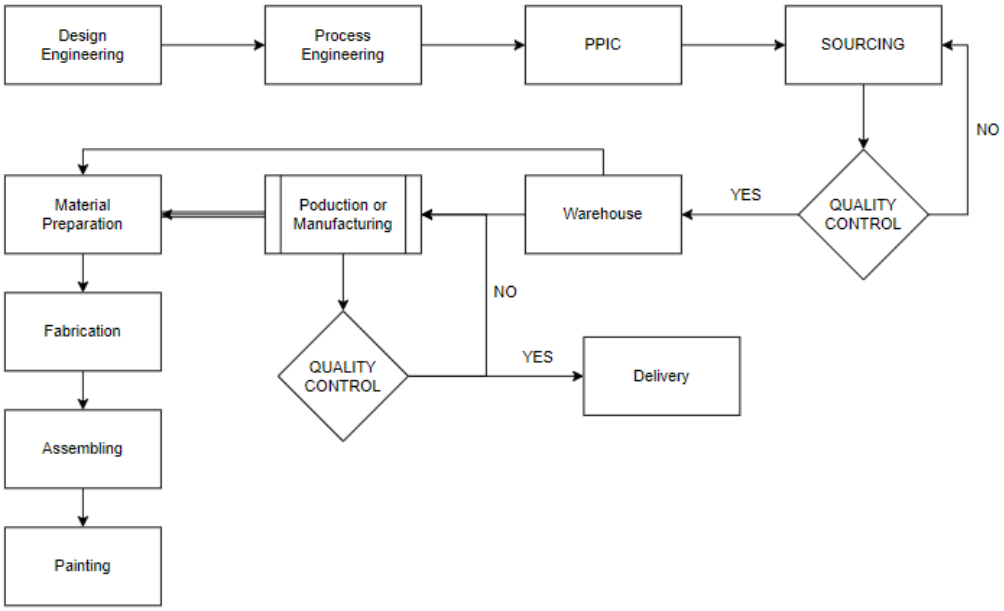


Figure 2. PT ABC Supply Chain Flow

Shebob et al (2012) said, delay in a production process is caused by various factors and will impact to the project are not completed on time, with excessive costs, and low quality. The factors are, wrong production planning, material availability, production capacity, and company performance. Based on data production achievement PT ABC are known, the achievement on 2020 is 89,90%, and 2021 is 88,02% from 100% that already planned in the beginning of years. It indicated the differences between the percentage of planning and the percentage of actual production achievement are delayed delivery. In the detail of data, group product of general trailer, giving most big impact to the production achievement, as shown on Table 1.

Table 1. Production Achievement 2020 – 2021 PT ABC

2020	Januari	Februari	Maret	April	Mei	Juni	Juli	Agustus	Septembe r	October	November	Desember	*Yearly Achieve ment*	*Achieve ment Rank*
Produk	%	%	%	%	%	%	%	%	%	%	%	%	%	
Attachment	-	-	-	-	-	100	-	-	-	-	-	-	100	9
Big Suppeq	-	-	50	-	-	100	50	100	-	-	-	-	75	2
Big Vessel	100	100	80	-	-	-	-	-	-	-	-	100	95	7
Construction	100	100	100	100	-	-	-	100	100	100	100	-	100	9
Foresty & Agro	63	100	-	-	100	75	62	75	85	-	-	-	80	3
General Trailer	100	85	100	25	100	93	39	0	53	100	100	100	74,58	1
Industrial	43	80	81	86	100	100	100	100	100	100	100	100	90,83	5
LBT	-	-	-	-	100	-	-	-	-	-	-	-	100	9
Small Medium Vessel	100	100	100	100	100	100	100	95	96	100	100	100	99,25	8
Small Suppeq	67	100	75	-	100	100	100	100	70	100	-	-	90,22	4
PSD	97	92	93	94	81,48	92	83	95	96	97	89	99	92,37	6
Achievment/period	83,75	94,63	84,88	81	97,35	95	76,29	83,13	85,71	99,5	97,8	99,8		
Achievment 2020	89,90													

2021	Januari	Februari	Maret	April	Mei	Juni	Juli	Agustus	*Yearly Achieve ment*	*Achieve ment Rank*
Produk	%	%	%	%	%	%	%	%	%	
Attachment	100	-	-	-	-	-	-	-	100	8
Big Suppeq	100	-	100	80	50	-	-	100	86	4
Big Vessel	100	-	-	100	100	100	92	90	97	6
Construction	100	100	100	100	100	-	100	100	100	8
Foresty & Agro	-	58	38	79	79	100	100	100	79,14	2
General Trailer	95	35	40	67	67	63	81	73	65,13	1
Industrial	100	100	100	92	92	100	100	100	98	7
LBT	-	100	-	-	-	-	-	-	100	8
Small Medium Vessel	89	77	60	80	80	79	100	100	83,13	3
Small Suppeq	-	-	100	100	100	100	25	100	87,5	5
Achievment/period	97,75	81,29	78,75	88,22	84,89	91	86,38	95,89		
Achievment 2021	88,02									

Source: Production Planning and Inventory Control PT ABC (2021)

Because the product delivery accuracy is the most aspect which influence the customer satisfaction index, this research are conducting in order to find the factors that affecting supply chain management that giving impact to the delay delivery product. And each factors will be analyzed in order to know the most importance factors that influences delay delivery product. Then the recommendation will be formulated as the risk mitigation of supply chain management.

2. LITERATURE REVIEW

Kotler and Keller (2016) suggested before a new product is introduced to the market, a manufacturing company may face many problems in the design, planning, production and delivery, it is very important to detect and solve this problem, before the product reaches the customer. Some failures are easy to detect while some of them remain hidden. The whole process should be carefully evaluated and proper quality control techniques should be used to find these hidden failures.

Failure Mode Effect and Analysis

Baynal et al (2018) giving recommendation about one of methodology effectively to find the failure in the system and in every process, it is failure mode effect and analysis (FMEA). Specifically to evaluate processes, systems, services or designs for the possibility where failure may occurring. It also can be used to identify and analyze to prevent problems before the process occur, or after the process occur and product problems.

Tafazzoli (2017) giving information in order to apply FMEA methodology, firstly the thing that must be understood is the elements that exist in the methodology, those are;

1) Component and Function, subsystems or objects to be researched. While the function describes the use of these components, under normal or ideal conditions.
2) Potential Failure Mode, is any possibility or abnormal condition that can be occurred that affecting normal function.
3) Potential Effect of Failure, is the impact of the potential failure.
4) Severity, object of assessment to show with quantitative data the value of the importance of a failure.
5) Potential Cause of Failure, explains how/why failures in components and functions can occur.
6) Occurrence, describes the approximate value or probability of how often a failure occurs in a system or process.
7) Current Control Prevention, an action prepared as a step in minimizing the risk for each failure model.
8) Detection, probability that the failure model can be detected.
9) Risk Priority Number, assigning a numerical value in each model of potential failure with the following formula;

RPN = (S) Severity x (O) Occurance x (D) Detection

10) Action, improvement plan that can be done.

Fuzzy Logic

Kharola and Sing (2014) suggested by collaborating the fuzzy methodology with the FMEA methodology, uncertain factors can be proven to be analyzed more realistically than the non-fuzzy approach. Sivanandam (2007) explain the fuzzy methodology helps in providing effective analysis for risk management and decision making, where the object is a factor of uncertainty, or factors that cannot be calculated or predicted in the process, and only based on qualitative data. It help to calculating qualitative data become quantitative data.

Triangular Fuzzy

Sivanandam (2007) suggested triangular fuzzy numbers are one of the most common types of fuzzy numbers or are widely used in fuzzy calculations. It help to give more specific result because the area from big area to specific area. A fuzzy Triangle number is represented by the following three points:

$$\mu_{(A)}(x) = \begin{cases} 0, & x < a_1 \\ \dfrac{x - a_1}{a_2 - a_1}, & a_1 \le x \le a_2 \\ \dfrac{a_3 - x}{a_3 - a_2}, & a_2 \le x \le a_3 \\ 0, & x > a_3 \end{cases}$$

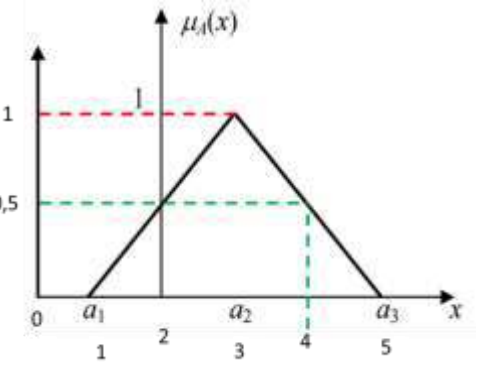


Figure 3. Triangular Fuzzy Numbers

3. METHODS

Focus Group Discussion

The process of research are started from focus group discussion with the expert from PT ABC. The focus group discussion are focusing to identification several element below;

1. Identify all component and function in the supply chain management of production process customized heavy equipment.
2. Identify all failure potential from each function.
3. Identify potential effect of each failure, the causes of failure, current control prevention, and current control detection.
4. Identify the value of severity, occurrence, and detection, with scale 1-10.
5. Formulated the appropriate recommendation of most importance failure.

All 5 agendas in the focus group discussion using brainstorming methodology.

FMEA

The FMEA methodology having standard table that consist of every element that should be identify in order to analyze the risk priority number (RPN). The RPN will determine the importance of each potential failure in the system.

Table 2. Standard FMEA Form

No	*Component and Function*	*Potential Failure mode*	*Potential Effect of Failure*	S	*Potential Cause of Failure*	O	*Current Controls, Prevention*	*Current Controls, Detection*	D	RPN (S x O x D)	*Rank* RPN
1											
2											

Source: (McDermott et al, 2009)

Fuzzyfication

Formulate the degree of membership as a stage of fuzzyfication. The purpose of this fuzzyfication process is to make the Severity, Occurrence, and Detection values into linguistic numbers with degree of membership as shown below;

Table 3. Linguistic Variable

Linguistic Variable	*Symbol*	*Rank*	*Fuzzy NumBer*
Very Low	VL	1,2	[0 0 2]
Low	L	3,4	[1 3 5]
Medium	M	5,6,7	[3 5 7]
High	H	8,9	[5 7 9]
Very High	VH	10	[8 10 10]

Source: (Khasha et al, 2013)

Fuzzy Inference System

Create a fuzzy rule (FIS / Fuzzy Inference System) according to the Mamdani Fuzzy methodology with the "if", and, "then" functions. The rules in fuzzy inference system are;

Table 4. Fuzzy Inference System

SEVERITY:VL						
FUZZY RPN		OCCURRENCE				
		VL	L	M	H	VH
DETECTION	VL	VL	VL	VL	VL	L
	L	VL	VL	VL	L	L
	M	VL	VL	L	L	M
	H	VL	L	L	M	M
	VH	L	L	M	M	H

SEVERITY:L						
FUZZY RPN		OCCURRENCE				
		VL	L	M	H	VH
DETECTION	VL	VL	VL	VL	L	L
	L	VL	VL	L	L	M
	M	VL	L	L	M	M
	H	L	L	M	M	H
	VH	L	M	M	H	H

SEVERITY:H						
FUZZY RPN		OCCURRENCE				
		VL	L	M	H	VH
DETECTION	VL	VL	L	L	M	M
	L	L	L	M	M	H
	M	L	M	M	H	H
	H	M	M	H	H	VH
	VH	M	H	H	VH	VH

SEVERITY:VH						
FUZZY RPN		OCCURRENCE				
		VL	L	M	H	VH
DETECTION	VL	L	L	M	M	H
	L	L	M	M	H	H
	M	M	M	H	H	VH
	H	M	H	H	VH	VH
	VH	H	H	VH	VH	VH

SEVERITY:M						
FUZZY RPN		OCCURRENCE				
		VL	L	M	H	VH
DETECTION	VL	VL	VL	L	L	M
	L	VL	L	L	M	M
	M	L	L	M	M	H
	H	L	M	M	H	H
	VH	M	M	H	H	VH

Source: (Rachieru et al, 2013)

Deffuzyfication

The step of fuzzyfication and FIS will processing by using MATLAB. After those 2 steps finished the process in the MATLAB, then the deffuzyfication can be analyzed. This is the proses to analyze the new RPN with the same of scale severity, occurrence, and detection.

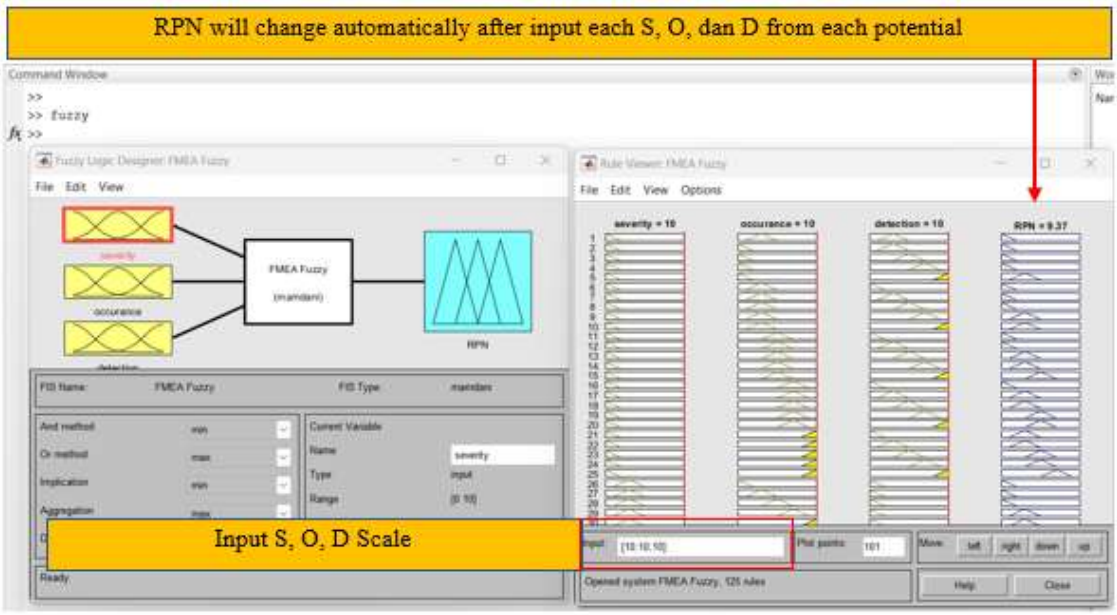


Figure 4. Defuzzyfication Process on MATLAB

Formulate Recommendation

The recommendation will be formulated in the focus group discussion with expert and agreed there are five groups of FRPN. For FRPN above 7 to 10 are classified into factors that very influencing the supply chain management in the production process at heavy equipment manufacturing. Then the recommendation that should be proposed is only for the potential with FRPN > 7. The way to formulated are using 5W + 1H methodology. And below are the data about the expert;

Table 5. Expert Information

No	Position	Experience
1	Manager PPIC	> 20 Years
2	Manager Production	> 20 Years
3	Manager Purchasing	> 20 Years
4	Manager Warehouse	> 20 Years
5	Manager Design	> 20 Years
6	Manager Process Engineering	> 10 Years
7	Manager Quality Control	> 10 Years

4. RESULTS

Based on the fuzzy FMEA methodology, can be identified 68 potentials that influencing supply chain management in the production process of customized heavy equipment. And there are 11 potentials failure included in the group of factors that very influencing the supply chain management in the production process. The most factor that very influencing is about drawing not completed, and the second is bill of material not complete, with value of FRPM 9,37. And there are ranking movement between methodologies FMEA with fuzzy FMEA. The detail information of 11 potentials as shown Table 6 below;

Table 6. Fuzzy FMEA Analysis

No	Component and Function	Potential Failure mode	S	O	D	RPN	Rank RPN	FRPN	Rank FRPN
1	Design Engineering	Drawing not completed	10	10	10	1000	1	9,37	1
2	Design Engineering	Revision image not confirmed	6	6	10	360	15	7,72	11
3	Process *Engineering*	Bill of Materials incomplete (100%)	10	10	10	1000	2	9,37	2
4	Process *Engineering*	Partial BOM update not communicated	10	8	7	560	7	9,25	7
5	Purchasing	Component urgency level priority is wrong	7	10	9	630	5	9,25	5
6	Purchasing	Import shipment delay scheduling	10	9	8	720	4	9,25	4
7	Purchasing	Frequently delayed vendor and subcontractor commitments	10	10	9	900	3	9,25	3
8	Warehouse	Good Issue process is not updated real time	9	8	8	576	6	9,25	6
9	Production	The IH (In-House) component that was prepared has the wrong priority	7	7	9	441	8	9,25	8
10	Production	Too late to know the lack of components from IH	7	7	9	441	9	9,25	9
11	Production	IH component handover data is not updated	6	7	9	378	14	7,72	10

Recommendation

By using 5W + 1H methodology, the detail of each potential the recommendation will be analyzed. It start from the kind of potential, when the potential occur, who that responsible with the potential, where the potential occur, why the potential can be occurred, and how to eliminate the potential. Then by answering all of the question, the recommendation to eliminate or as risk mitigation are formulated as shown in Table 7.

Table 7. Recommendation

No	Department	No	Failure Code	No	Recommendation	No	Person In Charge
1	Design	1	Drawing not completed	1	Centralize Design Engineering Database	1	Manager of Design Engineering
		2	Revision image not confirmed			2	Manager of Information System & Digitalitation
		3	Partial BOM update not communicated	2	Review and developing standarad operational procedure (SOP)	3	Manager of Management Development & Risk Management (MDRM)
		4	Component urgency level priority is wrong				
2	Process Engineering	5	Bill of Materials (BOM) incomplete (100%)	3	Standardize working instruction process to input BOM	1	Manager of Process Engineering
						2	Manager of MDRM
3	Purchasing	6	Import shipment delay scheduling	4	Standardize purchasing work instruction for Import Component or part processing	1	Manager of Purchasing
		7	Frequently delayed vendor and subcontractor commitments	5	Develop new SOP for subcont or vendor evaluation	2	Manager of MDRM
				6	Evaluation the SOP to purchase at subcont or vendor		
4	Warehouse	8	Good Issue process is not updated real time	7	Determine the standard level agreement of completeness component before production running	1	Manager of Warehouse
				8	Develop monitoring sistem kelengkapan komponen.	2	Manager of Information System & Digitalitation
5	Production	9	The IH (In-House) component that was prepared has the wrong priority	9	Developing Manufacturing (PB) scheduling system that integrated with dashboard monitoring	1	Manager of Production
		10	Too late to know the lack of components from IH	10	Propose special admin that responsible for maintaining dashboard PB	2	Manager of Information System & Digitalitation
		11	IH component handover data is not updated	11	Propose develop SOP PB after dashboard developed	3	Manager of MDRM

6. CONCLUSIONS

By using Fuzzy FMEA methodology, 68 potential are the factors that influences the production process of customized heavy equipment, that come from all department that involved in the supply chain of production process. From those potential, there are 11 potentials are the most that affecting the delay production process of customized heavy equipment. There are two potential that have biggest fuzzy risk priority number 9,37. The first potential is about drawing as the guidance for production are not complete, and the second potential is about bill of material incomplete (<100%).

Then 11 recommendation are formulated as the risk mitigation that spread to be implemented into 5 departments. There are 4 department that should be develop new SOP those are, department design, process engineering, purchasing, and production. And there are 2 departments should be develop new system is department warehouse and production.

At the end of this research impacted to the several managerial implication, those are;

1. Four departments that involved in the supply chain of heavy equipment production process should be determined standard operational procedure in order to eliminate the risk of delay delivery, those are department design, process engineering, purchasing, and production.
2. New system at department warehouse and production, that impact to preparing the people readiness by giving training.
3. The recommendation also can give an impact to the cost reduction of production, that come from, safe man-hour that waiting component and/or additional production process, safe cost when the component are not found, safe overtime cost, and safe cost when the order are bounded with penalty cost.
4. The methodology fuzzy FMEA more appropriate to be applicate by PT ABC depend current methodology it is DMAIC, as the methodology for risk mitigation. Because the fuzzy FMEA will identify the risk from the top of potential, while the DMAIC sometime identify risk from the middle moreover from the bottom.

REFERENCES

Baynal, K., Sari, T., & Akpinar, B. (2018). Risk Management in Automotive Manufacturing Process Based on FMEA and Grey Relational Analysis. *Journal Advances in Production Engineering & Management*. *Volume* 13 *Number* 1, *page* 69-80.

Kharola, A., & Singh, S, B. (2014). Development of Fuzzy Failure Mode Effect Analysis (FFMEA) Model for Risk Priority Number (RPN) Analysis. *Advanced Modelling and Optimization*. *Volume* 16 *Number* 1, *page* 211-222.

Khasha, R., Spehri, M., & Khatibi, T. (2013). A Fuzzy FMEA Approach to Prioritizing Gurgical Cancellation Factors. *International Journal of Hospital Research*. *Volume* 2 *Number* 1, *page* 17–24.

Kotler, P., & Keller, K. (2016). *Marketing Management global edition*, 15th Edition, *Pearson Education Limited*, Pearson, United State of America.

McDermott, R, E., Mikulak, R, J., & Beauregard, M, R. (2009). *The Basic of FMEA*, 2nd Edition, Taylor & Francis Group, New York.

Rachieru, N., Belu, N., & Anghel, D, C. (2013). Improvement of process failure mode and effects analysis using fuzzy logic. *Applied Mechanics and Materials*. *Volume* 371 *Number* 371, *page* 822–826.

Riaz, A. (2014). Factor Affecting Customer Satisfaction. *Journal of Finance and Economics*. *Issue* 60, *page* 46-51.

Russel, R., & Taylor, B. (2009). *Operation Management*, Seventh Edition, John wiley & sons, Virginia.

Shakya, R., & Chauhan, P. (2019). Modelling of Risk Analysis in Production System. *IOP Conf. Series: Materials Science and Engineering*, *page* 691.

Shebob, A., Dawood, N., Shah, R. K., & Xu, Q. (2012). Comparative study of delay factors in Libyan and the UK construction industry. *Engineering Construction and Architectural Management*. *Volume* 19 *Number* 6, *page* 688–712.

Sivanandam, S, N. 2007. Introduction to Fuzzy Logic using MATLAB, *Springer – Verlag Berlin Heidelberg*, Coimbatore, India.

Tafazzoli, M. (2017), Dynamic Risk Analysis of Construction Delays Using Fuzzy-Failure Mode Effects Analysis, Universitas of Nevada, United State of America.

Tsany, F., Santoso, I., & Ikasari, D, M. (2017). Identification and Risk Analysis of Mozarella Cheese Production Process. *Journal of Industrial and Information Technology in Agricultura*. *Volume* 1 *Issue* 2, *page* 18-26.

ASSESSMENT OF TRANSMISSION PROTECTION FOR ELECTRICITY RELIABILITY IN KALIMANTAN

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ABSTRACT

PT. PLN (Persero) is a State-Owned Enterprise, which is engaged in the electricity sector, Main Generation and Transmission Unit which manages the Generation and Transmission in Kalimantan called UIKL KAL. The transmission configuration of the long overhead line stretching from North, East, South, and Central to West Kalimantan with forest topography of hills and ravines has a high risk of disturbances causing huge losses for both PLN and customers. The maintenance has been carried out according to existing procedures. However, the failure of the protection function to localize these disturbances is still frequent and even causes widespread and prolonged outages. Hence, so it is necessary to identify the causes of frequent and large-impact transmission disturbances and a new method using Fault tree analysis and multi-linear regression that is better for ensuring the readiness of energy security to improve reliability and performance. By finding a strong correlation between each type of disturbance to the performance of the Auto Reclose Index, it was found that the disturbance by the tree caused the Auto Reclose Index performance to be very low and it was found that disturbance by lightning and kites caused the Auto Reclose Index performance to be very high.

Keywords: Assessment, Protection, Reliability, Regression, Fault, Security.

1. INTRODUCTION

In the framework of thinking as described in figure 1, starting from the initial data collection at PT PLN (Persero) UIKL KAL: Transmission assets, Asset Protection, Disturbance, and Performance. From this data, identification and formulation of problems can be carried out, so that the following can determine several problem diagnoses, including How to measure transmission protection reliability performance, what is the relationship and effect of disturbance on performance, how transmission protection studies provide solutions from Fault Tree Analysis, How is the transmission protection improvement implemented.

Based on the calculation process of protection and transmission performance, namely *Transmission Line Outage Frequency* (TLOF), *Transmission Line Outage Duration* (TLOD), Security Index (SI), Dependability Index (DI), Maintenance Index (MI), and Auto Reclose Index

(ARI) which requires asset data and data on how many times and how long the outages are caused by disturbances and how many times the success of the protection function works correctly and how long does the system recovery process take From the disturbance, it can be concluded that there is a relationship and influence between each cause of the disturbance to the protection and transmission performance at auto reclose index in a linear manner which can be analyzed using Correlate and Multiple Linear Regression.

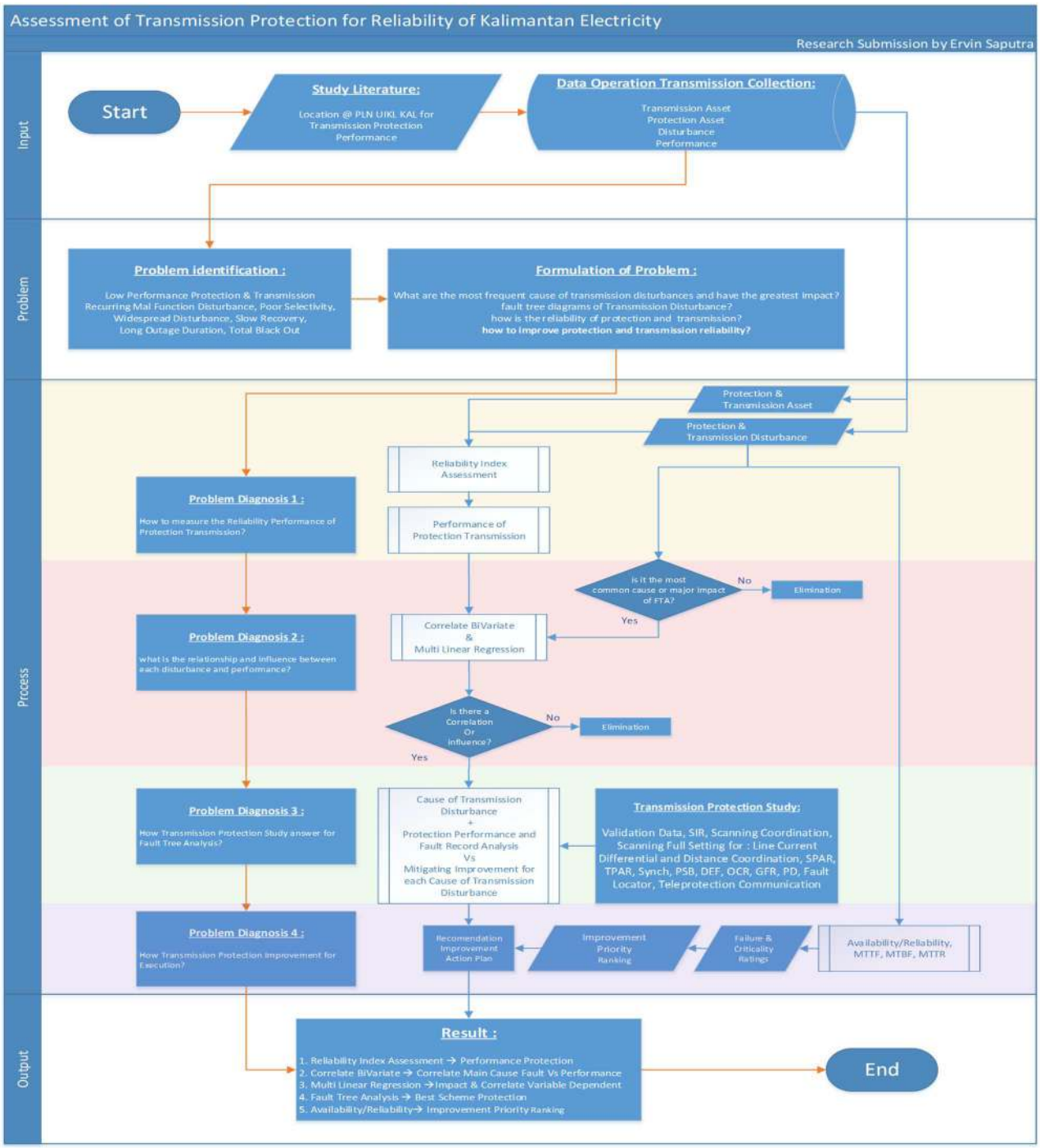


Figure 1.1 Kalimantan Transmission Protection Assessment research framework.

The data generated from the Multiple Linear Regression analysis becomes the basis for consideration in the Fault Tree Analysis process, which filters among the factors that cause frequent disturbances and have a large impact on whether they have a correlation and influence on performance. If the factors causing the disturbance do not have a correlation and influence performance, the factors causing the disturbance will be eliminated from the next analysis process to produce recommendations for scanning patterns and the best protection schemes.

The result is the recommendation of the best protection scheme for each bay line and substation, what improvements are the most prioritized for the maintenance action plan, and how to implement it most efficiently and effectively.

Finally, knowing that all primary and backup protections must have been set up and tested properly following the best choice to be implemented to increase Auto Reclose Index Performance and reliable Transmission and Substation network systems.

2. LITERATURE REVIEW

Junaidi, J. (2014) suggests that Microsoft Office Excel is capable of Regression analysis. *Karyana. (2013) explained how to design the best protection for each bay line transmission characteristic of fault and configuration of topology.* To make a more detailed Fault Tree Analysis of transmission (Schweitzer, E. O., Fleming, B., Lee, T. J., & Anderson, P. M., 1998) from data filtering. The probability value can be, for example, a calculated reliability (R) value or a failure (failure rate), so the failure probability (FP) value is = 1-R (Halme, J., & Aikala, A., 2012). The probability of failure at each node of the tree can be calculated by a method that resembles Boolean algebra. Causal connection with AND gate or OR gate with two input values each. The number of inputs to the gate is unlimited, but from a practical point of view, it may not be wise to connect too many inputs to a single gate.

3. METHODS

All data on transmission bay line assets, all types of interference, and transmission bay protection in transmission and Substation that have been collected were analyzed using correlation and multiple linear regression. From the correlation analysis, it is obtained what types of disturbances are associated with an increase or decrease in the performance of the auto-reclosed index. From the analysis of multiple linear regression, the formulation of the influence of each cause of disturbance on the performance of auto reclose can be obtained which can then be used to determine the best mitigation follow-up for each bay line according to the character of the cause of the disturbance.

4. RESULTS

Table 4.1 and figure 4.1 are the results of a correlation analysis of transmission disturbance data from 2018, 2019, 2020, and 2021 on auto reclose performance, and it is concluded that disturbance due to trees most often causes Auto Reclose failure, so double shot Auto Reclose cannot be applied and requires execution prevention immediately before a trip due to trees occurs.

Table 4.1 The results of the correlation analysis of the causes of disturbances to the performance of auto reclose.

	Long Lenght	*Obsolete*	*Lightning*	*Kites*	*Trees*	*Animal*	*Foreign Object*	*Primary Equipment*	*Secondary Equipment*	*Broken Conductor*	*Others*	*Auto Reclose Index*
Long Lenght	1.000											
Obsolete	0.075	1.000										
Lightning	0.480	0.181	1.000									
Kites	-0.001	0.114	0.143	1.000								
Trees	0.338	-0.005	0.425	-0.016	1.000							
Animal	0.148	0.029	0.351	-0.064	-0.001	1.000						
Foreign Object	0.165	0.151	0.281	0.248	0.079	-0.002	1.000					
Primary Equipment	0.103	0.056	0.125	0.141	0.128	0.066	0.217	1.000				
Secondary Equipment	-0.005	-0.001	0.121	0.021	-0.014	-0.069	0.042	0.031	1.000			
Broken Conductor	0.016	-0.017	0.092	0.089	0.206	-0.029	0.036	0.002	0.017	1.000		
Others	0.124	-0.037	-0.045	-0.050	-0.001	0.056	-0.040	-0.064	-0.052	-0.021	1.000	
Auto Reclose Index	0.170	0.038	**0.224**	**0.283**	**-0.111**	**0.127**	**0.064**	-0.030	-0.045	-0.024	0.078	1.000
Rank	3	7	2	1	11	4	6	9	10	8	5	

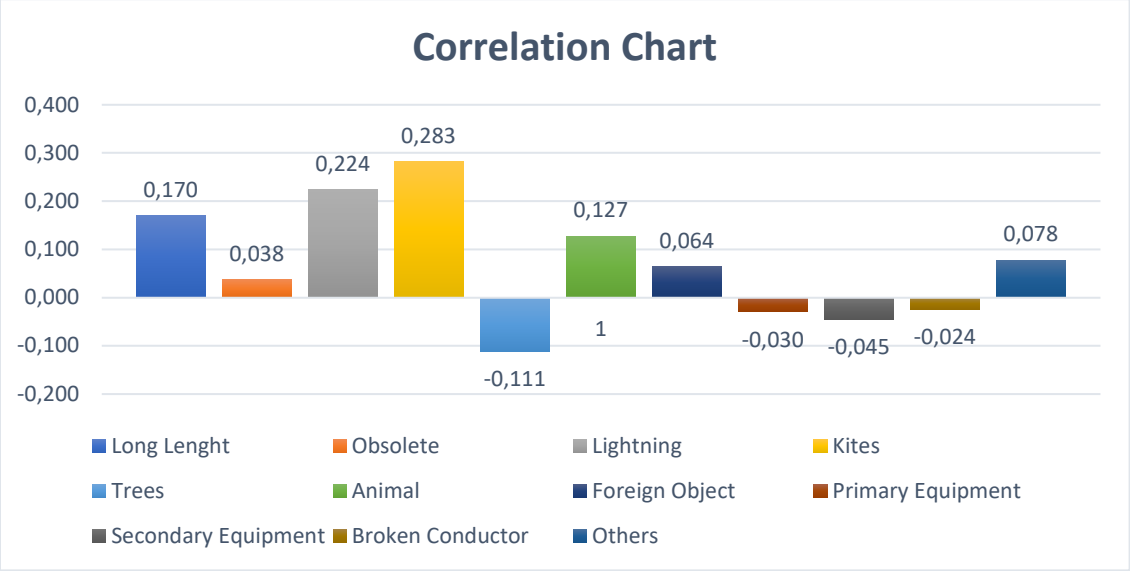


Figure 4.1 Correlation Chart between Type of Fault Cause to Auto Reclose Index.

Disturbances caused by kites often succeed in Auto Reclose, but sometimes they still fail to Auto Reclose if there is a follow-up kite, so it is necessary to activate Auto Reclose Double Shot to increase the success of Auto Reclose. In addition, disturbances caused by lightning also often succeed in Auto Reclose, but sometimes it still fails to Auto Reclose if there is a follow-up strike, so it is also necessary to activate Auto Reclose Double Shot to increase the success of Auto Reclose. Next is the disturbance caused by the animal being able to auto-reclose successfully, but it still often fails to auto-reclose if there is a follow-up disturbance because the tree and tree become the animal's path to the transmission so that the transmission is disturbed because the animal and tree cannot

activate Auto Reclose Double Shot. Meanwhile, interference due to foreign objects has succeeded in Auto Reclose, but sometimes it still fails to Auto Reclose if the foreign object is involved, so there is no need to activate Auto Reclose Double Shot. For very small equipment life affects the success of Auto Reclose. On the other hand, permanent cause of disturbance from Primary and Secondary Equipment causes Auto Reclose failure, prevention needs to be taken with extra treatment with a low Healthy Index of Primary and Secondary Equipment. Meanwhile, disturbances from broken conductors that are permanent cause Auto Reclose failure, prevention is needed with extra treatment, the Healthy Index of the main transmission equipment is low, but it is still infrequent. For other causes, it is very random, although it can still reclose if it is temporary, because the cause is uncertain so that the impact can be temporary and permanent, there is no specific treatment.

From multiple linear regression analysis, the Tabel 4.2 following results were obtained: statistical regression, ANOVA, the coefficient of intercept, and a beta of each independent variable causing transmission disturbances on the auto to reclose index performance.

Table 4.2 Stage 1 Multiple Linear Regression Output Summary with Microsoft Excel.

Regression Statistics	
Multiple R	0.44357
R Square	0.196755
Adjusted R Square	0.168435
Standard Error	0.359733
Observations	324

Table 4.3 Stage 1 Multiple Linear Regression ANOVA with Microsoft Excel.

	Df	*SS*	*MS*	*F*	*Significance F*
Regression	11	9.889896	0.899081	6.947657315	1.64328E-10
Residual	312	40.37525	0.129408		
Total	323	50.26515			

Table 4.4 Stage 1 Multiple Linear Regression Coefficient with Microsoft Excel.

	Coefficients	*Std Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	0.235	0.045	5.206	0.000	0.146	0.323	0.146	0.323
Long Length	0.002	0.001	2.234	0.026	0.000	0.003	0.000	0.003
Age	-0.003	0.005	-0.739	0.461	-0.013	0.006	-0.013	0.006
Lightning	0.015	0.004	3.616	0.000	0.007	0.023	0.007	0.023
Kites	0.004	0.001	5.156	0.000	0.003	0.006	0.003	0.006
Trees	-0.032	0.008	-4.104	0.000	-0.048	-0.017	-0.048	-0.017
Animal	0.023	0.043	0.529	0.597	-0.061	0.107	-0.061	0.107
Foreign object	-0.090	0.095	-0.951	0.342	-0.276	0.096	-0.276	0.096
Primary Equipment	-0.065	0.053	-1.223	0.222	-0.170	0.040	-0.170	0.040
Secondary Equipment	-0.096	0.067	-1.427	0.155	-0.227	0.036	-0.227	0.036
Broken Conductor	-0.015	0.042	-0.363	0.717	-0.098	0.068	-0.098	0.068
Others	0.142	0.100	1.418	0.157	-0.055	0.340	-0.055	0.340

The Formula of Mult-Linear Regression results are :

$$\boldsymbol{Y = \alpha + \beta_1.X_1 + \beta_2.X_2 + \beta_3.X_3 + \beta_4.X_4 + \beta_5.X_5 + \beta_6.X_6 + \beta_7.X_7 + \beta_8.X_8 + \beta_9.X_9 + \beta_{10}.X_{10} + \beta_{11}.X_{11} + \varepsilon_t}$$

$$\boldsymbol{Y = 0.23 + 0.00.X_1 + 0.00.X_2 + 0.02.X_3 + 0.00.X_4 - 0.03.X_5 + 0.02.X_6 - 0.09.X_7 - 0.07.X_8 - 0.1.X_9 - 0.02.X_{10} + 0.14.X_{11} + 0.359_t}$$

But we need to re-run the Multi-Linear Regression with only the 4 independent variables which have a P-value lower than 0.05. And there are Long Lenght, Lightning, Kites, and Trees.
And their result is:

Table 4.5 Stage 2 Multiple Linear Regression Output Summary with Microsoft Excel.

Regression Statistics	
Multiple R	0.37482
R Square	0.14049
Adjusted R Square	0.12527
Standard Error	0.36722
Observations	231

Table 4.6 Stage 2 Multiple Linear Regression ANOVA with Microsoft Excel.

	df	*SS*	*MS*	*F*	*Significance F*
Regression	4	4.981246	1.245311493	9.234917749	6.27708E-07
Residual	226	30.47568	0.134848141		
Total	230	35.45693			

Table 4.7 Stage 2 Multiple Linear Regression Coefficient with Microsoft Excel.

		Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
	Intercept	0.4287	0.0463	9.2566	0.0000	0.3374	0.5199	0.3374	0.5199
X1	Long Length	0.0010	0.0009	1.1318	0.2589	-0.0007	0.0027	-0.0007	0.0027
X2	Lightning	0.0031	0.0039	0.7949	0.4275	-0.0046	0.0109	-0.0046	0.0109
X3	Kites	0.0030	0.0008	3.6342	0.0003	0.0014	0.0046	0.0014	0.0046
X4	Trees	-0.0352	0.0077	-4.5972	0.0000	-0.0503	-0.0201	-0.0503	-0.0201

The Formula of Mult-Linear Regression results are :

$$\boldsymbol{Y = \alpha + \beta_1.X_1 + \beta_2.X_2 + \beta_3.X_3 + \beta_4.X_4 + \varepsilon_t}$$

$$\boldsymbol{Y = 0.4287 + 0.001.X_1 + 0.0031.X_2 + 0.003.X_3 - 0.0352.X_4 + 0.367_t}$$

Now a formulation is obtained to calculate the performance of the next auto reclose index using the data on the cause of the disturbance in each bay line with the application of mitigating the treatment of the auto recloses pattern according to the disturbance characteristics of each bay line. For the execution of repairs. priority is given to the bay line with the highest failure rate to obtain maximum effectiveness and efficiency of work programs. The most effective to increase Auto Reclose Index is to prevent the fault caused by the trees by immediately cutting the trees at critical spans. and then an increase in Auto Reclose Successful by activating double shoot Auto Reclose at all bay lines which never faults permanently.

The fault Tree Diagram in figure 4.2 describes the score and index failure rate of each fault cause.

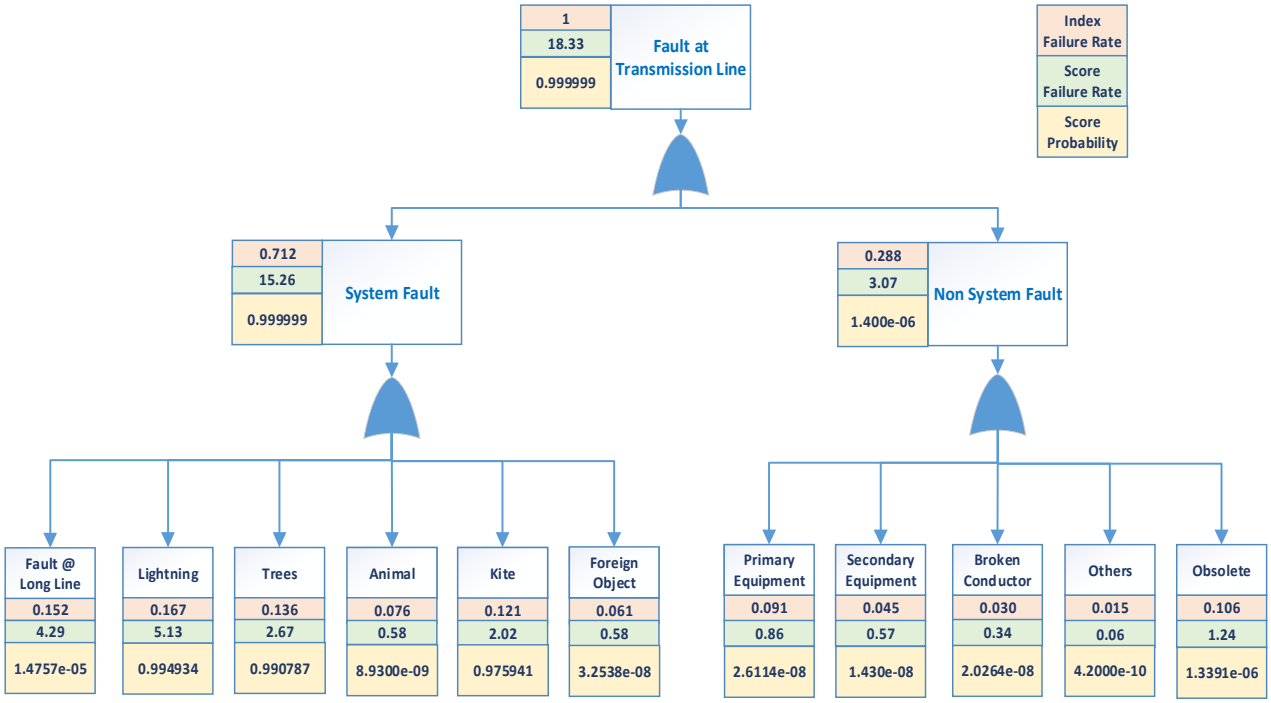


Figure 4.2 Fault Tree Diagram with Failure Rate and Probability.

Using the formulation of the multiple linear regression analysis results on each bay line asset. it is obtained in Table 4.8 a predictive summary of the lowest ARI low performance. which is less than 50% of the average bay line performance.

Table 4.8 ARI lowest-performance predictive summary of Multiple Linear Regression.

Location	Long Lenght	Lightning	Kites	Trees	TLOD	TLOF	ARI	Shot AR	Alarm Hi R	CUI/Norm	next A	next ARI %
GI_CENDANA Bay Line Siantan 150kV	33.25	3	18	0	0.00	18.05	0.63	2	Normal	CUI	0.525	46%
GI_SANGGAU Bay Line Tayan 1 150kV	77.58	5	0	0	0.00	1.29	0.75	1	Normal	CUI	0.520	46%
GI_SANGGAU Bay Line Tayan 2 150kV	77.58	3	0	0	0.00	1.29	0.50	1	Normal	CUI	0.514	45%
GI_SIANTAN Bay Line Cendana 150kV	33.25	3	19	0	0.06	18.05	0.65	2	Normal	CUI	0.528	46%
GI_BENGKAYANG Bay Line Ngabang 2 150kV	95.66	20	5	6	0.26	17.77	0.00	1	Hi Res	Normal	0.388	47%
GI_SELAT Bay Line Mintin 1 150kV	29.5	6	0	11	2.84	71.19	0.00	1	Hi Res	Normal	0.089	15%
GI_SELAT Bay Line Mintin 2 150kV	29.5	6	0	8	1.75	50.85	0.00	1	Hi Res	Normal	0.195	33%
GI_BANGKANAI Bay Line Muarateweh 1 150kV	44.43	3	0	10	0.00	9.00	0.64	1	Normal	CUI	0.130	22%
GI_BANGKANAI Bay Line Muarateweh 2 150kV	44.43	4	0	10	0.00	20.26	0.00	1	Hi Res	Normal	0.133	22%
GI_BUNTOK Bay Line Tanjung 2 150kV	78.687	24	0	27	1.19	33.04	0.04	1	Normal	CUI	-0.369	-62%
GI_BUNTOK Bay Line Muarateweh 1 150kV	117.28	21	0	21	1.20	21.32	0.00	1	Hi Res	Normal	-0.130	-22%
GI_MUARATEWEH Bay Line Buntok 1 150kV	117.28	21	0	21	0.00	21.32	0.00	1	Hi Res	Normal	-0.130	-22%
GI_MUARATEWEH Bay Line Buntok 2 150kV	117.28	19	0	22	0.00	17.05	0.05	1	Normal	CUI	-0.172	-29%
GI_MUARATEWEH Bay Line Bangkanai 1 150kV	44.43	3	0	10	0.90	9.00	0.64	1	Normal	CUI	0.130	22%
GI_MUARATEWEH Bay Line Bangkanai 2 150kV	44.43	4	0	10	2.17	20.26	0.00	1	Hi Res	Normal	0.133	22%

The calculation for Failure Rate. Availability. Performance. frequency. and duration of outages:

Table 4.9 Availability summary according to each cause of the disturbance.

No	Cause	No of Failures	Operating Time	λ	MTTF	MTTR	MTBF	Availability D	UnAvailability I	Durasi Off	Energy Off	ENS Off	AR	TRIP	TLOD	TLOF	ARI	Reliability
X1	Long Lenght	2948	134602	4.29	**12585**	3.44	12588.70	150	80.08	23:45:00	5742	6636776	1968	890	36	1489	87	5.12
X2	Oblosete	1139	39507	1.24	**3302**	1.08	3302.78	39	21.03	17:05:00	1552	955574	750	294	10	765	17	1.50
X3	Lightning	3949	152671	5.13	**15306**	4.49	15310.20	173	49.08	21:20:00	7869	13082729	2831	1041	49	2462	107	5.81
X4	Kites	2628	54087	2.02	**1871**	0.15	1870.65	43	2.00	20:41:00	2056	940996	2083	474	6	1165	29	2.06
X5	Trees	2189	89036	2.67	**7432**	2.11	7434.55	87	3.04	04:57:00	3642	2559220	1460	746	28	1443	31	3.39
X6	Animal	404	26290	0.58	**2537**	0.73	2537.67	30	2.01	18:59:00	846	507694	288	126	8	287	14	1.00
X7	foreign object	732	13058	0.58	**431**	0.08	431.44	12	0.00	11:34:00	772	636120	598	179	2	330	7	0.50
X8	Primary Equipment	980	32192	0.86	**2014**	0.82	2014.84	30	0.01	15:09:00	1187	796902	737	277	11	722	10	1.22
X9	Secondary Equipment	521	20753	0.57	**1554**	0.45	1554.81	19	1.01	10:23:00	1136	3399833	275	149	7	394	6	0.79
X10	Broken Conductor	456	7651	0.34	**255**	0.13	255.27	6	0.00	19:09:00	733	728647	339	136	5	252	3	0.29
X11	Others	78	11098	0.06	**2125**	0.34	2125.03	10	4.00	03:33:00	625	2735771	44	32	2	85	7	0.42

Table 4.10 Ranking and index of causes for Failure Rate. AR. Trip. ARI. and ENS.

No	Cause	Rank Reliability	Rank Failure Rate	Rank cause for AR	Rank cause for TRIP	Rank ARI	Rank ENS	Index Reliability	Index Failure Rate	Index cause for AR	Index cause for TRIP	Index ARI	Index Average	Rank Average
X1	Long Lenght	2	2	3	2	2	2	0.15	0.15	0.14	0.15	0.15	0.15	2
X2	Oblosete	5	5	5	5	5	6	0.11	0.11	0.11	0.11	0.11	0.11	5
X3	Lightning	1	1	1	1	1	1	0.17	0.17	0.17	0.17	0.17	0.17	1
X4	Kites	4	4	2	4	4	7	0.12	0.12	0.15	0.12	0.12	0.13	4
X5	Trees	3	3	4	3	3	5	0.14	0.14	0.12	0.14	0.14	0.13	3
X6	Animal	7	7	9	10	6	11	0.08	0.08	0.05	0.03	0.09	0.06	7
X7	foreign object	9	8	7	7	9	10	0.05	0.06	0.08	0.08	0.05	0.06	8
X8	Primary Equipment	6	6	6	6	7	8	0.09	0.09	0.09	0.09	0.08	0.09	6
X9	Secondary Equipment	8	9	10	8	10	3	0.06	0.05	0.03	0.06	0.03	0.05	9
X10	Broken Conductor	11	10	8	9	11	9	0.02	0.03	0.06	0.05	0.02	0.03	10
X11	Others	10	11	11	11	8	4	0.03	0.02	0.02	0.02	0.06	0.03	11
Total		66	66	66	66	66	66	1.00	1.00	1.00	1.00	1.00	1.00	66

5. CONCLUSIONS

The Conclusion is:

a. The top 4 causes of transmission interruptions are the most frequent and detrimental:
   1.Lightning
   2.Kite
   3.Tree
   4.Occurs on Long transmission

b. Based on the Fault Tree Diagram and failure rate score:
   Transmission disturbances are dominated by system fault types on long lines. the causes include Lightning. Kites. and Trees.

c. The results of the disturbance ranking and index cause failure rate. AR. TRIP. ARI and ENS are:
   1.Lightning
   2.Tree
   3.Kite
   4.Fault On Long Line

The Recommendation is:

a. Preventing Reclose Failed:
    1. prevent disturbance caused by trees by immediately cutting down trees in critical spans.
    2. activate double shoot Auto Reclose on all bay lines that never trip permanently (only due to lightning and kites).
    3. prevent insulator damage with Climb Up Inspection & ground repair on lines that often reclose successfully due to lightning.

b. Preventing Failed Re Close by Trip PUTT:
    1. Adding / Redundant Digital Multiplexer tele-protection channels. especially those that are still Analog / Power Line Carrier.
    2. Activate Zone Extension 100% Phase to Ground delay 200 ms SPAR with 1 second dead time.
    3. Priority on long lines and if Zone 2 delay is more than 0.4 seconds due to cascading scanning for selectivity.

c. The early Warning span is critical because of trees:
    1. Adding a high resistive phase to the ground protection element but only for triggering alarms and recording disturbances and fault locators.
    2. The operator reports to the maintenance team every time an alarm appears and a record is immediately followed up before a trip occurs.
    3. Activated on lines that already have critical span data because the tree must be immediately prioritized for logging execution if an alarm appears.

Of the 324 bay lines. only 25 bay lines need to use the double shot auto reclose pattern to increase the auto reclose success on the bay line where only kite and lightning disturbances occur. So 299 bay lines are still recommended to use single-shot auto reclose. And there are 111 bay lines whose spans need to be done. Climb Up Inspection insulator towers because too often auto reclose occurs from interference by lightning to prevent permanent insulator breakdown from occurring. For disturbances caused by trees. you cannot use double-shot auto reclose. so it is necessary to carry out an early warning of critical spans and immediate execution of tree felling in critical spans to prevent disturbances due to trees.

REFERENCES

Ghozali. I. (2018). *Aplikasi Analisis Multivariate Dengan Program IBM SPSS 25*. Edisi Kesembilan. Semarang: Penerbit Undip.

Halme. J.. & Aikala. A. (2012). *Fault tree analysis for maintenance needs. Journal of Physics: Conference Series*. 364(1). https://doi.org/10.1088/1742-6596/364/1/012102

Junaidi. J. (2014). *Regresi dengan Microsoft Office Excel.*

Karyana. (2013). *Pedoman dan Petunjuk Sistem Proteksi Transmisi dan Gardu Induk Jawa Bali*. Edisi Pertama: September.

PLN UIKL Kal Bidang Opsis. (2021). *Evaluasi Operasi Tahunan (EOT) Sistem Tenaga Listrik Kalimantan*.

Schweitzer. E. O.. Fleming. B.. Lee. T. J.. & Anderson. P. M. (1998). Reliability Analysis of Transmission Protection Using Fault Tree Methods.

Tim Standarisisasi Setting dan Logic Proteksi (2021). *PANDUAN PENERAPAN SETTING DAN LOGIC_V1*. Lampiran Surat EVP Transmisi Regional Sumatera Kalimantan PT PLN (Persero).

INFORMATION SECURITY RISK MANAGEMENT ANALYSIS IN CELLULAR OPERATOR USING ISO 27005 AND NIST SP 800-30

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ABSTRACT

Nowadays, Information Security Management System has become the greatest challenge in an organization and investing in information security has become a key factor to reach organization's goals. Saudi Arabia is one of the most targeted countries in cyber-attack, due to its geopolitical position and its abundant of oil resources. Cyber-attack not only happened in oil company, but also to other sector which is considered as critical infrastructure such as Telecommunication. Threats of information security not only happened externally, but also internally. This research will be done in one of cellular operator in Saudi Arabia. From 2019 until 2021, it raised 21 emergency tickets, which need immediate response and solution to fix the incident as soon as possible in timely manner, otherwise it could do harmful for the company in business mission perspective. In 2021, 741 incident tickets have been raised, with various asset as source of threats and vulnerabilities. This research explains how to identify assets, threats, and vulnerabilities, along with risk valuation, using ISO 27005:2018 and NIST SP800-30. Based on risk valuation using ISO 27005:2018 and maturity level of implemented control set from ISO 27001:2013, it will give control set recommendation that need to be implemented. This research will use qualitative approached via survey and questionnaire, in this cellular operator, Hopefully, it will give recommendation of control set based on prioritized scale to improve information security system.

Keywords: ISO 27001, ISO 27005, Information Security Management System, NIST, maturity level

1. INTRODUCTION

It is known that the usage of information technology has been part of our daily life, as society and enterprise, as in business perspective. Information communication technology has become part of companies culture to support their activities to achieve their business goals (Mgunda, 2019). Thus, a reliable and sustainable information technology system has become key factor for company to achieve their vision and mission.

Company has put more focus on information security in business process, more than ever. It has become strategically important in long term periods, for company to grow and sustain. In order to achieve that, well known international standard for Information Security Management Systems (ISMS), has been designed in ISO 27001:2013. This standard has been implemented in many big companies, globally. It provides control set to be used in the scope of information technology utilization and assets management , that helps company to have effective and efficient ISMS, including the assurance of Confidentiality, Integrity and Accessibility of information (British Standard Institution., 2013). In last years, cyber-attack has been increased significantly, in

Kingdom of Saudi Arabia (KSA). In the year 2012 only, Saudi Arabia has lost around 2.6 billion SAR, with increasing loss every years (Quadri & Khan, 2019).

In the year 2015, 160 thousand cyber-attacks have been reported daily. This country has been received increasingly 4% malware attacks and 378% ransomware attacks (Kaspersky, 2019). Saudi Arabia positioned number 2 in the security data breach attempts, at the year of 2019 ad 2020, with total loss of $5.97 million and $6.42 million, respectively (IBM, 2020). Therefore, Arab Saudi government has ordered to establish an organization, National Cybersecurity Authority (NCA), which responsible for cyber space security to protect resources and critical infrastructure from the possibility of cyber-attacks attempt. It is an obligation for the enterprise to register their solution or information security product to the NCA, in the end of August 2022 (Arab news, 2022). KSA has been one of main target for cyber-attack, due to following reasons: it has strategic geopolitical position and abundance of oil resources. Secondly, it has active internet users around 93.31%, and media social users around 72.38%, which spent their time online, approximately 7 hours daily (Alzubaidi, 2021).

Recently, KSA under progress of development in cyberspace, vigorously. This process accelerated significantly due to pandemic, Covid-19, and the downfall of oil price. In the early pandemic condition, first quarter of 2020, middle east countries received increasingly malware attack 22% and spam attack around 36%. It was the hardest time for any companies in Saudi Arabia, which starting to work from home remotely (Buller, 2020).

Since 2016, KSA has disclosed Saudi Vision 2030 strategy, which will abandon its dependency on oil industry and start to diversified economy and build public facility sector, such as health, education, infrastructure, and tourism sector (Vision 2030, 2020). This huge reformation has several key processes which has more focus on technology, digital transformation, and digital infrastructure development.

More than half, Chief Information Officer (CIO) in Saudi Arabia, considered that ISMS as the biggest technology challenge, and considerable investment in cybersecurity has become key factor to achieve their business goals. Information security enhancement has become main indicator to achieve good performance and to have digital transformation in the whole region of KSA. Thus, it will lead to increasing budget allocation, annually, in technology and protection to prevent data breach (Wright, 2020).

Government and owned-state company in Saudi Arabia, is not the only target in cyber-attack, which caused data elimination and information blockage. Attack attempts also targeting critical infrastructure, specifically, telecommunication and tourism sector which store personal data information, and government administration. According to Salem Alelyani, several solution recommendation to tackle cyber-attack in Saudi Arabia as follows (Alelyani & Kumar G R, 2018) : good password management, always use latest patch level software to prevent illegal access, all connection access request should be rejected (by default) and only granted service that allowed by design, make sure that all user account has the lowest privileges to be able to do their daily tasks, facilitate training for employees to increase information security awareness, only granted privileges access that has been approved, and lastly, conduct vulnerability scan to the network system, periodically to make sure it fulfilled certain security level.

This research will be done in one of the biggest cellular operator in Saudi Arabia, which already implement ISO 27001 since 2006, from British Standard Institution, for Security Operation Management Center (SOC) , Network Operation Center (NOC) and data center. Since cellular operator has wide area domain, we only cover on Network Management System (NMS), which belong to Network Access Operation department. In order to manage huge cellular network, we need integrated system which connect all those node elements in the network, thus NMS

comes in the picture. NMS is part of telecommunication industry which mainly responsible to deliver performance, configuration, and fault management function, for all nodes that are integrated within it. Multiple node element from multiple platforms and third-party vendor which integrated in NMS, and working remotely from home due pandemic, open up possibility to exploit vulnerability in its daily operation and maintenance tasks. There is urged to evaluate recent information security condition, based on ISO 27001, which follow up with treatment recommendation if needed.

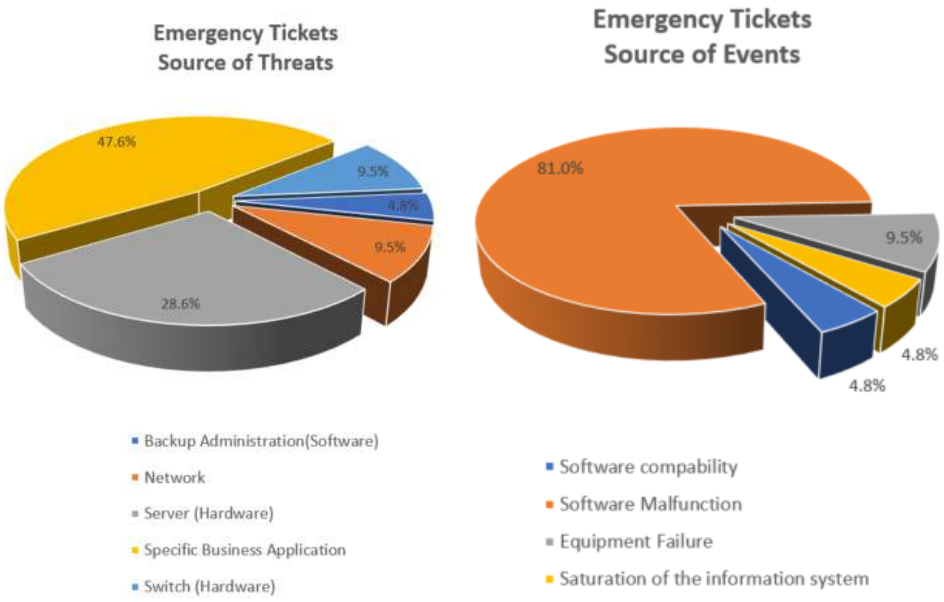


Figure 1. Emergency tickets Source of Events and Threats, 2019-2021

It has been observed that within daily operation and maintenance in NMS, in 2021, 794 incident tickets reported. Moreover, since 2019 till end of 2021, 21 emergency tickets have been raised, which need immediate response and solution in timely manner. Any delay to fix the issue, could hamper business operational activities, which could lead to business opportunity loss. Hopefully, this research findings could be used as reference to analyze information security risk in company, especially in cellular operator.

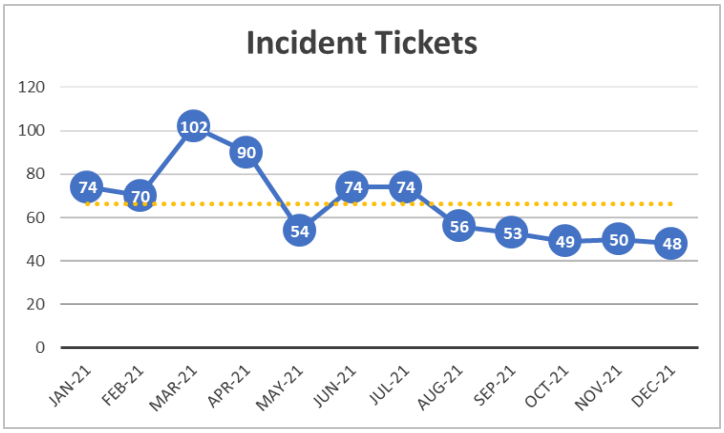


Figure 2. Monthly incident tickets, 2021

2. LITERATURE REVIEW

ISMS based on ISO 27001:2013 intended to give effective protection of information technology system, within Confidentiality, Integrity and Accessibility (CIA) scope. The purpose of the protection goes beyond CIA, it also supports business process, achieve business goals and maintain companies' assets, which provide and process information without any interruption.

Information security aims to protect information from any possible threats and vulnerabilities that might happen. Its purpose to make sure business sustainability, minimalize business risk and shortened investment payback period, and emerge new business opportunity (British Standard Institution., 2013). Information business process has correlation with information security , especially its association with documents, hardware, software, infrastructure, data center which used to protect it (Whitman & Mattord, 2011). The ability of a company to access and provide information accurately, is a must, since it related with its reputation as an organization. Thus, it is mandatory to protect information within fulfilling several aspects, CIA. Confidentiality, makes sure that specific information can be accessed only for authorized employees. Integrity, it confirms that certain information stays in its original form, not modified, corrupted in any ways. Availability, related with certain information, could be accessed by end user wherever and whenever needed, without any interruption.

2.1 ISO 27005 Framework

ISO 27005 is part of big family ISO 27000. Based on ISO 27005, an organization could establish dedicated committee to build regulation and policies of information security (International Standard, 2018). ISO 27005 gave more focus on Information Security Risk Management (ISRM). ISO 27005 being used in this research, since it can be used in variety if situation and condition. ISO 27005 can be used in organization, either profit or non-profit (Al Fikri et al., 2019). There are several phases on ISRM, as shown below:

- Context Establishment: ISRM context must be applied and cover basic information security criteria. Within defined scope and limitation, an organization could conduct ISRM properly, effectively and efficiently.
- Risk Assessment: It consists of risk identification, estimation, and evaluation. It allowed manager to prioritized risk, based on impact or other criteria.
- Risk Treatment: There are several risk treatments, i.e: modification, retention, avoid and share. Any specific control sets to handle risk, explained in details on ISO 27002 (ISO/IEC, 2013) or ISO 27001 Annex A.
- Risk Acceptance: Within this phase, all risk accepted along with its treatment, according to prioritized risk. Any decision taken to treat risks, are taken by the risk owner or manager.
- Risk Communication: All stakeholders must have good coordination within good communication line inside the organization. Thus, risk can be shared between risk owner for each specific asset.
- Risk Monitor and Review: Risk treatment is never ending process, since risk can be converted into another form within period of time. Thus, monitoring and review phase needed to handle any new risk may come.

2.2 NIST SP 800-30 Revision 1

One of guidance to implement risk assessment, provided by National Institute of Standard and Technology, Special Publication 800-30 Revision 1 (NIST SP 800-30 Rev1). It equips risk assessment for organization and government, as complementary of NIST SP 800-39 (NIST, 2012).

It can be used to fulfill details in ISO 27005, for conducting risk assessment. Steps under this guidance are:

- Identify threat source: it used to identify asset as source of threat. It categorized as adversarial and non-adversarial.
- Identify threat event: it used to identify potential threats, relation between threats event and threat source.
- Identify vulnerabilities: this phase identifies vulnerabilities and any condition that could lead to threats likelihood and caused any harmful impact in business perspective.
- Determine likelihood of threats: it describes how often threats could occur in some periods of time. Likelihood of threats are combination of likelihood of event with likelihood of event that could cause impact.
- Determine impact: determine impact level of threat event, based on assessment scale
- Determine risk level: risk level determines by multiplication of impact level and likelihood of threat event.

Picture below shown diagram combination of risk assessment phase in ISRM using ISO 27005, with guidance of NIST SP 800-30 Rev1.

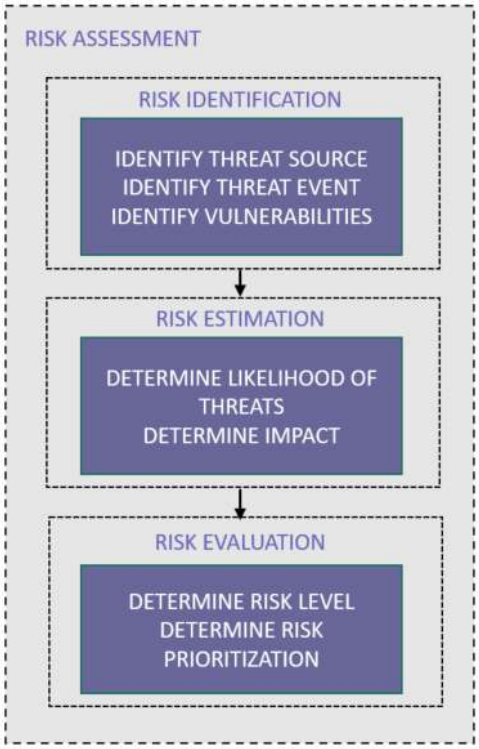


Figure 3. Risk Assessment in ISRM based on ISO 27005 framework, with guidance of NIST SP 800-30 Rev1

2.3 Previous Study

Nowadays, Information and Communication Technology (ICT) has been developed exponentially. Information has transformed into valuable assets for an organization or enterprise (Talabis & Martin, 2013). ISO 27001 framework has been planned and implemented for ISMS in

wide variety of industries around the world. ISMS practice has been grown in demand for many companies to reach their business goals. More and more organization and company utilize ISO 27001 framework, which needed to preserve information, to meet Confidentiality, Integrity and Availability criteria, as valuable assets of the company. ISO 27001 appliance not only merely in big enterprise, but also can be used on small and medium sized enterprise (SME). Even, it's been observed that readiness level for each SME to implement it, has huge disparity compare with enterprise level (Candiwan, 2014).

Even though, ISO 27001 framework is well known international standard for ISMS, but in reality, it's adoption in real world relatively low, since it's facing many challenges and obstacles. There are some factors that contribute to this fact, such as motives, experience impact, and implementation obstacles. According to Mirtsch et al., only impact prevention and operational investment that urge company to embrace its adoption (Mirtsch et al., 2021). Its best practice and implementation in each company also unique, since ISO 27001 framework only design as information security general guidance. Thus, for each type of industry, will pick and adopt control set which suitable for their needs and requirements (Achmadi et al., 2018).

The implementation of ISRM intended to manage the risk of opportunity loss and the consequences in information security business process. For this purpose, ISO 27005 framework designed in more details regarding ISRM, which related with ISO 27001 that has control objective for risk treatment. ISO 27005 frame also can be used in academic school, where the risk and control set implementation will be different with business company. While, it's been researched that ISO 27005 in telecommunication company used 26 risk scenario and 8 objective control in Annex A, ISO 27001 (Jaya Putra et al., 2020).

Risk management considered as best practice to treat risk scenario in an organization, including information security domain. There are several technique that can be used to make information security risk assessment, such as ISO 31000, OCTAVE allegro method, COBIT 5, FRAP method, NIST SP800-30 (Jaya Putra et al., 2020).

In its application, ISO 27005 can be combined with another standard method or guidance to fulfill company needs in ISRM perspective. This combination technique can be used to sharpen ISRM process. NIST SP 800-30 Rev1 can be used as complement for risk assessment process and applicable in ISO 27005 framework. Combination of both, ISO 27005 framework and NIST SP 800-30 Rev1, can be implemented in profit or no-profit organization (Al Fikri et al., 2019). This combination technique, has been used also in ISRM of data communication application, where ISO 27005 provides framework and NIST SP 800-30 SP Rev1 provides details guidance for risk assessment (Fandi Aditya Putra,Hermawan Setiawan, 2017). Candiwan et. al, has used this combination in academic entity, high school, which gave result on control set treatment based on prioritized risk scenario (Candiwan et al., 2015). Author would like to use it in telecommunication industry, which is one of the biggest Cellular Operator in Saudi Arabia specifically.

3. METHODS

In this research, we will use combination technique, IS) 27005 as framework and ISO NIST SP 800-30 Rev1 as detail guidance for ISRM. Methodology research can be observed in the figure 3.

Research Object

This research will be done in telecommunication industry, specifically, one of the biggest cellular operators in Saudi Arabia. Since, this industry consist large domain of departments, we only conduct it in Network Management System (NMS) domain, which is part of Network Access

Operation department. Even though it is in single domain, but this part hold very strategic and important role in the network, since whole node elements in KSA integrated with in it .

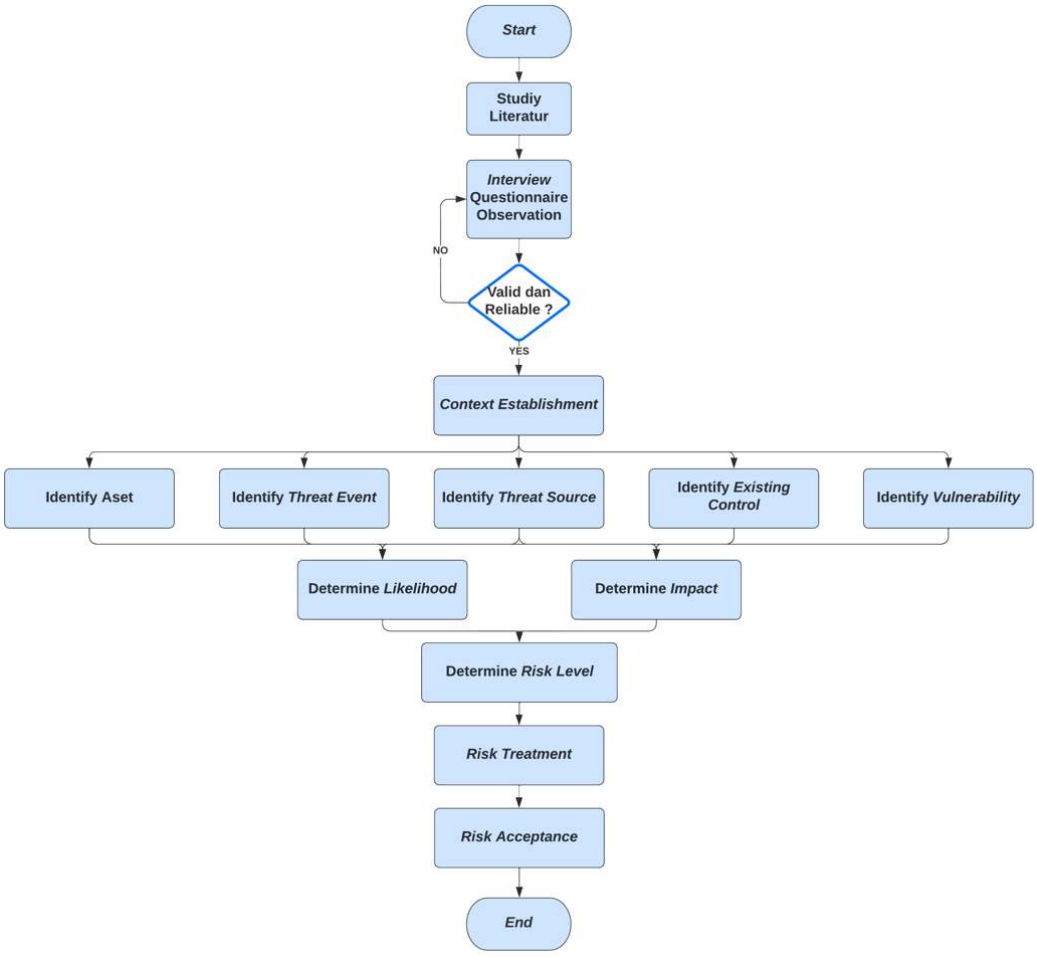


Figure 4. Flow chart methodology

Data Collection

This research will be done in qualitative research method, while data collection will be conducted in several manners:

- Literature study: Basically, all information categorized in two parts, public domains, such as: journals, academic articles, official websites, books, and private domain such as: data inventory, MBSS document, vulnerability scan result, internal technical documents.
- Interviews: Specific information need to be retrieved from authorized risk owner.
- Questionnaire: This information needed to identify source of threats and threat of events, identify vulnerabilities, and likelihood of threat to exploit vulnerability, determine impact level. Details of questionnaire refer to guidance from NIST SP 800-30 Rev1.
- Observation: There are some information or evidence that need to be collected by observation. Mostly, for any evidence that related with user behavior, individual habit or physical condition, which related with the research.

Data validation

The accuracy of the findings from all research stakeholder's point of view, i.e., researcher, the participant, and the reader, could determine the validity of the research, that makes it strength point of qualitative research. The validation technique used in this research is member checking, which taking back the final report to the participants to check the accuracy.

Analysis method

ISRM will be done using ISO 27005 as framework, with complementary of NIST SP 800-30 Rev1 as guidance details for risk assessment. The asset owner will be considered as primary source of information in assessing information security risk.

4. RESULTS

This research still ongoing process, especially there was hajj season coming where there was freeze period and we're focusing to deliver best service on this window period. As preliminary study, we've done questionnaire to see the landscape of information security risk management awareness internally. This questionnaire responded by 14 employees, with different domain and expertise.

Most of them, think that Telecommunication industry is very important (92.9%) in our daily life, and it is considered as critical infrastructure (85.7%), and 85.7% regard ISMS as very important.



Figure 5. Internal awareness of Information Security framework

All respondent answered that control set already implemented to protect critical asset in the company, but only 28.6% feel very confident that it will mitigate any impact occurred from threats and exploiting vulnerability. Confidential information ranked as top priority for critical asset (85.7%), followed by business process & activities and site/data center with 71.4% each.

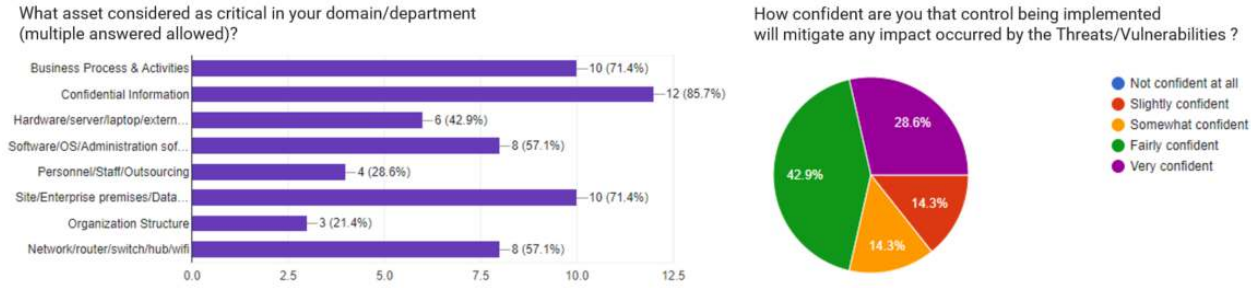


Figure 6. Critical assets and confidential level

5. CONCLUSIONS

ISMS is getting a lot of attention and focus on business process these days. It's become more and more important for a company to maintain sustainable business and support them to achieve business goals. Company tends to spend big investment for it, i.e., implementing control sets being recommended to mitigate any threats and vulnerability that could make impact on their business. With in this research, we'll analyze ISRM using combination technique of ISO 27005 framework and with detail guidance of NIST SP 800-30 Rev1. Hopefully, the findings could become reference for ISMS in the telecommunication industry, especially in cellular operator.

6. REFERENCES

Achmadi, D., Suryanto, Y., & Ramli, K. (2018). On Developing Information Security Management System (ISMS) Framework for ISO 27001-based Data Center. *2018 International Workshop on Big Data and Information Security, IWBIS 2018*. https://doi.org/10.1109/IWBIS.2018.8471700

Al Fikri, M., Putra, F. A., Suryanto, Y., & Ramli, K. (2019). Risk assessment using NIST SP 800-30 revision 1 and ISO 27005 combination technique in profit-based organization: Case study of ZZZ information system application in ABC agency. *Procedia Computer Science*, *161*, 1206–1215. https://doi.org/10.1016/j.procs.2019.11.234

Alelyani, S., & Kumar G R, H. (2018). Overview of Cyberattack on Saudi Organizations. *Journal of Information Security and Cybercrimes Research*, *1*(1), 32–39. https://doi.org/10.26735/16587790.2018.004

Alzubaidi, A. (2021). Measuring the level of cyber-security awareness for cybercrime in Saudi Arabia. *Heliyon*, *7*(1), e06016. https://doi.org/10.1016/j.heliyon.2021.e06016

Arab news. (2022). *National Authority launches Saudi cyber security registration push*. https://www.arabnews.com/node/2071071/business-economy

British Standard Institution. (2013). ISO/IEC 27001:2013 (2013). Information Tecnology-Security Techniques-Information Security Management Systems-Requirements. *BSI Standard Limited.*, *2*, ISO/IEC 27000:2009(E).

Buller, A. (2020). Saudi Arabia sees cyber security boom as coronavirus bites. *Computerweekly*. https://www.computerweekly.com/news/252489175/Saudi-Arabia-sees-cyber-security-boom-as-coronavirus-bites

Candiwan. (2014). Analysis of ISO27001 Implementation for Enterprises and SMEs in Indonesia. *Proceedings of the International Conference on Cyber-Crime Investigation and Cyber Security, Kuala Lumpur, Malaysia, 2014 ISBN: 978-1-941968-02-4 ©2014 SDIWC 50*, *1*, 50–58.

Candiwan, Sari, P. K., & Sebastian, J. (2015). Comparison Analysis of Information Security Risks and Implementation of ISO27001 on Higher Educational Institutions in Indonesia. *International Journal of Basic and Applied Science*, *Vol. 04*, *N*(November), 40–52.

Fandi Aditya Putra,Hermawan Setiawan, A. R. P. (2017). Design of information security risk management using ISO/IEC 27005 and NIST SP 800-30 revision 1: A case study at communication data applications of XYZ institute. *International Conference on Information Technology Systems and Innovation (ICITSI)*, 6.

IBM. (2020). *Cost of Data Breach Report 2020 (Highlights)*. https://www.ibm.com/security/digital-assets/cost-data-breach-report/#/

International Standard. (2018). *INTERNATIONAL STANDARD ISO / IEC 27005:2018. Information Security Risk Management*. *3*.

ISO/IEC. (2013). ISO/IEC 27002:2013.pdf. *Iec*, *2013*, 90. www.iso.org

Jaya Putra, S., Nur Gunawan, M., Falach Sobri, A., Muslimin, J. M., Amilin, & Saepudin, D. (2020). Information Security Risk Management Analysis Using ISO 27005: 2011 for the Telecommunication Company. *2020 8th International Conference on Cyber and IT Service Management, CITSM 2020*. https://doi.org/10.1109/CITSM50537.2020.9268845

Kaspersky. (2019). *Kaspersky Lab Helps Mitigate Security Risk at the Cyber Defense Summit 2019*. https://me-en.kaspersky.com/about/press-releases/2019_cyber-defense-summit

Mgunda, M. I. (2019). The Impacts Information Technology On Business. *Journal of International Conference Proceedings*, *2*(3), 149–156. https://doi.org/10.32535/jicp.v2i3.656

Mirtsch, M., Blind, K., Koch, C., & Dudek, G. (2021). Information security management in ICT and non-ICT sector companies: A preventive innovation perspective. *Computers and Security*, *109*, 102383. https://doi.org/10.1016/j.cose.2021.102383

NIST. (2012). NIST Special Publication 800-30 Revision 1 - Guide for Conducting Risk Assessments. *NIST Guide for Conducting Risk Assessments*, *September*, 95.

Quadri, A., & Khan, M. (2019). Cybersecurity challenges of the kingdom of saudi arabia: Past, Present and Future. *Global Foundation for Cyber Studies and Research (GFCyber)*, *Jan*, 1–22. https://www.researchgate.net/publication/331009167%0Ahttps://www.researchgate.net/publication/331009167%0ACYBERSECURITY

Talabis, M., & Martin, J. (2013). Information Security Risk Assessment: A Practical Approach. In *Information Security Risk Assessments*. https://doi.org/10.1016/b978-1-59-749735-0.00002-6

Vision 2030. (2020). Government of Saudi Arabia. *Vision 2030 Kingdom of Saudi Arabia*, 1–85. https://vision2030.gov.sa/download/file/fid/417

Whitman, M. E., & Mattord, H. J. (2011). Principles of Information Security Fourth Edition. In *Learning*.

Wright, B. (2020). *Saudi CIOs consider security their toughest tech challenge*. https://www.cio.com/article/217682/saudi-arabias-cybersecurity-concerns-increase-as-threats-evolve.html

RISK ANALYSIS TO EVALUATE TRUCKS RENEWAL AND UTILIZING 3PL SERVICES

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ABSTRACT

PT. X Indonesia is a multinational company engaged in the chemical distributor which was established in 2013 by acquiring local distributors for both business and the assets. Along with its development, the company changed the business direction from commodity to specialty goods, while the impact is ineffectiveness of operational activities, especially the trucks utilization was very low which is only 42% in average. The challenge is how the company can improve truck utilization back to normal capacity. There are 2 alternatives, which are by renewal all units or replacing the distribution system using 3PL services. This study focuses on analyzing the risks faced in determining decisions for the two alternatives using the questionnaire method, determining risk events, and calculating risk priority numbers. There are 20 risks which are then calculated based on the results of the questionnaire, with the result that alternative use of 3PL has a lower risk than renewal units. The next step is vendor selection by determining the criteria and calculated using the AHP method. From these results, it can be submitted to the management as a reference for further decision making so that truck utilization back to normal and operational costs can be reduced.

Keywords: 3PL, RPN, AHP.

1. INTRODUCTION

Providing the maximum service to customer is an important part of logistics management, especially for distributor companies that selling services. Stank (2003), Logistical services, a unique subset of industrial services that span the boundaries between suppliers and customers, have become increasingly important to successful supply chain operations.

PT. X Indonesia started the business in Indonesia in 2013 by acquiring local distributors, acquisitions were made in business, assets, and resources. Along the way, global management has changed the focus of the business from commodity to specialty products. The effect of the change, PT. X Indonesia with its existing fleet must distribute the product with less efficiency to consumers, moreover fewer products are loaded onto trucks with large dimensions. Meanwhile, the report from Ministry of Transportation (KIR) year by year was showing the maximum capacity per truck tend to lower because of the ages of trucks. It is meant the distribution of transportation costs for each product becomes high.

This research focuses on product distribution to customers which is increasingly less efficient and how to provide flexibility to adapt customer needs as well as compliance with

government regulations. Several previous studies on risk management research used to make decisions, especially in Indonesia, still have not used risk analysis to evaluate truck renewal and 3PL services such as by Amelia et al., 2017, Profita et al., 2014, Nurmalatya and Vanany, 2017; Wahyuni et al, 2018.

This the basis for the risk of distribution failure to customers which affects the company's revenue and the level of customer satisfaction. With the complexity of the problem, there are 2 alternative options to reduce this risk, which is regenerating all trucks or shifting distribution responsibility to 3PL (third party logistics).

The initial stage of this research is risk identification, risk analysis, determining risk and steps for mitigation. The risk analysis process is carried out using the risk event method by calculating the RPN (Risk Priority Number) of the 2 alternatives to determine which alternate having a lower risk which at the end for the decision-making recommendation. Then the next step is to determine the 3PL criteria by calculating the Eigen values to get the consistency ratio for each criterion which aims to get the best 3PL candidate. From the results of above data processing, the priority of risk mitigation steps is determined which can be used as a reference for the company to always consider risk in every decision making.

2. LITERATURE REVIEW

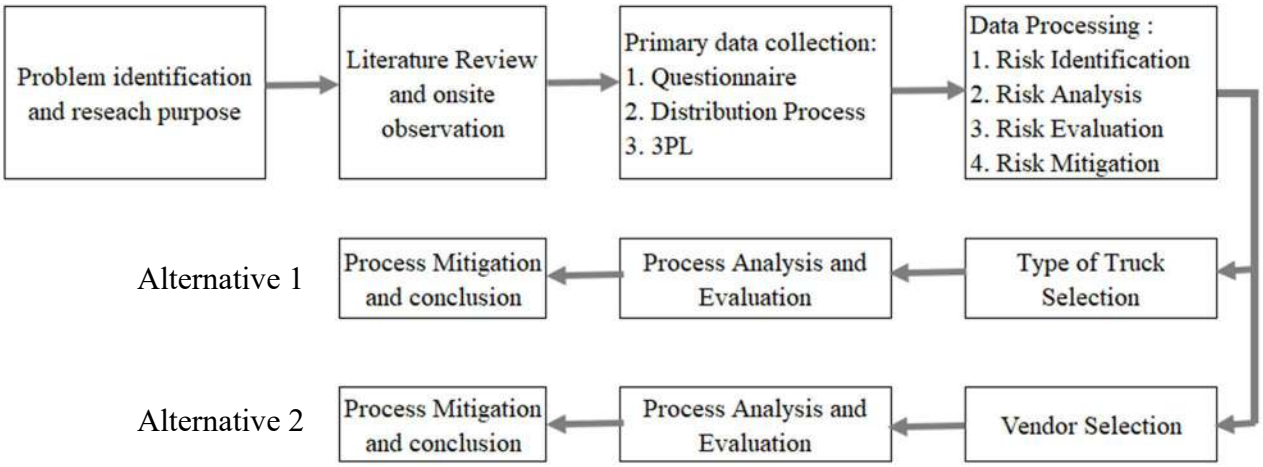
Distribution is a marketing channel of choice for manufacturers to deliver the product to industry or customers. Distribution channels include manufacturers, distributor, customer, or industry (Swastha, 2001). The product distribution channel bears the risk of order processing, inventory warehouse, inventory holding volume, delivery of orders to customers, as well as unpaid credit. Distribution and transportation activities can be carried out by the company manufacturing by establishing a separate distribution or transportation department or handed over to a third party. Pujawan (2005) said that there are 4 basic function of management distribution which is segmentation and target of service level, transportation mode, consolidation of information and delivery and scheduling and delivery route decision. Along the way, there must be many obstacles and risks faced both internally and externally. For this reason, a risk management process is needed that thoroughly explains the process from upstream to downstream through identification of threats, vulnerabilities and risks is based on events that may affect the achievement of goals identified in the first phase. After that, risk analysis and evaluation estimate the likelihood and impact of risks to the strategic goals, in order to be able to decide on the appropriate techniques to handle these risks (treat risks) Barateiro (2010).

Regarding the specific theory about discusses the distribution of goods used by the literature from Shanker (2021), which states that there are 4 factors to measure the risk of distributing goods to consumers, Macro-level risks, supply risks, operational risks, and demand risks. By those factors then continued to observe the risk derivatives are identified. The Risk Priority Number (RPN) is the next step after identification of risks, and it calculated the severity of event (S), the probability of occurrence (O) and probability of detection (D) according to the following formula: $RPN = S \times O \times D$ while the data was obtained based on questionnaire from the expert. The RPN value for each failure ranges between 1 and 1000 and an acceptance limitation was set for RPN score based on the previous studies however the higher score of RPN was considered more unsafe (Rezaei, et al. 2018). While the literature to follow up on the results of the RPN score are uses the 3PL selection process with the AHP method and a paired matrix of weight hierarchy for each category. The process selection of third-party logistics (3PL) providers is a further task that is no less important where the 3PL needs of many companies and industries related to distribution are also increasing. By making the right decisions about logistics service providers, companies can save costs and time and able to

increase their competitive advantage in their market (Jovčić, 2019). Bansal (2013) said that there are 6 factors to perform vendor selection which is logistic cost, quality of service, IT, delivery performance, trust factor dan geographical of area services.

3. METHODS

This section would describe the research methods or steps taken to achieve the objectives and obtain answers to research problems with the aim that the research process is carried out in a systematic, structured and directed manner. This research tries to identify the distribution risk of the business by analyzing and mitigating the risk effectively and efficiently. The following is a flowchart of the research process:



This research would conduct on 4 key stages, which is (1) risk event identification, (2) risk measurement (3) determination of Risk Priority Number (RPN), (4) Vendor selection. While the detail explanation for the stages would describe on below,

Stage 1. Identification of Risk Events: This stage aims to: (1) identify the scope of the research, which is focus on the distribution goods to customers, (2), identify the risk event of distribution based on the alternatives (3) determine respondence to assess the risk for each factor.

Stage 2. Risk Measurement: This stage aims to measure the risk by calculating the value of each risk based on value of Severity (S) and Occurrence (O). While the technique of data retrieval is done based on result of questionnaire with scale 1-10 for both severity and occurrence (see table 1)

Stage 3. Determination of Risk Priority Number (RPN): This stage aims to determinate of risk priority on distribution goods to customers. The preparation of RPN is based on the score generated during risk measurement. The making data procession is done by identify the score of RPN for both alternatives. The largest score of RPN has indicated as high risk while the lowest score of RPN has indicated as low risk. Meaning the decision could take based on the lowest risk of RPN values.

Stage 4. Vendor Selection: This stage aims to select the vendor either 3PL or vendor new truck by using method AHP. The step is: (1) define the assessment factors, (2) create pairwise comparison matrix, (3) normalization eigen vector, (4) calculate consistency ratio (CR).

Table 1. Identification risk events template

Alternatives	Factors	Risk Events	Severity (S)	Occurrence (O)	RPN (SxO)
Renewal Trucks	F1	R1	....	....	....
		R2	....	....	....
	F2	R1	....	....	....
		R2	....	....	....
	F3	R1	....	....	....
		R2	....	....	....
	F4	R1	....	....	....
		R2	....	....	....
Move to 3PL	F1	R1	....	....	....
		R2	....	....	....
	F2	R1	....	....	....
		R2	....	....	....
	F3	R1	....	....	....
		R2	....	....	....
	F4	R1	....	....	....
		R2	....	....	....

4. RESULTS

Basic function of the distributor business is very simple, it consists of 3 essential processes which is (1) purchase to the vendors, (2) storing in the warehouses and (3) distribute to the customers. Those processes can be achieved through a proper approach as well as by appropriate other supported functions. Driven by the goal is delivery on time to customer and customer satisfaction (Parkhi, 2014), distributor should consider many risks how to achieve the goal with efficient way and competitive cost. Located in the territory of Indonesia as an archipelagic country, the distribution goods are very challenging in term of cost and lead time, driven by the facility of road, port and access to the remote area. The sample of risk even calculation based on questionnaire from respondence, and the alternative can be described on table 2 and table 3, while this practice would continue for the other respondence both alternatives to gain the RPN score in total.

Table 2. Risk even calculation from respondence 1 Alternative 1

		Respondence 1		
Factors	**Risk Event**	**Severity**	**Occurrence**	**RPN (S x O)**
Micro-Level Risks	Natural disasters	9	2	18
	Disease outbreaks and epidemic	8	2	16
	Political unrest	7	4	28
	Government regulation	7	8	56
Supply Risks	Supplier (Distributor) bankruptcy	7	1	7
	Communication failure	8	7	56
	Failure of the partnership	7	3	21

		Respondence 1		
Factors	**Risk Event**	**Severity**	**Occurrence**	**RPN (S x O)**
	Quality of goods	6	4	24
	Incapability supply	6	5	30
Operational Risks	Service level	9	4	36
	Type Truck	8	7	56
	Capacity load	9	7	63
	Cost constraint	9	5	45
	KIR test	8	3	24
	Repair & Maintenance	8	4	32
	Driver capability and behaviors	8	6	48
Demand Risks	Customer bankruptcy	8	2	16
	Fluctuation of Demand	9	7	63
	Specific requirement from customer	9	7	63
	Communication failure	8	7	56

Table 3. Risk even calculation from respondence 4 alternative 2

		Respondence 4		
Factors	**Risk Event**	**Severity**	**Occurrence**	**RPN (S x O)**
Micro-Level Risks	Natural disasters	9	1	9
	Disease outbreaks and epidemic	8	1	8
	Political unrest	7	3	21
	Government regulation	7	5	35
Supply Risks	Supplier (Distributor) bankruptcy	7	2	14
	Communication failure	8	5	40
	Failure of the partnership	7	2	14
	Quality of goods	6	3	18
	Incapability supply	6	2	12
Operational Risks	Service level	9	3	27
	Type Truck	7	2	14
	Capacity load	7	2	14
	Cost constraint	7	3	21
	KIR test	7	1	7
	Repair & Maintenance	7	2	14
	Driver capability and behaviors	6	5	30
Demand Risks	Customer bankruptcy	8	1	8
	Fluctuation of Demand	9	3	27
	Specific requirement from customer	9	5	45
	Communication failure	8	5	40

This practice should continue to calculate all respondence for both alternatives. It shown on below table 4 for the summary calculation of RPN.

Table 4. RPN calculation for alternative and respondence

		Alternative 1				Alternative 2			
Factors	**Risk Event**	**R1**	**R2**	**R3**	**Average**	**R1**	**R2**	**R3**	**Average**
Micro-Level Risks	Natural disasters	18	8	16	19.4	9	9	18	14.2
	Disease outbreaks and epidemic	16	8	8	10.1	9	8	9	8.2
	Political unrest	28	21	16	15.1	16	14	21	21.9
	Government regulation	56	42	49	38.8	24	32	35	28.8
Sub Total					**83.4**				**73.1**
Supply Risks	Supplier (Distributor) bankruptcy	7	7	14	8.6	7	7	16	8.7
	Communication failure	56	35	48	34.7	14	35	48	29.7
	Failure of the partnership	21	35	12	15.9	21	16	7	12.2
	Quality of goods	24	12	18	21.8	14	12	18	17.2
	Incapability supply	30	42	28	28.6	14	21	7	21.2
Sub Total					**109.4**				**89.0**
Operational Risks	Service level	36	27	45	33.3	16	35	45	32.7
	Type Truck	56	48	63	39.8	12	14	12	14.4
	Capacity load	63	63	63	46.0	10	12	12	15.8
	Cost constraint	45	27	24	23.4	42	21	40	23.6
	KIR test	24	18	24	14.2	6	7	7	6.4
	Repair & Maintenance	32	40	45	29.7	5	12	7	12.6
	Driver capability and behaviors	48	63	40	44.6	24	18	21	24.9
Sub Total					**231.0**				**130.3**
Demand Risks	Customer bankruptcy	16	7	7	8.3	10	7	8	8.4
	Fluctuation of Demand	63	63	54	44.1	40	32	27	32.6
	Specific requirement from customer	63	48	56	48.0	45	27	45	37.0
	Communication failure	56	32	35	34.4	35	21	40	30.4
Sub Total					**134.9**				**108.4**
Total Score RPN					**558.8**				**400.9**

Based on the RPN score, the alternative 2 shown the score less than alternative 1, meaning the risk of renewal truck is higher than move to 3PL. According to this result the research can be continued for the next step which is to select the right and good vendor.

First step for the preparation hierarchy vendor selection for 3 3PL's paired with 6 criterions of vendor selection (figure 1), Pairwise comparison matrix for 6 factors assessment vendor to calculate the assumption weight of each factor (table 5).

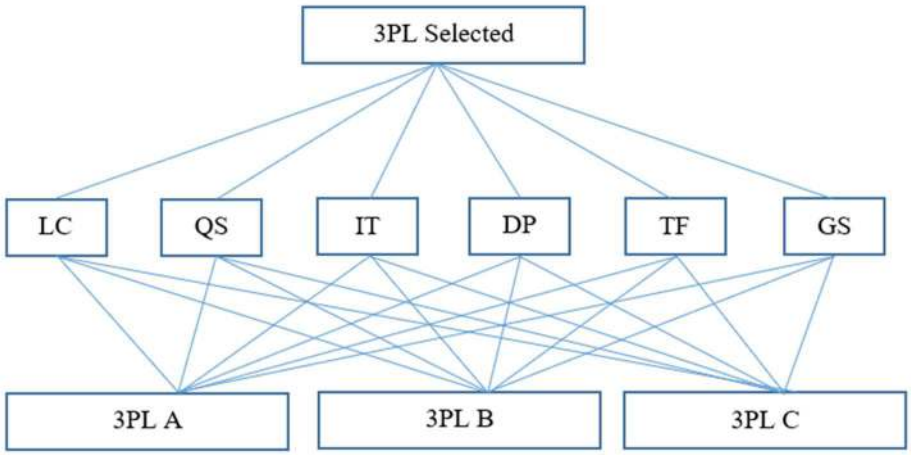


Figure 1. Hierarchy vendor selection

Table 5. Pairwise comparison matrix

Factors	LC	QS	IT	DP	TF	GS
LC	1.00	0.14	5.00	0.20	0.20	3.00
QS	7.00	1.00	0.14	3.00	0.11	0.20
IT	0.20	7.00	1.00	0.33	0.20	3.00
DP	5.00	0.33	0.33	1.00	0.20	3.00
TF	5.00	9.00	5.00	5.00	1.00	5.00
GS	0.33	5.00	0.33	0.33	0.20	1.00
Total	**18.53**	**22.48**	**11.81**	**9.87**	**1.91**	**15.20**

Table 6. Normalization vector eigen

Factors	**Eigen Vector**						**Total**	**Average**
	LC	**QS**	**IT**	**DP**	**TF**	**GS**		
LC	0.054	0.006	0.423	0.020	0.105	0.197	0.806	0.134
QS	0.378	0.044	0.012	0.304	0.058	0.013	0.810	0.135
IT	0.011	0.311	0.085	0.034	0.105	0.197	0.743	0.124
DP	0.270	0.015	0.028	0.101	0.105	0.197	0.716	0.119
TF	0.270	0.400	0.423	0.507	0.523	0.329	2.453	0.409
GS	0.018	0.222	0.028	0.034	0.105	0.066	0.473	0.079

Table 5 and 6 shown the weight of each factor with total and average value to be calculated with each 3PL's candidates.

$$\lambda \text{ Max} = 6{,}5886$$

$$CI = \frac{\lambda \text{ Max} - \text{n}}{\text{n} - 1} \qquad CI = \frac{6{,}5886 - 6}{6 - 1} = 0{,}1177$$

$$CR = \frac{CI}{RI} \qquad CR = \frac{0{,}1177}{1{,}24} = 0{,}095 \quad \longrightarrow < 0{,}1 = \text{consistent}$$

Table 7. Random index table

n	1	2	3	4	5	**6**	7	8	9	10
Random Index (RI)	0.00	0.00	0.00	0.58	1.12	**1.24**	1.32	1.41	1.45	1.49

Based on the calculation of consistency ratio, the result is 0,095 which is under 0,1 and it categorized as consistent result. The next calculation is pairwise for each 3PL compare with each factor.

Table 8. Pairwise comparison matrix vendor

Logistic Cost	3PL A	3PL B	3PL C	Eigen Vector			Ave rage	Priority
3PL A	1.00	0.11	0.20	0.067	0.077	0.048	0.064	3
3PL B	9.00	1.00	3.00	0.600	0.692	0.714	0.669	1
3PL C	5.00	0.33	1.00	0.333	0.231	0.238	0.267	2
Total	**15.00**	**1.44**	**4.20**	**1.00**	**1.00**	**1.00**	**1.00**	

λ Max	3.0453	
CI (λ Max-n / n-1)	0.0226	
RI	0.58	
CR (CI/RI)	**0.039**	**< 0,1** ***(Consistent)***

Then the final calculation for the pairwise comparison matrix for the factor compares with each 3PL's done with the result as table 9 3PL C is the priority.

Table 9. Final result calculation vendor selection

3PL	**Total Score**	**Priority**
3PL A	0.244	2
3PL B	0.123	3
3PL C	**0.254**	**1**

5. CONCLUSIONS

Based on the results of the risk identification of alternative renewal trucks or using 3PL services, there are 4 risk factors which are macro level risk, supply risk, operational risk, and demand risk. And it was identified 20 risks while 7 of the 20 risks come from operational factors. Refer to the calculation of the risk priority number (RPN), the result of the first alternative has RPN value is 558 while the second alternative has RPN value is 400, meaning that second alternative which is transfer responsibility of delivery product to 3PL services have a smaller risk than replacing the truck with a new unit. This result can be used as a reference for companies in making decisions for both alternatives. While the advantages of using 3PL compared to replacing trucks are more beneficial, in particular it will greatly reduce or even eliminate complexities in operations that are not the focus of the company's business.

Then as a continuation of this research, 3PL vendor selection was conducted using the AHP method. Where there are 6 vendor selection criteria, which are logistics costs, service quality, information technology, delivery performance, trust factor and geographical range of services. there are 3 vendors selected, which are 3PL A, 3PL B and 3PL C. And based on the results of the calculation of the paired matrix between criteria, normalization of eigenvectors and the calculation of the consistency ratio, 3PL C becomes the first priority with a total value of 0.254 and the second priority is 3PL A with a value of 0.244 and the third priority is 3PL B with a value of 0.123.

By these results, tiered risk mitigation is carried out to prevent the more serious impact. First, companies should work together with 3PL by make an agreement to recruit drivers and co-workers for 3PL companies, this is to facilitate knowledge transfer and rapid adaptation process. Second, the proportion of transfers to 3PL in stages is 25%-50%-75%-100%. Third, if the first and second mitigations are still not successful, the collaboration with 2 3PL vendors is 50% for 3PL C and 50% for 3PL A with aim to head-to-head comparing the performance. The fourth is a review of KPIs and the last one uses the method of identifying the source of the problem with fishbone diagrams.

As a suggestion for the company, the risk by optimizing truck load capacity is to combine several orders in one shipment and the impact is some orders experiencing delays in delivery. By this reason, companies must classify products between products with high margin values and products with standard margins, and only products with standard margins must optimize the fulfillment of truck capacity, so that products with large margins do not have an impact on risk of late delivery. Suggestions for further researchers is to conduct further research on the route of delivery of goods to customers with purpose to be more effective in terms of time and cost, so that the distribution cost of each product will be efficient.

REFERENCES

Amelia, P., Vanany, I., & Indarso. (2017). Analisis risiko operasional pada divisi kapal perang PT. PAL Indonesia dengan metode House of Risk. Jurnal Sistem Informasi Indonesia, 2(1).

Ankit, Bansal. Pravin, Kumar (2013), 3PL Selection Using Hybrid Model of AHP-PROMETHEE, *Int. J. Services and Operations Management, Vol. 14, No. 3, 2013*

Barateiro, José, Borbinha, José. (2010). Designing digital preservation solution: A risk management-based, International Journal of Digital Curation, DOI: 10.2218/ijdc.v5i1.140

Jovčić, Stevan. Průša, Petr. Dobrodolac, Momčilo and Švadlenka, Libor (2019), A Proposal for a Decicion-Making Tool in Thrid-Party Logistics (3PL) Provider Selection Based on Multi-Criteria Analysis and the Fuzzy Approach

Nurmalatya, N., & Vanany, I. (2017). Optimasi Penentuan Jumlah Truk Dan Penjadwalan Pengiriman Beras Raskin Dengan Data Penunjang Dari Sistem Informasi Geografis (SIG) Pada Perum Bulog Sub Divre Surabaya Utara. Institut Teknologi Sepuluh Nopember.

Parkhi, Shilpa, Kumar, R Arun. (2014). A study on transport cost optimization in retail distribution. Journal of supply chain management systems, Volume 3 issue 4 October 2014

Profita, A., Vanany, I., & Siswanto, N. (2014). Managing risk in supply chain: a framework for supply chain risk mitigation decision-making. 6th Operations and Supply Chain Management (OSCM) Conference, 10-12 December 2014.

Pujawan, I. N. (2005). Supply Chain Management (1st Edition ed.). Indonesia: Gunawidya

Rezaei, Fatemeh, Ferdosi, Masoud, Yarmohammadian, Mohammad. (2018). Revised risk priority number in failure mode and effect analysis model from the perspective of the healthcare system, International journal of preventive medicine, DOI: 10.4103/2008-7802.224046

Saket, Shanker. Hritika, Sharma (2021), *Assessment of risks associated with third-party logistics in restaurant supply chain*, Benchmarking: An International Journal © Emerald Publishing Limited 1463-5771 DOI 10.1108/BIJ-06-2020-0343

Stank, T.P., Goldsby, T.J., Vickery, S.K., Savitskie, Katrina. (2003). Logistic service performance: Estimating its influence on market share. Journal of Business Logistics 24(1):27 – 55 DOI:10.1002/j.2158-1592.2003.tb00031.x

Swastha, Basu, Irawan. (2001). Marketing Management Modern. Yogyakarta: Liberty.

Wahyuni, H. C., Vanany, I., & Ciptomulyono, U. (2018). Identifying risk event in Indonesian fresh meat supply chain. 1st International Conference on Industrial and Systems Engineering, IConISE 2017, 337.

MANAGEMENT STRATEGY DISTRIBUTION & SERVICES IN A NATIONAL ELECTRICITY COMPANY

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ABSTRACT

With changes of behavior patterns, market shifts after COVID 19 and increasingly high public demands, especially demands related to electricity services in lean business processes and flexible product service mechanisms. Electricity Company with a complex line of business which in this thesis is focused on distribution and services supported by a corporate culture aligned with Key Performance Indicators, it is hoped that growth in the company's will be well sustainability maintained in line with increasing customer engagement in accordance with changing conditions with is happening right now. The purpose of this study is to make recommendations related to the management of distribution and service strategies at Electricity Companies. Several approaches were used in this research, namely the SWOT method, BMC, Pestle Analysis, Performance Maintenance and the Shikumi Gemba Matrix which are expected to support better strategic management decision making.
Keywords: ***SWOT,Mapping_Tool, lean, flexible services***

1. INTRODUCTION

With changes in behavior patterns, disruptions, market shifts after COVID 19 and increasingly high public demands, distribution is maintained according to the level of absolut. by minimizing waste in distribution.

To get the recommendations as mentioned above, it is necessary to do research on the downstream side of the company, starting with a survey that is limited to customers, employees, and stakeholders at Electricity Companies with analysis and evaluation by combining several methods in management strategy.

This is to realize more sustainable management of distribution and service strategies, by providing a recommendation formulation of a lean downstream business process framework and flexible services for service products that are in line with strategic management composed of key performance indicators and corporate culture.

To achieve the vision of PLN and subsidiaries, is "Being the Leading Electricity Company in Southeast Asia and #1 Customer Choice for Energy Solutions", this Problem Formulation : The

absence of a lean business process framework and flexible services for service products that are in line with strategic management on distribution and services supported by:

1. Strategic management to get the composition in the business process on the downstream side of the electricity company with each ranking both on the service and distribution side.
2. Mapping tools and analysis mapping tools that have been aligned to eliminate waste to obtain solutions in accordance with the company's vision, mission and culture as well as key performance indicators for the Distribution Parent Unit that have been prioritized in an absolute matrix.

Customer of PT PLN Persero are devided in 3, namely :

1. *Business to business* (B2B) is a sales model that occurs between business people and other business people. One example of B2B is the import of electrical energy to a wood factory or IPP.
2. *Business to consumer* (B2C) is a sales model between business people and consumers. This B2C example feels more familiar and we can see it every day, at PLN from PLN to all its customers.
3. *Business to Government* (B2G) is a sales model between bussines people with the government . example B2G is PLN with goverment in lighting public roads as well as the need for electrical energy for the benefit of government offices.

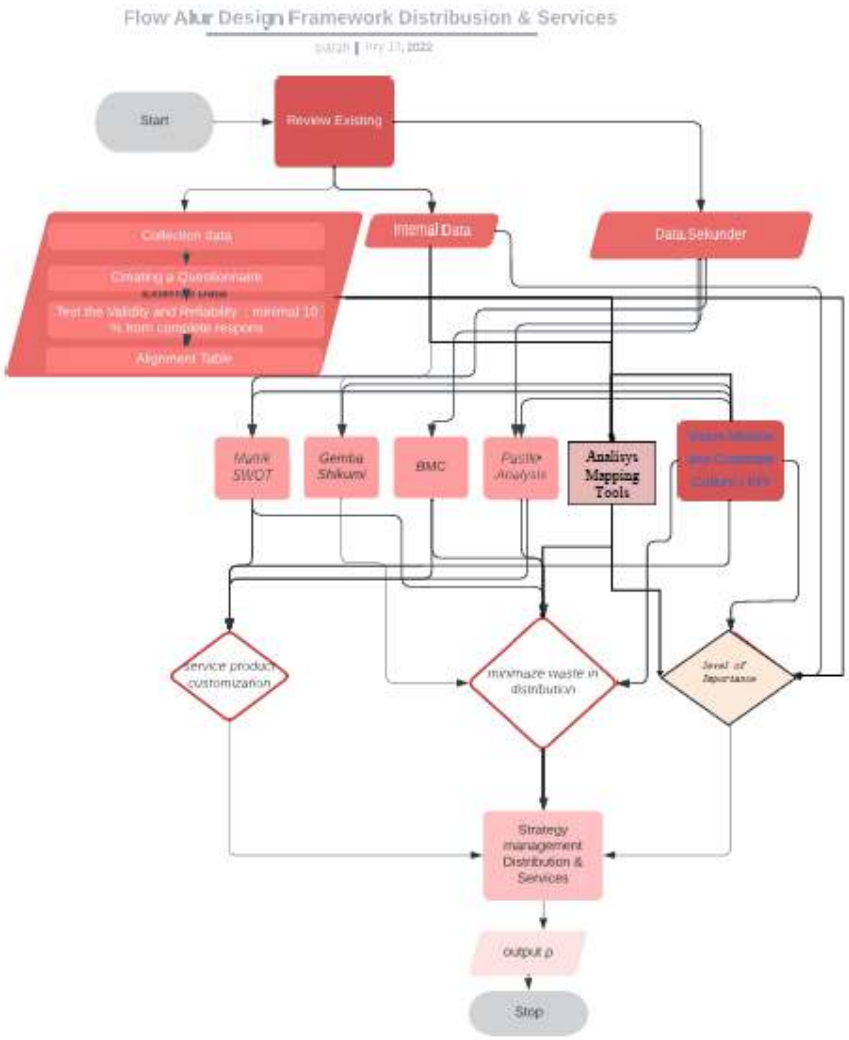
The largest customers are regular customers, because for regular customers even though the profit is the smallest among premium and super ultima customers, the number of regular customers is the most and will continue to grow so that when totaled it will provide a lot of profit.

However, for customers who need a better quality of service, the company offers Premium Service (No Blackout) and Ultra Ultima Service (No Blackout and No Flickering).

Premium and Super Ultima customers provide a lot of profit and of course will continue to grow as well so that these customers need to be improved and maintained so that their services continue to increase.

2. DESIGN AND LITERATURE REVIEW

The whole process of making distribution and service frameworks is as shown in the flow in the following figure:



Gambar2.1 Process Flow Framework improvement

The research was conducted by combining the results of surveys, group discussion forums, and existing data at Electricity Companies, the results of the analysis and evaluation were also adjusted to the circulars of the Directors of Electricity Companies and the current regulations.

The survey as mentioned above is carried out to stakeholders, customers, and customers of Electricity Companies with the realization of the survey results of at least 10 percent of the surveys that have been circulated.

In the analysis and evaluation method, it is carried out by aligning the SWOT matrix, Gemba Shikumi, BMC, Pestle Analysis, and the level of reliability in one decision-making goal, namely the distribution and service strategy management at Electricity Companies which is lean with flexible service products.

In the process shown in the picture above, 3 things support the improvement of the conditions that have been running in the preparation of the distribution and service framework, namely:

a. Service product customization
b. Minimize waste in distribution
c. Level of importance solution

3. METHODS

The research was conducted by combining the results of surveys, group discussion forums, and existing data at Electricity Companies, the results of the analysis and evaluation were also adjusted to the circulars of the Directors of Electricity Companies and the current regulations.

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4. RESULTS

The survey was conducted to stakeholders (agencies or companies) at Electricity Companies and employees or customers of Electricity Companies with the results of responses as many as 386 survey visits and 76 complete responses, The results of the responses as many as 386 survey visits and 76 complete responses are the same as 20% of respondents who are willing to fill out the survey.

a. The diagram is clear that the complete responsibility for the Survey is 83% for men (63 for complete responses) and 17% for women (13 for complete responses).
b. The diagram is clear that the complete responsibility for the survey by 22% was by employees of Electricity Companies who were also customers and 78% were Stakeholders and also customers of Electricity Companies
c. The largest in Central Java with 66 % for the composition of the service rating of the survey results per Province

With the results of the level of service from a scale of 1 to 5 where the number 1 = Very Inappropriate,

5 = Very Appropriate, then the recapitulation of the average service rating according to the elements in the service dimension which has been summarized into five dimensions (Parasuraman, 1988), namely tangible, reliability, responsiveness, assurance, and empathy, is 4.17 for a scale of 1 to 5, as detailed in the image below.

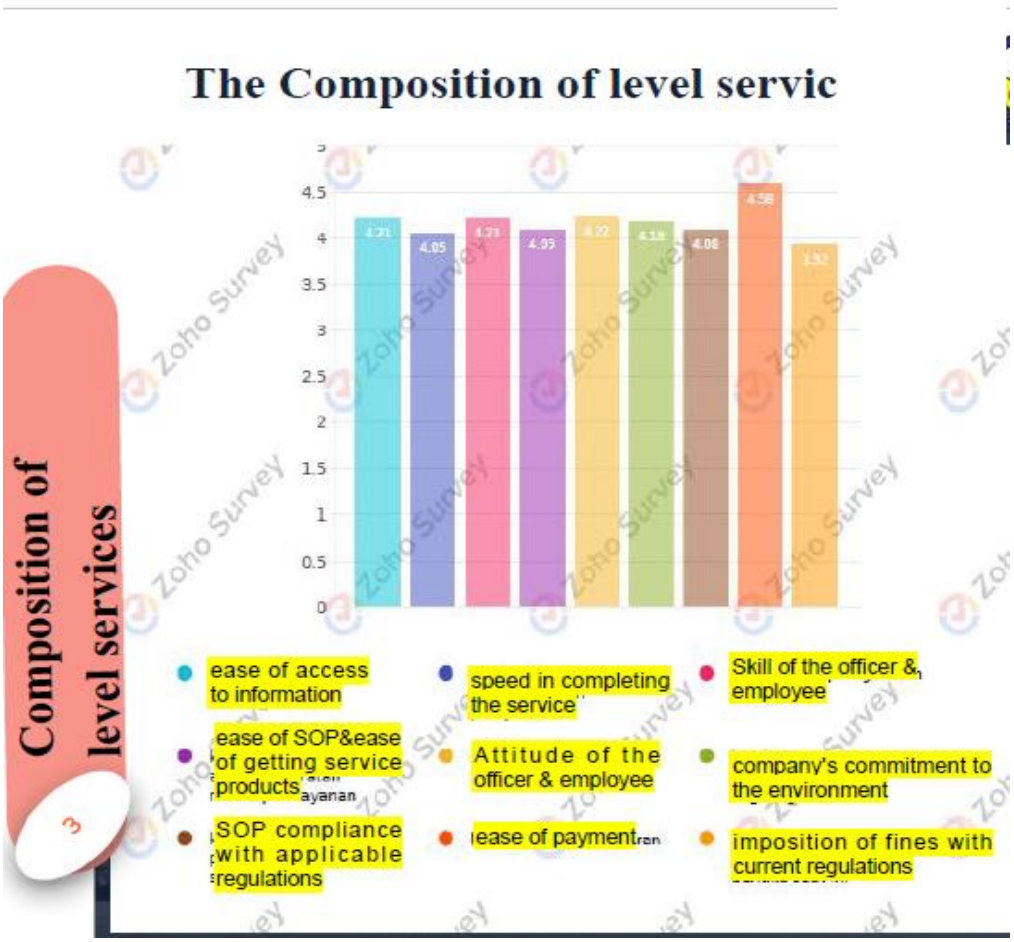


Figure 4.1 Rating Graph of Electricity Companies' Service Level

With the desired level of product service according to mass customization, the following are:

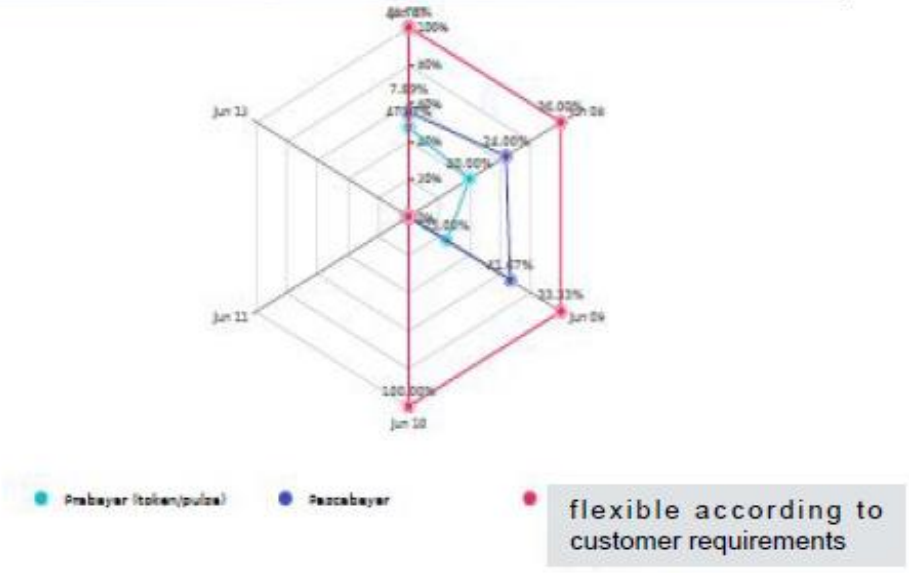


Figure 4-2 Detailed matrix diagram regarding the choice of Electricity Companies' service products

The framework of improvement opportunities for services is as follows:

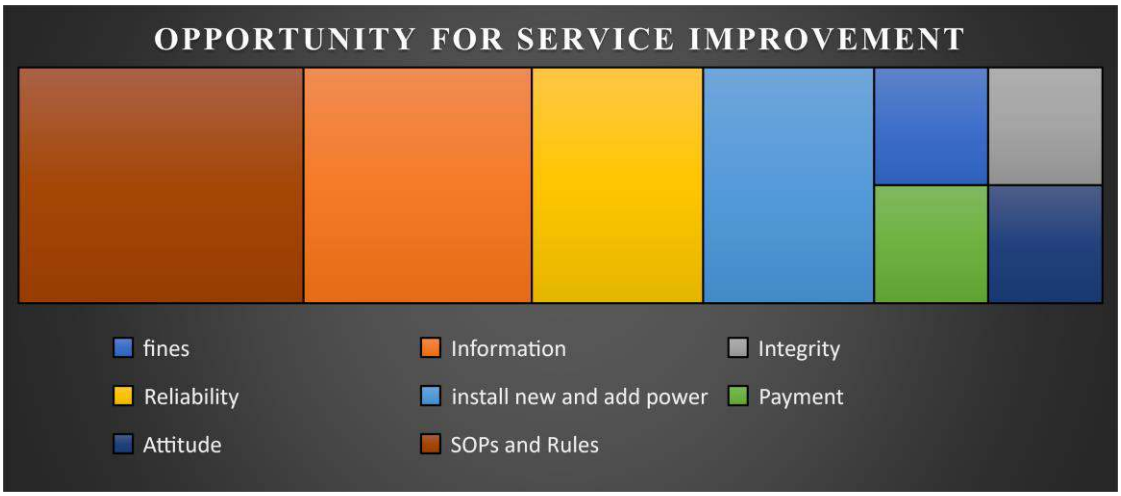


Figure 4-3 Framework level of service improvement opportunity

With the top 3 recommendations: SOPs and rules to get the largest service = 24%, the second on information needs is = 19%, while for install new and add power and reliability, it is in the top 3 as much as 14%.

As for the distribution line of business, it is obtained as follows:

Table 4-1 analysis mapping tool of the FGD results

RESULT

ANALYSIS MAPPING TOOL

<< View Mapping Tool | << View Lean Matrix | << View Waste&NVAA&RSOW

Note: H = High Correlation and usefullness (5) | M = Medium Correlation and usefullness (3) | L = Low Correlation and usefullness (1)

Distribution Management Strategy

	Wastes/Structure	Detail_Waste	JTR fault	SR fault	Voltage Drop	TOTALS	Overall Structure
1	Lifetime	Equipment Age is old	5	5	5	15	5,00
2	Procedure Error	SOP error since installation	1	1	5	7	2,33
3	Overload	Overload	5	5	3	13	4,33
4	tree	Tree disturbance	5	5	1	11	3,67
5	Loose connection / contact loss	Loose connection or contact loss caused by poor quality material or heat	5	5	1	11	3,67
6	Under Investigation	Trouble still not found	5	1	1	7	2,33
7	Construction Works	Improper construction during installation	5	1	5	11	3,67
8	Foreign object	Impact with a foreign body causing partial or complete tissue damage	1	5	1	7	2,33
9	Fire	due to contact loss connection, overload, heat or poor material quality	5	5	1	11	3,67
10	Voltage Drop	supply from PLN is not standard	1	1	5	7	2,33
11	Non-Standard Material	Poor material quality	5	5	5	15	5,00
	Overall Structure		3,9	3,5	3,0	10,5	3,48

Table 4-2 young matrix alignment result of FGD with analysis mapping tool.



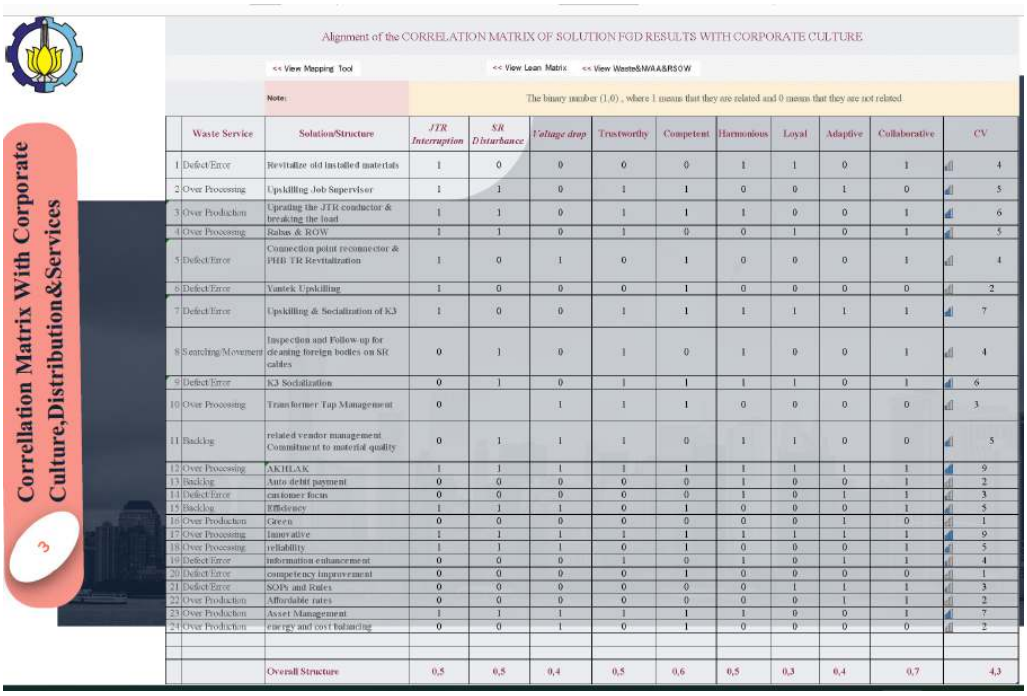
YOUNG MATRIX ALIGNMENT RESULTS OF Forum Group Discussion WITH ANALYSIS MAPPING TOOL

<< View Mapping Tool << View Lean Matrix << View Waste&NVAA&RSOW

Note:

	Waste Service	Solution/Structure	Proses Activity Mapping	Supply Chain Respon Matrix	Production Variaty Funnel	Quality Filter Mapping	Demand Amplification Mapping	Decition point Analisys	Fisical Structure : 1. Volume 2. Value	MV
1	Defect/Error	Revitalize old installed materials	1	1	1	1	0	1	1	6
2	Over Processing	Upskilling Job Supervisor	1	0	1	1	0	1	0	4
3	Over Production	Uprating the JTR conductor & breaking the load	0	1	1	1	1	1	1	6
4	Over Processing	Rabes & ROW	0	0	0	0	0	1	1	2
5	Defect/Error	Connection point reconnector & PHB TR Revitalization	1	0	0	1	0	1	0	3
6	Defect/Error	Yantek Upskilling	1	0	0	0	0	0	0	1
7	Defect/Error	Upskilling & Socialization of K3	1	1	1	1	1	1	1	7
8	Searching/Movement	Inspection and follow-up for cleaning foreign bodies on SR cables	0	0	1	0	0	0	0	1
9	Defect/Error	K3 Socialization	1	0	0	0	0	0	0	1
10	Over Processing	Transformer Tap Management	1	1	1	1	1	1	1	7
11	Backlog	related vendor management Commitment to material quality	1	1	1	1	1	1	1	7
12	Over Processing	AKHLAK	1	1	1	1	1	1	1	7
13	Backlog	Auto debit payment	0	0	1	1	1	1	1	5
14	Defect/Error	customer focus	1	0	1	1	1	1	1	6
15	Backlog	Efficiency	1	1	1	1	0	1	0	5
16	Over Production	Green	1	1	0	0	0	1	0	3
17	Over Processing	Innovative	1	1	1	1	1	1	1	7
18	Over Processing	reliability	1	1	1	1	1	1	1	7
19	Defect/Error	Information enhancement	0	0	1	0	1	1	1	4

Table 4-3 table of correlation matrix with corporate culture and distribution&services



Correllation Matrix With Corporate Culture,Distribution&Services

Alignment of the CORRELATION MATRIX OF SOLUTION FGD RESULTS WITH CORPORATE CULTURE

<< View Mapping Tool << View Lean Matrix << View Waste&MWAA&RSOW

Note: The binary number (1,0) , where 1 means that they are related and 0 means that they are not related

	Waste Service	Solution/Structure	JTR Interruption	SR Disturbance	Voltage drop	Trustworthy	Competent	Harmonious	Loyal	Adaptive	Collaborative	CV
1	Defect/Error	Revitalize old installed materials	1	0	0	0	0	1	1	0	1	4
2	Over Processing	Upskilling Job Supervisor	1	1	0	1	1	0	0	1	0	5
3	Over Production	Uprating the JTR conductor & breaking the load	1	1	0	1	1	1	0	0	1	6
4	Over Processing	Rabas & ROW	1	1	0	1	0	0	1	0	1	5
5	Defect/Error	Connection point reconnector & PHB TR Revitalization	1	0	1	0	1	0	0	0	1	4
6	Defect/Error	Yantek Upskilling	1	0	0	0	1	0	0	0	0	2
7	Defect/Error	Upskilling & Socialization of K3	1	0	0	1	1	1	1	1	1	7
8	Searching/Movement	Inspection and Follow-up for cleaning foreign bodies on SR cables	0	1	0	1	0	1	0	0	1	4
9	Defect/Error	K3 Socialization	0	1	0	1	1	1	1	0	1	6
10	Over Processing	Transformer Tap Management	0		1	1	1	0	0	0	0	3
11	Backlog	related vendor management Commitment to material quality	0	1	1	1	0	1	1	0	0	5
12	Over Processing	AKHLAK	1	1	1	1	1	1	1	1	1	9
13	Backlog	Auto debit payment	0	0	0	0	0	1	0	0	1	2
14	Defect/Error	customer focus	0	0	0	0	0	1	0	1	1	3
15	Backlog	Efficiency	1	1	1	0	1	0	0	0	1	5
16	Over Production	Green	0	0	0	0	0	0	0	1	0	1
17	Over Processing	Innovative	1	1	1	1	1	1	1	1	1	9
18	Over Processing	reliability	1	1	1	0	1	0	0	0	1	5
19	Defect/Error	information enhancement	0	0	0	1	0	1	0	1	1	4
20	Defect/Error	competency improvement	0	0	0	0	1	0	0	0	0	1
21	Defect/Error	SOPs and Rules	0	0	0	0	0	0	1	1	1	3
22	Over Production	Affordable rates	0	0	0	0	0	0	0	1	1	2
23	Over Production	Asset Management	1	1	1	1	1	1	0	0	1	7
24	Over Production	energy and cost balancing	0	0	1	0	1	0	0	0	0	2
		Overall Structure	0,5	0,5	0,4	0,5	0,6	0,5	0,3	0,4	0,7	4,3

Table 4.4 table of matrix level of importance

	Waste Service	Solution/Structure	MV	CV	PV	AIV
1	Defect/Error	Revitalize old installed materials	6	4	8	18
2	Over Processing	Upskilling Job Supervisor	4	5	8	17
3	Over Production	Uprating the JTR conductor & breaking the load	6	6	7	19
4	Over Processing	Revitalize old installed materials	2	5	6	13
5	Defect/Error	Upskilling Job Supervisor	3	4	5	12
6	Defect/Error	Uprating the JTR conductor & breaking the load	1	2	7	10
7	Defect/Error	Rabas & ROW	7	7	6	20
8	Searching/Movement	Connection point reconnector & PHB TR Revitalization	1	4	5	10
9	Defect/Error	Yantek Upskilling	1	6	2	9
10	Over Processing	Upskilling & Socialization of K3	7	3	5	15
11	Backlog	Inspection and Follow-up for cleaning foreign bodies on SR cables	7	5	1	13
12	Over Processing	AKHLAK	7	9	2	18
13	Backlog	Auto debit payment	5	2	7	14
14	Defect/Error	customer focus	6	3	9	18
15	Backlog	Efficiency	5	5	8	18
16	Over Production	Green	3	1	3	7
17	Over Processing	Innovative	7	9	6	22
18	Over Processing	reliability	7	5	10	22
19	Defect/Error	information enhancement	4	4	3	11
20	Defect/Error	competency improvement	3	1	14	18
21	Defect/Error	SOPs and Rules	7	3	7	17
22	Over Production	Affordable rates	7	2	3	12
23	Over Production	Asset Management	7	7	3	17
24	Over Production	energy and cost balancing	7	2	5	14
		Overall Structure	5,0	4,3	5,8	15,2

This table is absolute matrix results of alignment of solution forum group discussion and evaluation from surveys which is the sum of the previous 3 matrices:

$$AIV = MV + CV + PV$$

Keterangan :

AIV	*= absolute importance vector*	*CV*	*= Correlation Vector*
PV	*= Priority Vector*	*MV*	*= muda vector*

6. CONCLUSIONS & SUGESTIONS

A. CONCLUSIONS

The conclusions that can be drawn from the thesis entitled Management of Distribution and Service Strategy at Electricity Companies are as follows:

a. The highest level of service improvement proposals is SOP and Rules for getting service = 24%, the second is for information needs as much as = 19%, while for PB / PD and reliability, it is in the top 3 as much as 14%.
b. As for the distribution, there is a material with a total AIV absolute matrix value of = 16, followed by a voltage drop improvement with a total AIV absolute matrix value of = 15 and the third is the anticipation of overload and construction in accordance with the number of absolute AIV matrix values of = 13.

B. SUGGESTIONS

Suggestions from Customers & Stakeholders Towards the Vision Mission To become the No. 1 Company in Southeast Asia prioritizes :

a. customer focus, AKHLAK, Improved reliability, Innovative, Affordable Rates, Green, Efficiency, Review of SOPs and Rules, AutoDebit Payments, Improved Information, and Competence
b. Implementation of the Flexible Service Product Mechanism according to customer needs with the auto debit method to maximize PLN Mobile in fulfilling its business processes such as Swa Cam.

Further research can be conducted on stakeholders in Southeast Asia so that improvement opportunities can be directly focused on the company's vision and mission of Electricity Companies, namely to become a leading company in Southeast Asia and the number #1 Customer Choice as an energy solution.

From the line of business of Electricity Companies in the field of distribution and service, it has not been fully accommodated in our research so that further research can be carried out to complement it with the same method and model.

REFERENCES

[1] Akbarzadeh, F. (2012). The Balanced Scorecard (BSC) Method : From Theory to Practice. Oman Chapter of Arabian Journal of Business and Management Review, 2(5), 88–98. https://doi.org/10.12816/0002273
[2] analisis yuridis penghapusan UJL. Sirait, Gabriella. (2012),Universitas Indonesia

[3] Anshika, Singla, A., & Mallik, G. (2021). Determinants of financial literacy: Empirical evidence from micro and small enterprises in India. Asia Pacific Management Review, 26(4), 248–255. https://doi.org/10.1016/j.apmrv.2021.03.001
[4] Bayer, O. (2015). Relevance of Input Data Time Series for Tax Revenue Forecasting. Procedia Economics and Finance, 25, 518–529. https://doi.org/10.1016/s2212-5671(15)00765-0
[5] Blahova, N. (2015). The Relation between Macroprudential and Macroprudential Policy: An Example of Regulatorily Bank Capital. Procedia Economics and Finance, 25, 428–434. https://doi.org/10.1016/s2212-5671(15)00754-6
[6] Boučková, M. (2015). Management Accounting and Agency Theory. Procedia Economics and Finance, 25, 5–13. https://doi.org/10.1016/s2212-5671(15)00707-8
[7] Brůna, K. (2015). Segments of Money Market Yield Curves in a Dealers Model of Optimum Interest Rate Margin. Procedia Economics and Finance, 25, 435–444. https://doi.org/10.1016/s2212-5671(15)00755-8
[8] Bušovský, L. (2015). The Impact of Public Finance on Tertiary Education. Procedia Economics and Finance, 25, 530–534. https://doi.org/10.1016/s2212-5671(15)00766-2
[9] Cahyaningtyas, R., & Aditya Patra, D. Rancang Bangun Aplikasi Informasi Listrik Prabayar Berbasis Multimedia.
[10] Center for International Trade (2011), "Government Procurement Summary." Harvard University. [Online]. Available at www.cid.harvard.edu/cidtrade/issues/govpro.html. (Retrieved March 5, 2012).
[11] Changes, K. (2016). CS ENERGY PROCEDURE FOR BUSINESS CONTINUITY MANAGEMENT FRAMEWORK AND PROGRAM CS-RISK-09 Responsible Officer: Senior Governance, Risk and Compliance Advisor Responsible Manager: Group Manager Governance Risk and Compliance Responsible Executive: Executive General Counsel and Company Secretary DOCUMENT HISTORY.
[12] Dan Petunjuk, P., & Pln Kantor Pusat, P. TATA USAHA PELANGGAN MANUAL (TUL-MAN).1995. www.pln.co.id.Email
[13] Dufek, L. (2015). Public Procurement: A Panel Data Approach. Procedia Economics and Finance, 25, 535–542. https://doi.org/10.1016/s2212-5671(15)00767-4
[14] Erika Hamdi, Energy Finance Analyst The Case for System Transformation in Indonesia Time for a Full Electricity System Audit. (2019).
[15] ESDM.2016." permen-esdm-28-th-2016". Jakarta
[16] Fičura, M. (2015). Modeling Jump Clustering in the Four Major Foreign Exchange Rates Using High-Frequency Returns and Cross-exciting Jump Processes. Procedia Economics and Finance, 25, 208–219. https://doi.org/10.1016/s2212-5671(15)00731-5
[17] García Castro, J. P., Duque Ramírez, D. F., & Moscoso Escobar, J. (2021). The relationship between intellectual capital and financial performance in Colombian listed banking entities. Asia Pacific Management Review, 26(4), 237–247.
[18] Ginting, Rosnani. (2009). Perancangan Produk, Graha Ilmu, Yogyakarta.
[19] Gokmenoglu, K. K., & Fazlollahi, N. (2015). The Interactions among Gold, Oil, and Stock Market: Evidence from S&P500. Procedia Economics and Finance, 25, 478–488. https://doi.org/10.1016/s2212-5671(15)00760-1
[20] Gokmenoglu, K. K., Amin, M. Y., & Taspinar, N. (2015). The Relationship among International Trade, Financial Development, and Economic Growth: The Case of Pakistan. Procedia Economics and Finance, 25, 489–496. https://doi.org/10.1016/s2212-5671(15)00761-3

[21] Gokmenoglu, K. K., Sehnaz, Z., & Taspinar, N. (2015). The Export-Led Growth: A Case Study of Costa Rica. Procedia Economics and Finance, 25, 471–477. https://doi.org/10.1016/s2212-5671(15)00759-5
[22] Gokmenoglu, K. K., Taspinar, N., & Sadeghieh, M. (2015). Military Expenditure and Economic Growth: The Case of Turkey. Procedia Economics and Finance, 25, 455–462. https://doi.org/10.1016/s2212-5671(15)00757-1
[23] Gokmenoglu, K., Azin, V., & Taspinar, N. (2015). The Relationship between Industrial Production, GDP, Inflation and Oil Price: The Case of Turkey. Procedia Economics and Finance, 25, 497–503. https://doi.org/10.1016/s2212-5671(15)00762-5
[24] Gokmenoglu, K., Ozatac, N., & Eren, B. M. (2015). Relationship between Industrial Production, Financial Development, and Carbon Emissions: The Case of Turkey. Procedia Economics and Finance, 25, 463–470. https://doi.org/10.1016/s2212-5671(15)00758-3
[25] 41–52. https://doi.org/10.1016/s2212-5671(15)00711-x. Indonesia Industry 4.0 Readiness Index.2018
[26] Jacobs, R., (1997). Mengevaluasi kepuasan pelanggan terhadap produk dan layanan media.Jurnal Manajemen Media Eropa, 32,11 – 18.
[27] Kábrt, T. (2015). The Relationship between Discounts and Premiums and Value Investing Theory. Procedia Economics and Finance, 25, 220–226. https://doi.org/10.1016/s2212-5671(15)00732-7
[28] Kano, N. Origin of the Kano Model.
[29] Kaur, S., & Gupta, P. K. (2015). Productive Efficiency Mapping of the Indian Banking System Using Data Envelopment Analysis. Procedia Economics and Finance, 25, 227–238. https://doi.org/10.1016/s2212-5671(15)00733-9
[30] Kepdir No. 717 2010 Kebijakan Persediaan Material Di Lingkungan PT PLN. 2010
[31] Keputusan-menteri-esdm-no-159.k-tl.04-djl.3-2021-ttg-besaran-tmp-pt-pln-persero-tahun-2021.
[32] Kopecka, N. (2015). The Balanced Scorecard Implementation, Integrated Approach and the Quality of Its Measurement. Procedia Economics and Finance, 25, 59–69. https://doi.org/10.1016/s2212-5671(15)00713-3
[33] Kopecka, N. (2015). The Balanced Scorecard Implementation, Integrated Approach and the Quality of Its Measurement. Procedia Economics and Finance, 25, 59–69. https://doi.org/10.1016/s2212-5671(15)00713-3
[34] Krabec, T., & Schäfer, C. (2015). Valuing Direct Real Estate Investments by Using the ADAM Modelling Approach. Procedia Economics and Finance, 25, 362–370. https://doi.org/10.1016/s2212-5671(15)00746-7
[35] Krch, P. (2015). The Investment Recommendations in the Czech Republic: An Appraisers Perspective. Procedia Economics and Finance, 25, 371–377. https://doi.org/10.1016/s2212-5671(15)00747-9
[36] Kuchyňa, P. (2015). Problems Associated with Value of Life. Procedia Economics and Finance, 25, 378–385. https://doi.org/10.1016/s2212-5671(15)00748-0
[37] Kulašin, D., & Fortuny-Santos, J. (2005). REVIEW OF THE SERVQUAL CONCEPT.
[38] Langer, T. (2015). Metaphors in Economics: Conceptual Mapping Possibilities in the Lectures of Economics. Procedia Economics and Finance, 25, 308–317. https://doi.org/10.1016/s2212-5671(15)00741-8
[39] London. IMPLICATIONS OF THE DIGITAL TRANSFORMATION FOR THE BUSINESS SECTOR Conference summary.

[40] Mansur, A., Farah, A. N., & Cahyo, W. N. (2019). Integration of Servqual, Kano Model, and QFD to Design Improvement on Public Service System. IOP Conference Series: Materials Science and Engineering, 598(1). https://doi.org/10.1088/1757-899X/598/1/012101

[41] McNichols, T., Hassinger, R., & Bapst, G. W. (1999). "Quick and Continuous Improvement through Kaizen Blitz." Hospital Material Management Quarterly, 20 (4): 1-7. Proudlove, N., Moxhad, C. and Boaden R. (2008). Lessons for Lean in Healthcare from Using Six Sigma in the NHS." Public Money and Management, 28 (1): 27-34.

[42] Menteri, P., Dan, E., & Daya Mineral, S. MENTERI ENERGI DAN SUMBER DAYA MINERAL REPUBLIK INDONESIA.

[43] Menteri, P., Dan, E., & Daya Mineral, S. MENTERI ENERGr DAN SUMBER DAYA MINERAL REPUBLIK INDONESIA MENTERI ENERGI DAN SUMBER DAYA MINERAL REPUBLIK INDONESIA.

[44] Molín, J., & Jirásková, S. (2015). Is the Accrual Principle Fully Applied in Corporate Income Taxation in the Czech Republic? Procedia Economics and Finance, 25, 79–86. https://doi.org/10.1016/s2212-5671(15)00715-7

[45] Moradi, E., Jafari, S. M., Doorbash, Z. M., & Mirzaei, A. (2021). Impact of organizational inertia on business model innovation, open innovation and corporate performance. Asia Pacific Management Review, 26(4), 171–179. https://doi.org/10.1016/j.apmrv.2021.01.003

[46] Multimedia Appendix A Technology Acceptance Questionnaire Item # Corresponding dimension Statement.

[47] Mundel, J., Soopramanien, D., & Huddleston, P. (2021). Affordable luxuries: Comparing American and Chinese millennial consumers. Asia Pacific Management Review, 26(4), 215–225. https://doi.org/10.1016/j.apmrv.2021.02.003

[48] Nguyen, N. T. (2021). A study on satisfaction of users towards learning management system at International University – Vietnam National University HCMC. Asia Pacific Management Review, 26(4), 186–196. https://doi.org/10.1016/j.apmrv.2021.02.001

[49] Nugraha, L., & Harsono, A. (2015). USULAN PENINGKATAN KUALITAS PELAYANAN JASA PENDIDIKAN BAHASA INGGRIS MENGGUNAKAN METODE SERVICE QUALITY (SERVQUAL) DI LBPP LIA MARTADINATA KOTA BANDUNG *. Jurnal Online Institut Teknologi Nasional Januari.

[50] Olejniczak, J., & Bednarska-Olejniczak, D. (2015). Participation of Non-Resident Students in the Creation of Participatory Budget in Wroclaw. Procedia Economics and Finance, 25, 579–589. https://doi.org/10.1016/s2212-5671(15)00772-8

[51] Patil, S., & Bagodi, V. (2021). "A study of factors affecting investment decisions in India: The KANO way." Asia Pacific Management Review, 26(4), 197–214. https://doi.org/10.1016/j.apmrv.2021.02.004

[52] Permen-esdm_27-tahun-2017-ttg-tmp-dan-biaya-penyambungan-listrik-pln.

[54] Permen-esdm-nomor-18-tahun-2017-ttg-perubahan-permen-28-tahun-2016-tentang-tarif-tenaga-listrik.

[55] Permen-esdm-nomor-24-tahun-2017-mekanisme-penetapan-bpp.

[57] Playing With Matches-Who Should Take Responsibility for PLN's Financial Mess? (2020).

[58] Pospíšil, J. (2015). Valuation Date in the Process of M&A. Procedia Economics and Finance, 25, 106–115. https://doi.org/10.1016/s2212-5671(15)00718-2

[59] Prasad, K., & Suprabha, K. R. (2015). Measurement of Exchange Rate Exposure: Capital Market Approach versus Cash Flow Approach. Procedia Economics and Finance, 25, 394–399. https://doi.org/10.1016/s2212-5671(15)00750-9
[60] Procházka, D., & Pelák, J. (2015). The Development of Capital Markets of New EU Countries in the IFRS Era. Procedia Economics and Finance, 25, 116–126. https://doi.org/10.1016/s2212-5671(15)00720-0
[61] Purina, M. (2015). Tax Accounting in the Russian Federation. Procedia Economics and Finance, 25, 127–133. https://doi.org/10.1016/s2212-5671(15)00719-4
[62] Radnor, Z. & Boaden, R. (2008). "Editorial: Lean in Public Services
[63] Radnor, Z. & Walley, P. (2008). "Learning to Walk Before We Try to Run: Adapting Lean for the Public Sector." Public Money and Management, 28 (1): 13-20.
[64] Reyes, M. G. M., & Redoña, B. M. (2021). Personal attributes and behavioral response of academic heads of private higher education institutions: Basis for human reSumber intervention development model. Asia Pacific Management Review, 26(4), 180–185.
[65] Rybová, J. (2015). The Share of Excise Taxes on Consumption Expenditure of Consumers in the European Union. Procedia Economics and Finance, 25, 590–597. https://doi.org/10.1016/s2212-5671(15)00773-x
[66] Salinan_permen-esdm-no.-10-tahun-2017-ttg-pokok2-dalam-pjbl.
[67] Sample Business Plan Framework 1: A program seeking to continue operations in the post-grant period as a not-for-profit (NGO) entity Governance Financial Structure Assets & Infrastructure Service Offering Customer Partners Define internal responsibilities.
[68] Sauerwein, E., Bailom, F., Matzler, K., & Hinterhuber, H. (1996). Model kano: Cara menyenangkan pelanggan Anda.Seminar Kerja Internasional Ekonomi Produksi, 19,313 – 327.
[69] Schiele, J.J. and McCue, C.P. (2006). "Professional service acquisition in public sector procurement: A conceptual model of meaningful LEAN THINKING WITHIN PUBLIC SECTOR PURCHASING DEPARTMENT 527 involvement." International Journal of Operations and Production Management, 26 (3): 300-325.
[70] Schiele, J.J. and McCue, C.P. (2011). Lean thinking and its implications for public procurement: moving forward with assessment and implementation, Journal of Public Procurement, 11 (2): 206-239.
[76] Skálová, J., & Mejzlík, L. (2015). The Harmonization of the Legal Regulation of Mergers: The Example of the (Dis)Harmony of Czech and Slovak Regulations. Procedia Economics and Finance, 25, 148–155. https://doi.org/10.1016/s2212-5671(15)00723-6
[77] Šnajberg, O. (2015). Valuation of Real Estate with Easement. Procedia Economics and Finance, 25, 420–427. https://doi.org/10.1016/s2212-5671(15)00753-4
[78] Strategic Imperatives of Total Quality Management and Customer Satisfaction in Organizational Sustainability. (2015).
[79] Strauß, E., & Zecher, C. (2013). Management control systems: A review. In Journal of Management Control (Vol. 23, Issue 4, pp. 233–268). Physica-Verlag. https://doi.org/10.1007/s00187-012-0158-7
[80] Sulistiyowati, W., Supriyanto, H., & Suef, M. INTEGRASI METODE SERVQUAL, LEAN DAN SIX SIGMA IMPLEMENTASI : PT.PLN (Persero) DISTRIBUSI JAWA TIMUR, APJ SURABAYA SELATAN-UPJ NGAGEL.
[81] Suti'ah. Managemen Meter Sebagai Transaksi Energi Listrik.PT.PLN (Persero). 2013.
[82] Sutoni, A., & Ramadian, P. (2019). Seminar dan Konferensi Nasional IDEC Analisis Kepuasan Konsumen dan Pengembangan Produk Menggunakan Metode Kano dan House Of Quality.

[83] Tapera, J. (n.d.). The Importance of Strategic Management to Business Organizations Corporate Social Responsibility (CSR) Philantropy or Marketing Strategy? View project Strategic Marketing Management View project. www.theinternationaljournal.org
[84] Taufik, T. A., & dari, D. MODEL SERVQUAL Manajemen Teknologi & Inovasi BM185204 Manajemen Teknologi & Inovasi BM185204. www.onlinedoctranslator.com
[85] Tegowanu.Team. Sistem PMP.PT.PLN (Persero) ULP Tegowanu. 2021.
[86] Teoh, C. H., Zain, Z. M., & Lee, C. C. (2021). Manufacturing organization transformation – How customization of project life cycle and project governance for custom solution enhances the chances of success. Asia Pacific Management Review, 26(4), 226–236. https://doi.org/10.1016/j.apmrv.2021.03.003
[87] Thai, K. (2007). Introduction to Public Procurement. Herndon, VA: NIGP.
[88] Toader, S., & Petrice, A. (2015). Major Players in the Credit Market in Romania in the European Context. Procedia Economics and Finance, 25, 285–296. https://doi.org/10.1016/s2212-5671(15)00739-x
[89] Ulas, E., & Keskin, B. (2015). Performance Evaluation and Ranking of Turkish Banking Sector. Procedia Economics and Finance, 25, 297–307. https://doi.org/10.1016/s2212-5671(15)00740-6
[90] Ungvari, S., (1999). Menambahkan dimensi ketiga ke auqlity.Jurnal Triz, 40,31 – 35.
[91] Walder, D., (1993). Model Kano untuk memahami kualitas yang ditentukan pelanggan.Jurnal Pusat Kualitas Manajemen, 39,65 – 69.
[92] Weber, D. O. (2006, January–February). "Toyota-Style Management Drives Virginia Mason." The Physician Executive: 12–17.
[93] Womack, J.P. & Jones, D.T. (1996). Lean Thinking: Banish Waste and Create Wealth in Your Corporation. New York: Simon & Schuster.
[94] Womack, J.P. (2002). "Lean Think: Where Have We Been and Where Are We Going?" Forming and Fabricating, 9 (9): 2-6.
[95] Wysocki, B. (2004, April 9). "Industrial Strength." Wall Street Journal.
[96] Yin, R. K. (2009). Case Study Research: Design and Methods. Thousands Oak, CA" Sage Publications, Inc.
[97] Zultner, RE & Mazur, GH (2006). Model Kano: Perkembangan Terbaru.

DIGITAL TRANSFORMATION OF GATE AUTOMATION SERVICE WITH WEIGH IN MOTION TECHNOLOGY AT THE CONTAINER TERMINAL PT XYZ

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ABSTRACT

This digital transformation process is a solution alternative to avoid traffic congestion problems at the gate area of PT XYZ Container Terminal. This study aims to evaluate the problem of traffic congestion at the gate area of PT XYZ Container Terminal by increasing the effectiveness of the existing facilities, exploring the generic transformation process from manual processes to digitalization, and exploring the service optimization process from the gate operational with digital systems and technology. The Analytical Hierarchy Process method is used to determine the criteria for selecting the container weighing method to get efficiency, speed, and accuracy with an average container weight weighing result, a maximum error of 1% is obtained. The manual service process goes digital with the implementation of the Terminal Booking System, it is expected that traffic density will be evenly distributed for 24 hours. Optimizing existing services with the development of the Quick Response Code system and the use of container Scanning Seal Barcode devices will accelerate services at the gate terminal to be more efficient.

Keywords: Weigh in Motion, Analytical Hierarchy Process, technology, digitalization, automation, Terminal Booking System

1. INTRODUCTION

The construction of the container terminal makes the trade, transportation, and logistics sectors interconnected and well-integrated in terms of services, systems, and business processes that can encourage the growth of industrial estates around ports. The container terminal is a link that connects container ships at sea with trucks on land (Zhang et al., 2003).

PT XYZ's container terminal has the highest throughput with a market share of 44% of international container volume at the Tanjung Priok port, making the movement of container flows in and out of the container terminal very congested and has the potential to contribute to road congestion in the port area and logistical problems.

The direct impact of the traffic jam is felt by trucking entrepreneurs, not only in operating costs but also a loss of opportunity because truck productivity decreases due to the longer time it takes to complete an export container delivery service or take imported containers to the port. This study analyzes that there is an important problem that must be resolved where the growth of incoming and outgoing truck traffic has the potential for congestion at the container terminal gate at any time because it is followed by the volume of export-import which is predicted to continue to increase.

Gate automation services are supported by Weight in Motion (WIM) technology as one of the many innovative solutions for traffic management. Automation is one way to calculate how to efficiently handle cranes without the need to physically do the work. Liu, Jula, and Ioannou (2002)

explored the benefits of using automated storage/retrieval systems to reduce container-terminal problems. Weigh in Motion (WIM) is the process of measuring the dynamic tire strength of a moving vehicle and is the benchmark for estimating the static weight of the vehicle. (Szary & Maher, 2009).

Weigh in Motion (WIM) technology is a method of dynamically weighing container weights where trucks carry containers without having to stop and Weigh in Motion technology will read and provide container weight results automatically through sensor technology. The accuracy of the container weight provided by PT XYZ Container Terminal to port service users, especially exporters, is the main requirement for the terminal in guaranteeing the accuracy of the weight of the container before being loaded onto the ship.

In general, this study aims to improve services for speed, efficiency, and accuracy to service users at the PT XYZ Container Terminal gate service area. In detail, it can be formulated into three main objectives in this research, namely:

1. Evaluating the level of traffic congestion problems at the PT XYZ Container Terminal gate area by increasing the effectiveness of the facilities owned.
2. Explore the generic transformation process from manual process to digitization.
3. Explore the optimization process in terms of gate operational services with digital systems and technology.

2. LITERATURE REVIEW

Innovative systems and technologies increase port capacity and ensure optimal efficiency. New technology monitors, controls, and accelerates cargo flow at berths, in warehouses, and throughout the supply chain. Port traffic, berthing scheduling, and cargo handling are processed using the most advanced technology, software, and equipment. Port gate technologies, Optical Character Recognition (OCR), and Technology of Information enable rapid cargo and container processing and documentation clearance, with little or no human intervention. (Burns, 2014).

Soberon et al., (2014) explained that port container terminals have certain facilities that give them the ability to achieve a much higher level of systematization than other types of cargo terminals such as standardization of container transport equipment, standardization of cargo handling methods, high level of relationship between modes that occur, the high impact of technology on the profitability of the terminal.

Digital transformation includes an evolutionary process that generates new value, based on its capacity and digital technology to create or change business processes, operational processes, and customer experiences (Morakanyane et al., 2017). Factors that drive digital transformation include changes in regulations and competitive landscapes, shifts or changes from industry to digital forms, changes in behavior, consumer expectations, capabilities, and digital technology (Osmundsen et al., 2018).

Technology has become an important part of the transformation process to improve comfort, quality, and efficiency as new technologies emerge. All container terminal systems can be viewed independently, but the interaction between them is inevitable and plays an important role in the efficient management and operation of container terminals. One of the implementations carried out by PT XYZ Container Terminal is to implement a gate automation system, where the service system from the old gate service model (manual) becomes gate automation. Gate automation is a container service system at the gate without involving officers. The process of checking documents and entering container data will be carried out automatically through a computer system. Typical in-gate processes include truck driver manual verification and

inspection of containers and equipment. This delay varies according to the type of transaction and the level of experience of manual inspection at the terminal gate (Moszyk, 2021).

Weigh in Motion (WIM) consists of a set of sensors and data collection or analysis equipment. Its sensors detect the presence of a moving vehicle and the dynamic tire effect concerning time. Data is collected and processed to estimate vehicle weight, speed, axle distance, and vehicle type according to the number of axles and axle distances. Accuracy is the quality of conformity of the measured value with the accepted standard value. The overall accuracy of the WIM system is a function of the actual difference in the dynamic tire force of a moving vehicle and the corresponding constant tire force of a static vehicle (Szary & Maher, 2009).

3. METHODS

This study chose Multi Criteria Decision Making (MCDM) because this approach helps in making increasingly complex management decisions. To analyze the data, the problem-solving technique uses the Analytical Hierarchy Process (AHP). The analysis of the selection of container weighing methods has an important meaning in management decisions to choose a more appropriate container weighing method by considering future business aspects and future developments. Currently, there are two methods of weighing containers used in the port industry, especially at the container terminal, namely the static weighing method and the dynamic weighing method.

The criteria for selecting the container weighing method will be arranged in a hierarchical form. The criteria used are to choose the method of weighing container weights at PT XYZ Container Terminal arranged in two hierarchical levels. Zero level indicates the destination, level one is the criterion in selecting the container weighing method. At level one, three criteria have been determined, namely efficiency, speed and accuracy. Level two is an alternative weighing method that should be chosen. The determination of various criteria for level one and level two was obtained based on a literature analysis with the AHP hierarchical structure in Figure 1 below:

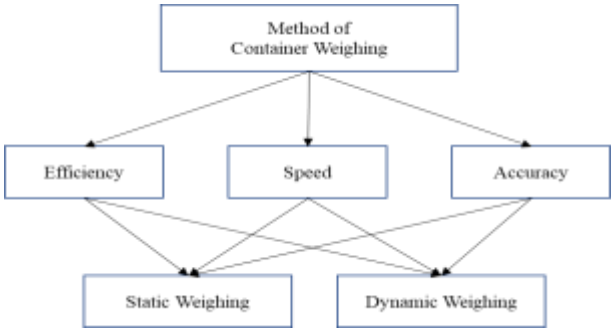


Figure 1. Problem Hierarchy Structure

AHP data processing has appointed one respondent who has special expertise and has criteria in testing and assessing the level of importance of an element. The selected respondents are professionals who have experience and knowledge in weighing containers using static and dynamic methods in the port industry, especially in container terminals. Respondents also have certificates as surveyors who have national and international licenses. After completing the stages in selecting the container weighing method, the next research is to analyze various aspects to explore further developments in the gate automation service system with weigh in motion technology.

4. RESULTS

This research is to test the container weighing method, which is still in operation today, whether it is still effective and does not cause traffic jams in the area of the road to the container terminal gate. The selection of container weighing using the Analytical Hierarchy Process (AHP) method will be analyzed for its effectiveness in gate operations. Explanation of the three criteria in the container weighing method:

1. Efficiency is a criterion in the service system in the process of weighing container weights without using the services of gate officers who meet face to face with customers.
2. Speed is the process of weighing the weight of the container since the truck enters the gate lane, then the truck driver makes a transaction to verify the export document until the process is correctly identified until the weight of the container is recorded in the terminal system.
3. Accuracy is an indicator to get the results of the weight of the container in accordance with the export document as the basis for the issuance of the Verify Gross Mass (VGM) document which is an explanation of the verified weight of the container before being loaded onto the ship according to the regulations in IMO Solas.

Processing of the Analytical Hierarchy Process (AHP) method to determine the criteria for selecting the container weighing method is shown in the results of Tables 1 to 6 below:

Table 1. Priority Criteria for Container Weight Weighing Method

Criteria	Weight	%	Priority
Efficiency	0,062	6,23%	3
Speed	0,236	23,64%	2
Accuracy	0,701	70,13%	1

Table 2. Priority of Interest (Weight) Alternative on Efficiency Criteria

Alternative	Weight	%	Priority
Static Weighing	0,20	20%	2
Dynamic Weighing	0,80	80%	1

Table 3. Priority of Interest (Weight) Alternative on Speed Criteria

Alternative	Weight	%	Priority
Static Weighing	0,166	16,67%	2
Dynamic Weighing	0,833	83,33%	1

Table 4. Priority of Interest (Weight) Alternative on Accuracy Criteria

Alternative	Weight	%	Priority
Static Weighing	0,111	11,11%	2
Dynamic Weighing	0,888	88,89%	1

Table 5. Consistency Index of Container Weight Weighing Methods

Test Consistent	Efficiency	Speed	Accuracy	Weight (W)	Expectation (E)	E /W	λ max	CI
Efficiency	1	0,2	0,11	0,062	0,187	3,011	3,072	0,036
Speed	5	1	0,25	0,236	0,723	3,058		
Accuracy	9	4	1	0,701	2,207	3,147		

Table 6. Overall Alternative Priority Weight

Alternative	Weight	Priority
Static Weighing	0,477	2
Dynamic Weighing	2,521	1

The analysis in the selection of weighing containers at PT XYZ using the Analytical Hierarchy Process (AHP) method has been described in the explanation above starting from compiling a hierarchical structure of the problem to getting the results of calculating the weights or choosing the priority of weighing container weights at the gate service according to expert respondents' assessments. From these results, weighing with the Dynamic Weighing system is still relevant and in accordance with service needs for weighing container weights currently. Efficiency, speed, and accuracy are the measures of service at the gate terminal to be maintained and other optimization steps are needed in the development of service standards to be better in the future.

Weigh in Motion (WIM) technology in operation for container weighing services is still carried out periodically for maintenance where this process aims to maintain weight accuracy properly. PT XYZ carries out maintenance with the WIM vendor every month by testing the results of the scales totaling 18 lane gates. This maintenance process is referred to as WIM balance calibration carried out by WIM vendors and appointed surveyors.

This study shows the test results of weighing accuracy during 2021 with the maximum value of weighing error for each lane at the gate as shown in Table 7 below:

Table 7. Summary of WIM Result Test by Surveyor

Gate Lane	1	2	3	4	5	6	7	8	9
Average Error 5x test (%)	-1,22	0,72	0,37	2,0	2,3	1,7	0,52	0,79	-0,23
Gate Lane	10	11	12	13	14	15	16	17	18
Average Error 5x test (%)	1,75	1,54	0.04	-0,04	0,48	0,04	2,56	1,08	2,37

Analysis during 2021 is testing the accuracy of weighing with a total of 18 gate lanes and testing using trucks that pass through the WIM area five times for each lane with the result of WIM calibration with a maximum error value of 1%. The result with a maximum error of 1% shows that the Weigh in Motion technology used to weigh the container at the gate terminal area of PT XYZ still meets the service standard set by the manufacturer with the maximum error being 2.5%.

The problem of congestion to access the container terminal is more dominant due to the uneven volume of trucks on receiving and delivery services every hour. The handling capacity of the terminal that exceeds the service limit, especially from the limited number of loading and unloading equipment, causes congestion. Working hours at the terminal are divided into 3 service

shifts, namely shift 1 (07.00-15.30), shift 2 (15.30-23.00), and shift 3 (23.00-07.00). The truck volume data for 2021 can be shown in Figure 2 below:

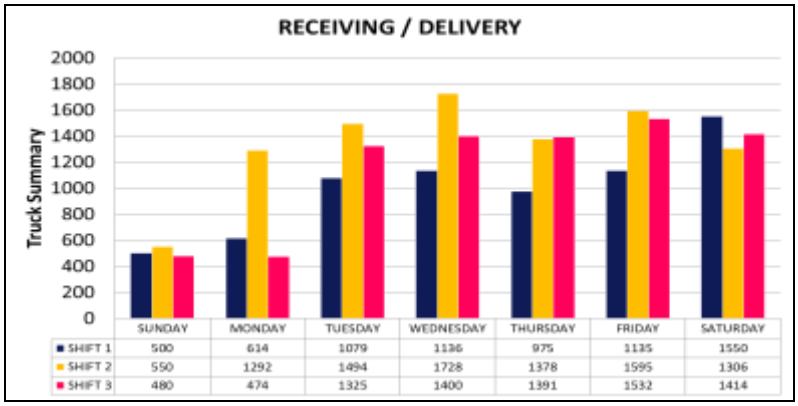


Figure 2. Data Volume Traffic Receiving & Delivery 2021

Statistical data on the pattern of truck arrivals entering the container terminal gate area during the period July to December 2021 every hour can be seen in Table 8 below:

Shift	Sun	Mon	Tue	Wed	Thu	Fri	Sat
1	66	79	169	161	153	143	144
2	71	160	180	170	172	164	131
3	38	200	196	191	187	175	66

Table 8. Volume Truck Receiving Delivery per day per hour

This study provides analysis for optimizing the development of digital services on gate automation with more integrated weigh-in-motion technology by providing ideas and suggestions to optimize existing facilities and technologies to be more efficient and optimal in providing satisfaction to port service users. There are two analyzes for optimizing development in the gate automation area, namely:

4.1 Explore the transformation process from manual service to digitization.

The Terminal Booking System is a service innovation where every truck that will enter the container terminal is required to make a booking process for the service time provided by the container terminal. The development of this digital-based service in this study is very appropriate to be carried out to overcome congestion outside the port area or function to regulate the workload inside the terminal. It is recommended that digital-based services be created and implemented immediately because the Terminal Booking System is an idea and solution that can be used as a pilot project for all ports in Indonesia.

An interface system is needed on the Terminal Booking System that connects with the existing Weigh in Motion technology in the Gate Automation area to reduce the level of traffic congestion in the container terminal gate area. Services using a quota system will distribute truck movement that enters the container terminal evenly per hour. The results of the analysis in this study that the quota that can be allocated to serve trucks entering the

terminal is 150 trucks per hour. Figure 3 below shows the recommended average quota amount per hour per day.

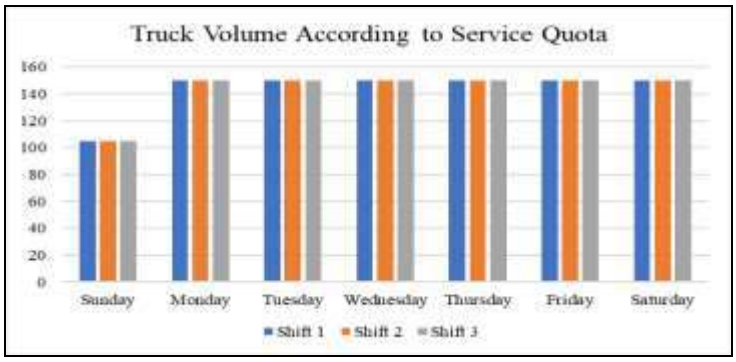


Figure 3. Terminal Booking System Quota Per Shift / Jam

4.2 Exploration of existing gate operational services towards digital systems and technology.

This research shows that there is room for improvement and development in the service process in the gate automation area. An e-ticket is an electronic document for the receiving and delivery process in the form of a card in which a chip is embedded to read data on export or import containers that will enter or leave the terminal. The use of this e-ticket is affixed to the card reader of the enclosure machine which is installed in the gate automation facility and also connected to the weighing system in weigh in motion.

In this study, it is shown that the gate operational service development room is where the existing system for export and import services that uses the card on the e-ticket to enter and exit the terminal is recommended to be replaced with a Quick Response Code (QR Code). The E-Ticket design that is replaced with a QR Code can be in the form of Figure 4 below.



Figure 4. E-Ticket replaced with QR Code

The development of the existing physical inspection device system for containers by inputting the seal number with a handheld device is still not optimal because it still performs manual input of the seal number. With efforts to optimize the system towards digital technology, efforts are needed to make this service function more efficient, fast, and accurate. Currently, handheld devices are equipped with a scan function that can speed up reading the container seal number. This handheld device has been produced industrially and can be used to replace existing devices at the gate terminal. Handheld devices with barcode scanning technology (Figure 5) can be used to scan the barcode of the container seal number (Figure 6) instead of manual input as in the model below.



Figure 5. Handheld Scanning



Figure 6. Container Seal & Barcode

6. CONCLUSIONS

Digital transformation in gate automation services with weigh in motion technology for container weighing systems with dynamic weighing methods is still relevant to keep operating compared to static weighing methods in terms of efficiency, speed, and accuracy. The results of tests conducted by independent surveyors in 2021 at 18 lane gate terminals have proven that the Weigh in Motion (WIM) technology has a weighing accuracy with a maximum error of 1% from the maximum standard error of 2.5%.

PT XYZ Container Terminal to carry out the transformation process from manual services to digitalization, especially in implementing the Terminal Booking System (TBS) to overcome traffic congestion problems in the terminal gate area. Optimization in existing services at the gate automation terminal can be developed towards digital systems and technologies such as changing E-Ticket documents into more efficient Quick Response Code (QR Code) forms and change the function of the gate inspector's Handheld from manual input of container seal number to Scanning Barcode Seal.

The expected managerial implication from the results of this research is that the company continues to schedule regularly and periodically for calibration work on Weigh in Motion (WIM) technology so that accuracy in weighing container weights is maintained. issued while still prioritizing service development which is very important to improve service quality and long-term business sustainability.

REFERENCES

Arora, M., Kanjilal, U., & Varshney, D. (2012). Successful Efficient and Intelligent Retrieval Using Analytic Hierarchy Process. In L. Cao, A. L. C. Bazzan, A. L. Symeonidis, V. I. Gorodetsky, G. Weiss, & P. S. Yu (Eds.), *Agents and Data Mining Interaction*, 331–343

Burns, M. G. (2015). *Port Management and Operations*. CRC Press.

Bushman, R., & Pratt, A. J. (1998). *Weigh in motion technology-economics and performance.* In Presentation on the North American Travel Monitoring Exhibition and Conference (NATMEC). Charlotte, North Carolina.

Cheng, E. W. L., Li, H., & Ho, D. C. K. (2002). Analytic hierarchy process (AHP): A defective tool when used improperly. *Measuring Business Excellence*, Vol 6*,* No 4, 33–37

Hernandez, S. V., Tok, A., & Ritchie, S. G. (2016). Integration of Weigh-in-Motion (WIM) and inductive signature data for truck body classification. *Transportation Research Part C: Emerging Technologies*, No 68, 1–21.

Ishizaka, A., Balkenborg, D., & Kaplan, T. (2011). Does AHP help us make a choice? An experimental evaluation. *Journal of the Operational Research Society*, *62*(10), 1801-1812.

Jiang, X., Chew, E. P., & Lee, L. H. (2015). Innovative Container Terminals to Improve Global Container Transport Chains. In C.-Y. Lee & Q. Meng (Eds.), *Handbook of Ocean Container Transport Logistics: Making Global Supply Chains Effective*, 3–41. Springer International Publishing.

Kim, K. H., & Lee, H. (2015). Container Terminal Operation: Current Trends and Future Challenges. In C.-Y. Lee & Q. Meng (Eds.), *Handbook of Ocean Container Transport Logistics: Making Global Supply Chains Effective*, 43–73.

Lee, E.-S., & Song, D.-W. (2015). Competition and Co-operation in Maritime Logistics Operations. In C.-Y. Lee & Q. Meng (Eds.), *Handbook of Ocean Container Transport Logistics: Making Global Supply Chains Effective*, 477–496. Springer International Publishing.

Liu, C. I., Jula, H., & Ioannou, P. A. (2002). Design, simulation, and evaluation of automated container terminals. *IEEE Transactions on Intelligent Transportation Systems*, 3, 12–26

Martín-Soberón, A. M., Monfort, A., Sapiña, R., Monterde, N., & Calduch, D. (2014). Automation in Port Container Terminals. *Procedia - Social and Behavioral Sciences*, No 160, 195–204.

Morakanyane, R., Grace, A., & O'Reilly, P. (2017, December 14). *Conceptualizing Digital Transformation in Business Organizations: A Systematic Review of Literature*.

Motono, I., Furuichi, M., Ninomiya, T., Suzuki, S., & Fuse, M. (2016). Insightful observations on trailer queues at landside container terminal gates: What generates congestion at the gates? *Research in Transportation Business & Management*, No 19, 118–131.

Plum, C. E. M., Pisinger, D., & Jensen, P. N. (2015). Bunker Purchasing in Liner Shipping. In C.-Y. Lee & Q. Meng (Eds.), *Handbook of Ocean Container Transport Logistics: Making Global Supply Chains Effective*, 251–278. Springer International Publishing.

Steenken, D., Voß, S., & Stahlbock, R. (2004). Container terminal operation and operations research—A classification and literature review. *OR Spectrum*, Vol 26, No 1, 3–49.

Szary, D. P. J., & Maher, D. A. (n.d.). *Implementation of Weigh-in-Motion (WIM) Systems*. 125.

Tavasszy, L. A., Ivanova, O., & Aprilyanto Halim, R. (2015). Modelling Global Container Freight Transport Demand. In C.-Y. Lee & Q. Meng (Eds.), *Handbook of Ocean Container Transport Logistics: Making Global Supply Chains Effective,* 451–475. Springer International Publishing.

Tijan, E., Jović, M., Aksentijević, S., & Pucihar, A. (2021). Digital transformation in the maritime transport sector. *Technological Forecasting and Social Change*, *170*, 120879.

W, Budisantoso. (2020), *Analytical Hierarchy Process (AHP)*, Lecture handout: Analisis dan Sistem Keputusan, MMT ITS, Surabaya.

Xu, Z., & Lai, X. (2015). Purchasing Transportation Services from Ocean Carriers. In C.-Y. Lee & Q. Meng (Eds.), *Handbook of Ocean Container Transport Logistics: Making Global Supply Chains Effective*, 399–427. Springer International Publishing.

Zhang, C., Liu, J., Wan, Y. W., Murty, K. G., & Linn, R. J. (2003). Storage space allocation in container terminals. *Transportation Research: Part B: Methodological*, 37, 883–903

SIX SIGMA APPLICATION TO IMPROVE PROCUREMENT PERFORMANCE IN THE NICKEL EXTRACTION COMPANY

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ABSTRACT

The Procurement Section of Company X has not been able to fulfil the performance set by management for two consecutive years. The current Sigma is 3.0 for Sourcing on Time and Sigma 3.1 for On Time in Full (OTIF) while the sigma target is 3.6 for Sourcing on Time and 3.4 for OTIF. The purpose of this study is to identify the root causes of the Sourcing on Time and OTIF performance not being achieved and provide program suggestions on how to improve performance in the Procurement section by using the DMAIC approach from the Six Sigma method. From the research, it was found that the main cause of defects in the Sourcing on Time process is the time used by Procurement to negotiate. Meanwhile, the main cause of the OTIF process defect is the timeliness of material delivery by the Supplier. The results of the analysis of the root causes of the Sourcing on Time process defects, including the Procurement Analyst does not have the authority to determine the minimum limit of the negotiation value so that negotiations are carried out repeatedly, while the root cause of the OTIF process defect is that Procurement does not consider poor supplier performance before giving a PO and inconsistently giving sanctions to suppliers. Proposed improvements include Procurement Management need to determine the frequency of the number of negotiations based on the complexity of the work to be more effective and Procurement needs to make supplier and contractor performance reports in the form of Dashboard and apply sanctions/penalties consistently to suppliers who violate, and consistently submit monthly reports to suppliers regarding their performance.

Keywords: DMAIC, KPI, Root Cause Analysis, SIPOC, Six Sigma.

1. INTRODUCTION

Six Sigma method has the main goal of finding and eliminating the root causes of product defects or the causes of errors (Tieman and Ghazali, 2014), so that there is an increase in the company's operating performance in certain fields such as procurement, production, distribution, and others. The Six Sigma approach uses an improvement process cycle with a five-phase cycle, namely the Define, Measure, Analyze, Improve and Control (DMAIC) approach (Pande et al., 2000; Andersson et al., 2006). DMAIC is a problem-solving procedure that is widely used in quality improvement and process improvement problems (Desai &

Shrivastava, 2008; Evans & Lindsay 2007). DMAIC is always associated with Six Sigma activities, and almost all Six Sigma implementations use the DMAIC approach.

This study focuses on two Key Performance Indicator (KPI) of Procurement Division namely Sourcing on Time and OTIF which were not achieved their target in 2020. Procurement is one of essential division in any industry as well as Company X that extracting nickel. Delay in procurement processes will certainly leads to impede extraction operations. In the process of measuring the performance of Sourcing on Time, with a sample of 500 contract processes carried out during 2020 with a total of 258 process failures, the achievement rate was only 48.4% or equivalent to a sigma level of 3.0. While for the OTIF process with a sample of 63,493 material purchasing processes with a total of 18,813 failures, the achievement rate is only 70.4% or equivalent to a sigma level of 3.1. The failure to achieve this performance has an impact on Company X, such as work cannot be completed on time and has a domino effect on other projects such as equipment and labor having to wait on standby, and the OTIF impact is not achieved, making the Company pay more for material delivery to the site so that the project schedule can still be met, or the project delay is not too significant. It is expected that the implementation of the proposed improvements from this research can improve the performance of the procurement department by achieving a performance target of 85% or equivalent to the level of sigma 3.6 for the Sourcing on Time process and sigma 3.4 for the OTIF process. With the aim to improve the future performance achievement, the research was conducted and the following are the objectives:

1. Identify the cause of KPI Sourcing on Time and OTIF not being achieved, analyze, and validate the real root cause of the problem.
2. Recommend several programs to improve the Procurement department performance achievement.

2. LITERATURE REVIEW

Based on previous research, the implementation of the Six Sigma approach has been carried out to improve the procurement process and improve the performance (quality) of the Procurement section carried out by Cheshmberaha and Nabavi (2021), to improve outsourcing management and reduce delivery time delays, and there are Ottou et al. (2020) used a Six Sigma approach to improve the effectiveness of construction procurement, identified the root causes of delays to overcome them and also Kochov and Argilovski (2021), to improve the raw material purchasing process in the company's real factories. With the above reasons and the existing procurement process for PT X, as well as improvements prioritized in the process, the use of Six Sigma is the best choice to improve the performance of the Procurement Department at PT X.

3. METHODS

This study uses the Six Sigma method but is limited to the Define (D), Measure (M), Analyze (A) stages and propose improvements to Improve (I). The six-sigma stage, Control (C) was not used due to time constraint of the study. This research is a case study conducted at the nickel extraction company in Indonesia. Data collection and processing begins by describing the flow of the procurement and OTIF process. Furthermore, in the Define stage, the development of the Procurement and OTIF process flow is carried out with the SIPOC scheme; and in the Measure stage to determine critical to quality (CTQ), Measure the current sigma level as a basis for Improvement and determine the main causes of failure of the Sourcing on time and OTIF processes with Pareto Analysis. At the Analysis stage, it aims to identify the root cause and analyze the priority problems in each CTQ to be overcome. Fishbone diagrams are used to illustrate RCA (Root Cause Analysis. And improve is the phase of improving the process and eliminating the factors that cause defects by establishing an action plan to implement Six Sigma Quality Improvement

4. RESULTS

4.1 Define

At this stage, the identification of problems from the ongoing process and describing the problems in the Procurement section with a SIPOC diagram in accordance with the Procurement process flow and OTIF process. Based on the existing attribute data related to Sourcing On time, it can be concluded that if a service procurement process does not meet the target time for signing the contract is in accordance with the specified time, the process is categorized as a defect process. Likewise, for the On Time in Full (OTIF) process, if the material delivery process by the supplier does not meet the quantity written in the PO and does not meet the delivery target according to the date written in the PO, then the process is categorized as a defect process. The Procurement and OTIF process flows outlined in this case study are built using high-level SIPOC tools, which include suppliers, input, output, and customer processes to clarify the relationship between suppliers, internal processes, and customers.

Figure 4.1 shows the SIPOC procurement process at Company PT X. Based on observations and data collected, critical points in the procurement process were identified in six processes, namely (1) when issuing a Request for Proposal (RFP), (2) when evaluating technical proposals, (3) when evaluating commercial proposals, (4) during commercial negotiations, (5) when making award reports and (6) when contractors sign contracts.

SUPPLIER	INPUT	PROCESS	OUTPUT	CUSTOMER
S	I	P	O	C
Requesting Area	Detail Scope of Work, specification, contract duration and budget	Purchase Demand formalization	Contract Requisition	Procurement team
Procurement Analyst	Detail Scope of Work, specification, duration, project schedule, tender schedule	Tender package preparation	Tender package and tender schedule	Procurement Analyst, Procurement Manager, Requesting Area
Procurement Analyst Requesting Area, contractor	Scope of Work, technical Specification & Pricing schedule	Issue Request for Proposal (RFP)	Tender package and tender schedule	Contractor
Receiving Cell / e-Procurement, contractor	Technical proposal and commercial proposal	Proposal Receiving	Technical and commercial proposal document	Receiving Cell / e-Procurement
Receiving Cell, Procurement Analyst	Technical proposal	Proposal Opening	Opened technical proposal document	Receiving Cell / e-Procurement, Procurement Analyst and Requesting Area
Requesting Area, EHS	Contractor's technical proposal for work method, safety program, equipment, tools, labour	Technical proposal evaluation	Technical evaluation result	Requesting Area and Contractor
Procurement Analyst	Contractor's commercial proposal for Unit Rates manpower, equipment, taxes, term of payment	Commercial proposal Evaluation	Commercial evaluation result (commercial equalization)	Procurement team
Procurement Analyst	Result of Commercial evaluation	Commercial negotiation	Negotiation result comparison	Procurement Analyst & Manager, contractor
Procurement Analyst	Procurement Proses, recommended contractor, vendor code, saving, contract duration, contract value, procurement software	Award Report Writing	Award Report approval in Procurement software	Procurement Supervisor, Managers as per Authority Matrix
Procurement Analyst	Contract document, contract value, contract terms and conditions	Contract Document Finalization	Agreed Contract document between PT X and contractor	Procurement Analyst and Contractor
Management PT X as per Authority Matrix	Contract document, contract value, contract terms and conditions	Contract signed by PT X	Signed contract document by PT X	PT X Management as per Authority Matrix
Contractor as per Authority Matrix	Contract document, contract value, contract terms and conditions	Contract signed by contractor	Complete signed contract document by PT X and contractor	Contractor Management as per Authority Matrix

Figure 4. 1 SIPOC Diagram of Procurement of PT X (Contract)

The SIPOC diagram in the OTIF process at PT X is shown in Figure 4.2. Based on the observations and data collected, critical points in the process are identified in two processes, namely (1) during the supplier stage updating the PO Progress and delivery confirmation and (2) during the supplier sending material to the Point of Delivery according to Incoterm, as per quantity and delivery date PO.

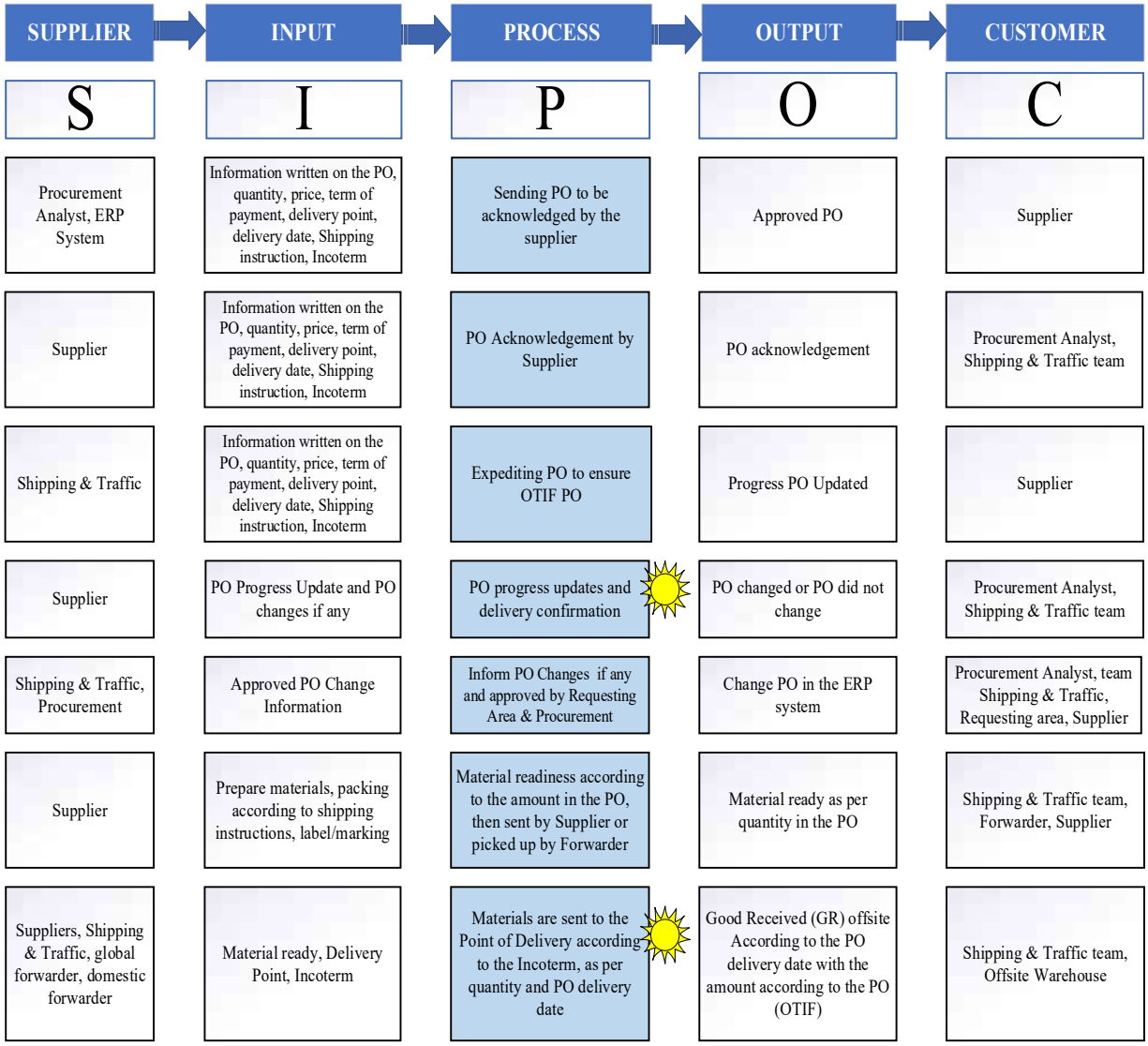


Figure 4.2 SIPOC Diagram of OTIF PT X (PO material)

4.2 Measure

The purpose of the measurement phase is to determine what quality characteristics (CTQ - Critical-to-quality) can cause a process not meeting customer expectations, measure the current level of sigma as a basis for improvement and determine the cause of the failure or defect.

4.2.1 Critical to Quality (CTQ)

Table 4.1 shows that there are 8 CTQs from the Sourcing on Time Procurement process. Data collection on defects in the Sourcing on Time Procurement process is carried out to determine the quality level baseline based on the sigma indicator and defects per million opportunities (DPMO).

Table 4. 1 CTQ Sourcing on Time Procurement

No	Procurement Proses Critical Points	Critical to Quality	No. CTQ
1	Issue Request for Proposal (RFP)	The time used by the Procurement Analyst to carry out the tender process	CTQ 1
2	Technical proposal evaluation	Time spent by the technical team to evaluate technical proposals	CTQ 2
3	Commercial proposal evaluation	Time spent by the Procurement Analyst to equalize commercial proposals	CTQ 3
4	Commercial Negotiation	Time spent by the Procurement Analyst to negotiate contract conditions, contract prices and payment terms	CTQ 4
5	Award Report Writing	Time taken by Supervisor/Approver to do approval in PT X Procurement software tool	CTQ 5
		The accuracy and completeness of the information entered by Procurement Analyst at Award Report in Procurement software tool	CTQ 6
		Procurement Analyst's accuracy in planning procurement completion	CTQ 7
6	Contract Signed by Contractor	Time taken by the Contractor to sign the contract	CTQ 8

Table 4.2 shows there are 5 CTQs of the On Time in Full (OTIF) process. OTIF Procurement process defect data collection is carried out to determine the quality level baseline based on sigma indicators and defects per million opportunities (DPMO).

Table 4. 2 CTQ On Time in Full (OTIF)

No	OTIF Proses Critical Points	Critical to Quality	No. CTQ
1	PO progress updates and delivery confirmation	The accuracy of sending PO by PT X to Supplier	CTQ 1
		The accuracy of the information provided by the Supplier to PT X regarding changes in the contents of the PO	CTQ 2
2	Materials are sent to the Point of Delivery according to the Incoterm, as per quantity and PO delivery date	On time delivery material by Supplier	CTQ 3
		The accuracy of the amount of material delivered by the Supplier	CTQ 4
		Fulfillment of material delivery from suppliers	CTQ 5

4.2.2 Current Sigma Level

Sigma and DPMO level calculation for Sourcing on Time with sample size of 500 contract processes carried out during 2020 and the number of failures observed was 258 processes, while for On Time in Full (OTIF) sample size are 63,493 material purchasing processes with number of failures observed was 18,813 processes.

Table 4.3 Current Sigma Level Sourcing on Time & OTIF

Step	Action	Equality		Calculation Result	
1	What process do you want to know			Proses Sourcing on Time	Proses On Time in Full (OTIF)
2	How many units carried out through the procurement process			500	63.493
3	How many units of process failed			258	18.813
4	Calculate the defect rate (Failure) based on step 3	Defects per Unit (DPU) = (Defects/Unit)	Step 3 / Step 2	51,6	0,296
5	Determine the number of potential CTQs that can result in defects (Failures)	The number of Critical to Quality (CTQ)		8	5
6	Calculate the probability of defect rate (Failure) per CTQ characteristic	Defects per Opportunity (DPO) = (Defects/(Process x opportunities)	Step 4/ Step 5	0,0645	0,0593
7	Calculate the probability of defects per million opportunities (DPMO)	Defects Per Million Opportunities (DPMO) = DPO x 1,000,000	Step 6 x 1,000,000	64.500	59.260
8	Convert DPMO (Step 7) into Sigma value			3.0	3.1
9	Make a Conclusion			The sigma capability is 3.0	The sigma capability is 3.1

4.2.3 Determination of the main causes of failure Sourcing on Time with Pareto

Pareto analysis is used to prioritize the causes of defects in the procurement process based on CTQs. From the analysis of determining the causes of problems in the CTQ Sourcing on Time process using the Pareto 80/20 principle, it was found that CTQ 4 is the main cause, where almost 80% of the problems that arise in the Sourcing on Time process are generated by CTQ 4, which is the time used by the Procurement Analyst to negotiate contract conditions, contract prices and payment terms.

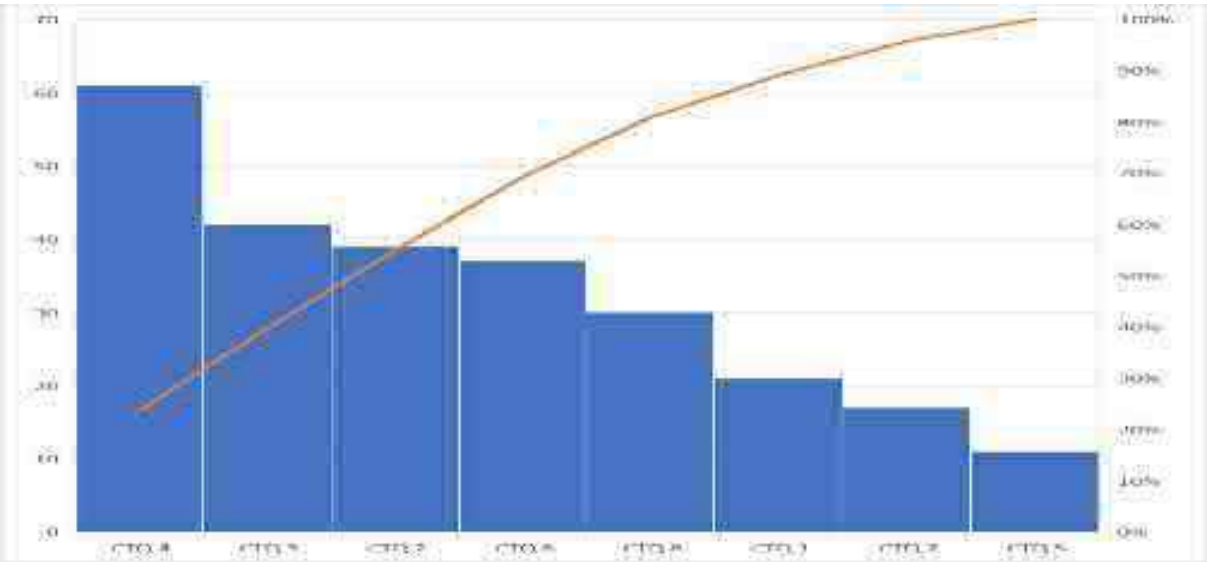


Figure 4.3 Pareto Analysis CTQ Sourcing on Time

From the analysis of determining the causes of problems in the On Time in Full (OTIF) process using the Pareto 80/20 principle, it was found that CTQ 3 is the main cause of problems that arise in the On Time in Full (OTIF) process, which is the timeliness of material delivery by the supplier.

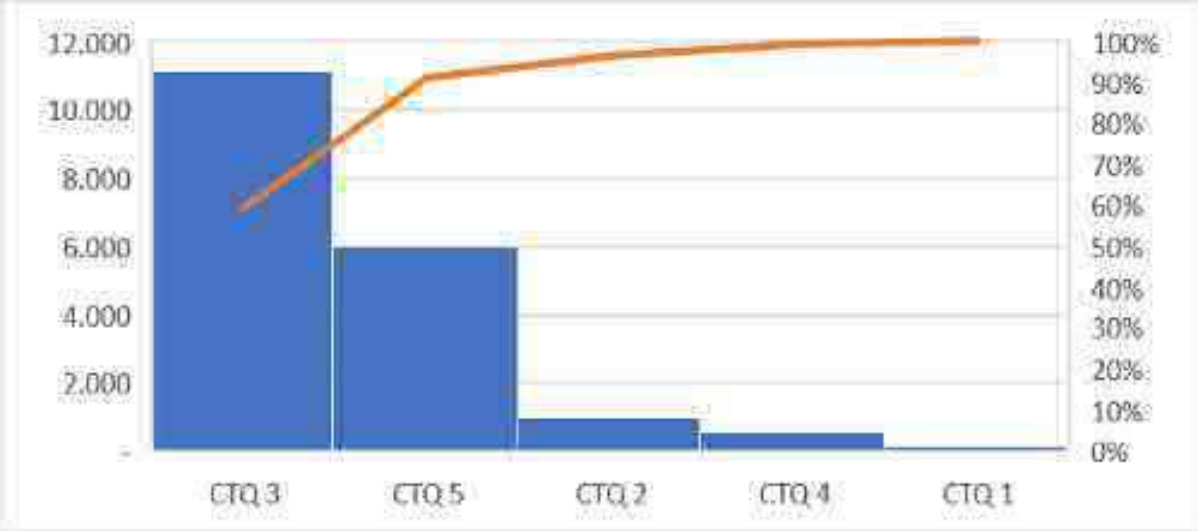


Figure 4.4 Pareto Analysis CTQ On Time in Full (OTIF)

4.3 Analyze

The analysis phase aims to identify the root of the problem and analyze the priority problems in each CTQ to be overcome. Based on the brainstorming result with Procurement management, shipping & traffic, suppliers, and forwarders, it was agreed to find the cause of the non-achievement of KPI Sourcing on Time on the biggest causes of process defects, namely CTQ 4. Meanwhile, based on the results of the Pareto on Time in Full (OTIF), the identified significant process defect is CTQ 3. furthermore, the researcher describes the possible causes of failure using the RCA fishbone diagram.

Figure 4.5 Fishbone Diagram CTQ 4 Sourcing on Time, shows the root causes of failure of CTQ 4, which is the time spent by the Procurement Analyst to negotiate contract conditions, contract prices and payment terms.

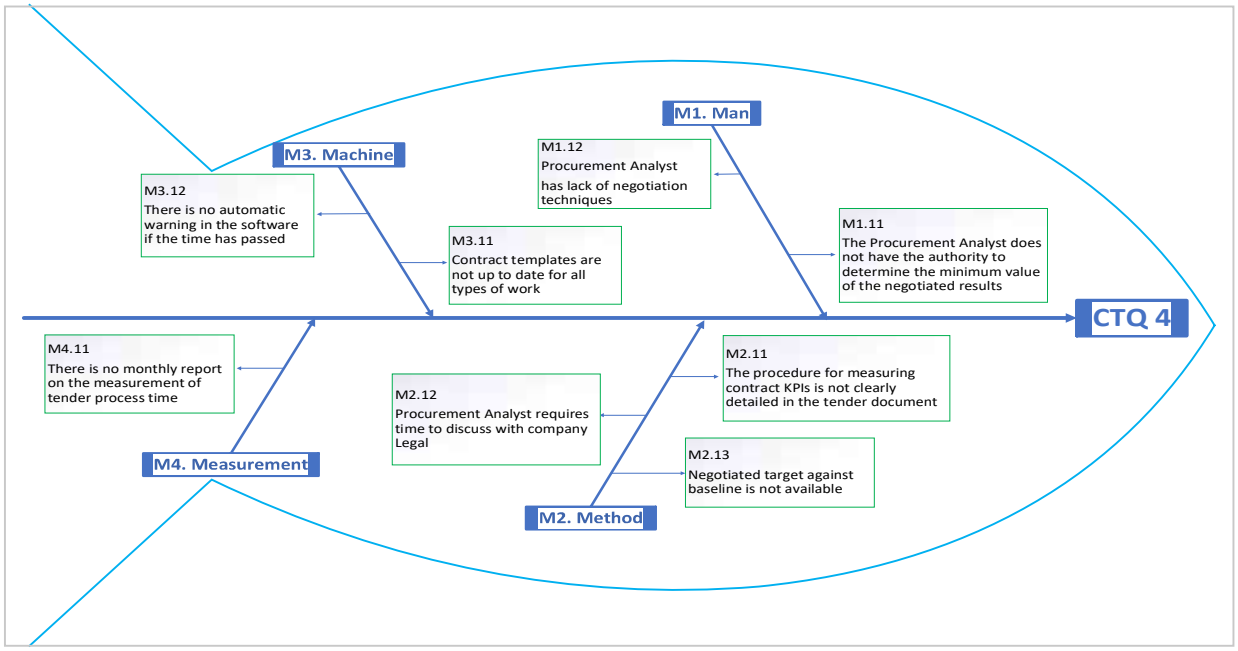


Figure 4.5 Fishbone Diagram CTQ 4 Sourcing on Time

Figure 4.6 Fishbone Diagram CTQ 3 On Time in Full (OTIF), showing the root cause of failure of CTQ 3, which is the timeliness of material delivery by the Supplier.

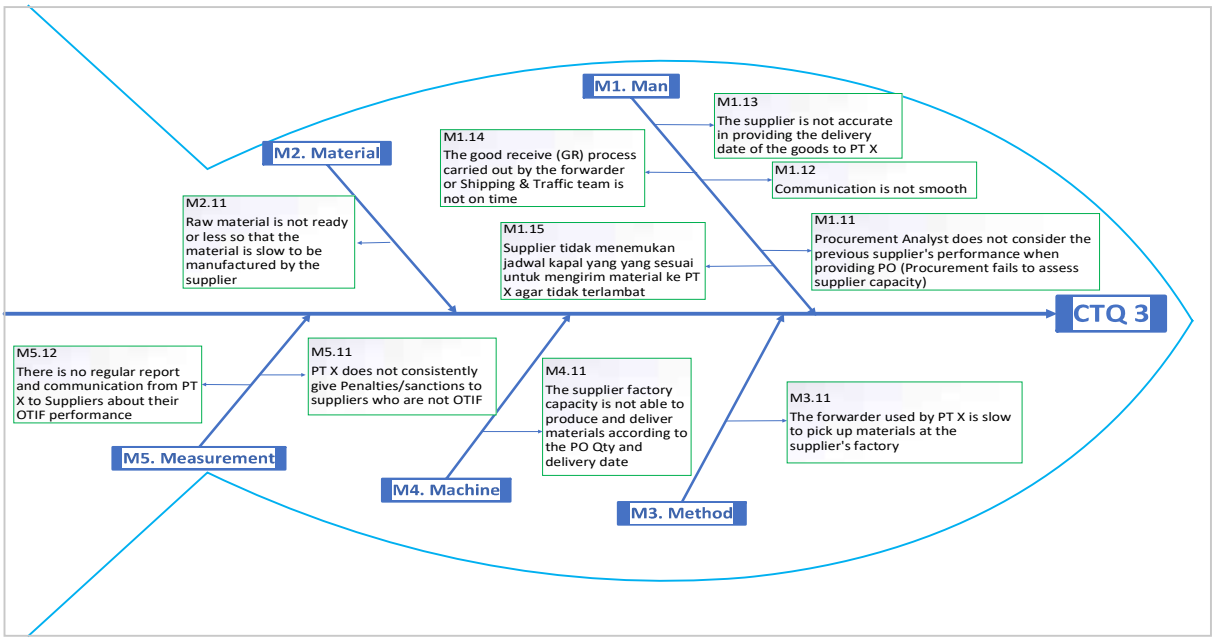


Figure 4.6 Fishbone Diagram CTQ 3 OTIF

4.4 Improvement

The improvement plan is obtained by searching references (eg journals, research reports), and holding meetings with the Senior Management of Procurement and Middle

Management of Procurement to brainstorm and investigate possible solutions for each root cause. The meeting was held on June 8, 2022, and June 10, 2022. The tool used in determining the priority of improvement plans is 5W+1H.

4.4.1 Improvement Plan Sourcing on Time

5 (five) priority list of improvements that must be implemented in terms of Sourcing on Time:

1. Procurement management to determine the number of negotiations based on the complexity of the work, which is:
   - 1x negotiation if the work is repetitive, low safety risk, low value up to USD 375,000/contract
   - Maximum 3x negotiations if the work is complex, high safety risk, medium value > USD 375,000 up to USD 900,000/contract
   - Contracts with high value of > USD 900,000/contract are not subject to a limit on the number of negotiations.

   If the result of the negotiation remains above the baseline price, while the negotiation time has expired, an approval from the Manager is required to stop or continue the negotiation before moving on to the next stage in the form of making an Award Report.
2. The Procurement Section needs to make an SLA (Service Level Agreement) with the company's Legal team to determine the duration of the review from the Legal team so that it can provide feedback if there are clarifications or exceptions from bidders on tender documents/contracts.
3. Procurement Management to assign Junior Procurement Analysts directly in the operation or on the field for 3 months so they can learn the operation process as well as get to know end users who use purchased materials and services and to the SCM area to find out the warehouse process, delivery and receipt of goods and inventory.
4. Procurement to provide an automatic reminder due date completion by email to the technical team to evaluate technical proposals.
5. Procurement provides regular monthly reports to all Procurement teams on the time spent by each Procurement Analyst completing a procurement process as well as to the technical team for the time spent evaluating technical proposals.

4.4.2 Improvement Plan on Time in Full

5 (five) priority list of improvements that must be carried out in the case of On Time in Full:

1. Procurement makes supplier and contractor performance reports in the form of a Dashboard that can be accessed by all Procurement Analysts.
2. Procurement, Supplier, forwarder, and shipping & traffic team need to hold monthly meetings or bi-weekly meetings to anticipate delays.
3. Procurement needs to consistently apply sanctions to suppliers who violate and do not award any PO or contract if they violate 3 times in a row. This needs to be written in the contract or PO so that the supplier knows it.
4. Procurement needs to send supplier performance reports every 3 months so that suppliers know that their performance is being measured and suppliers can improve their performance.
5. Procurement must ensure the supplier's ability to produce and deliver materials before the number of orders is written in the PO and the PO is sent to the Supplier. If the delivery of materials is partial, the last shipment must be considered. Suppliers need to be given a warning on partial shipments and back-charge costs incurred.

4.4.3 Comparison of Current SOP and Sigma Value versus estimated New Sigma Value

Below in Table 4.4 and Table 4.5 are comparisons of the currently available SOPs and their sigma values and the estimated new sigma values if SOP changes are made as improvements are implemented.

Table 4.4 Comparison of SOP Process Sourcing on Time

Current SOP	Current Sigma Value	Additional SOP at Procurement	Estimated New Sigma value
The number of negotiations with contractors and suppliers for each process is not limited	3.0	The number of negotiations will be based on the complexity of the work: 1x negotiation if the work is repetitive, low safety risk, low value ≤ USD 375,000/contract - Maximum 3x negotiations if the work is complicated, safety risk is high, medium value > USD 375,000 to USD 900,000/contract - Contracts with high value of > USD 900,000/contract are not subject to a limit on the number of negotiations. If the negotiation result is still above the base price, while the negotiation time has ended, approval from the Manager is required to stop or continue the negotiation before proceeding to the next stage in the form of making an Award Report.	+
All contracts above $1M or if there is a change in the standard conditions of PT X's contract, it must be reviewed again by the Legal Dept. and there is no standard time for review	3.0	Make an SLA (Service Level Agreement) with the company's Legal team, for example 3 working days to complete the review	+
SOP is not available. The existing practice is that every new hire directly works in the Procurement section and there is no obligation to go to the field.	3.0	Assign the Junior Procurement Analyst to work in the: Operation area = 3 months SCM area = 3 months Before being given the task as Procurement Analyst	+
The SOP regarding the rules for giving overdue warnings to the technical team is not available. what is being done now is just a reminder in the email and sometimes forget to follow up	3.0	Procurement to provide a due date completion reminder in an email to the technical team to remind the deadline for evaluating technical proposals	+
SOPs related to providing monthly performance reports for each Procurement Analyst and technical team in carrying out the procurement process are not available	3.0	Procurement provides regular monthly reports to all Procurement teams on the time spent by each Procurement Analyst completing each procurement process as well as to the technical team for the time spent evaluating technical proposals.	+

Table 4.5 Comparison of SOP process On Time in Full

Current SOP	Current Sigma Value	Additional SOP at Procurement	Estimated New Sigma value
SOP is not available	3.1	Make Supplier and contractor performance reports in the form of a Dashboard that can be accessed by all Procurement Analysts	+
SOP is not available	3.1	Procurement, Supplier, forwarder, and shipping & traffic team hold monthly meetings to anticipate delays	+
SOP is not available	3.1	Apply sanctions to suppliers who violate and do not provide PO or contracts if they violate 3 times in a row.	+
SOP is not available	3.1	Procurement must ensure the Supplier's ability to produce and deliver materials before the order quantity is written in the PO and the PO is sent to the Supplier. If the delivery of materials is partial, then the last shipment must be considered. Suppliers need to be given a warning on partial shipments and back-charge costs incurred.	+
SOP is not available	3.1	Sending performance reports every 3 months to all Suppliers and Contractors.	+

5. CONCLUSIONS

1. The main cause of process defects based on CTQ Sourcing on Time after Pareto analysis is the time used by Procurement to negotiate. While the main cause of process defects based on CTQ On Time in Full (OTIF) after Pareto analysis is the timeliness of material delivery by the Supplier.
2. The results of the root causes analysis of defects in the Sourcing on Time process, including the Procurement Analyst does not have the authority to determine the minimum limit for the value of the negotiation so that negotiations are carried out repeatedly to get large savings, payment terms are not up to standard or change the standard contract provisions, while The root cause of the On Time in Full (OTIF) process defect is that Procurement does not consider poor suppliers performance before giving POs and does not consistently provide sanctions to suppliers.
3. Proposed improvements based on research for the Sourcing on Time process are that Procurement Management needs to determine the frequency of the number of negotiations based on the complexity of the work to be more effective, provide negotiation training to the Procurement team, provide reminders in email regarding the due date completion to anticipate potential delays in evaluating proposals and provide monthly reports to the Procurement team and the Technical team regarding the time they spend in completing a procurement process.

4. In the case of On Time in Full, the proposed improvement based on research is that Procurement needs to make suppliers and contractors performance reports in the form of a Dashboard that can be accessed by all Procurement Analysts, Procurement needs to hold regular meetings with suppliers, forwarders and shipping & Traffic, Procurement needs to apply sanctions/penalties consistently to suppliers who violate and submit monthly reports consistently to suppliers regarding their performance.

REFERENCES

Adriyanti D.W., Vanany I. (2019). Application Six Sigma Method in Green Leaf, Threshing Tobacco Plant. The 1st International Conference on Business and Management of Technology (IConBMT), August 3rd, 2019, Institut Teknologi Sepuluh Nopember, Surabaya, Indonesia. IPTEK Journal of Proceedings Series No. (5) (2019), ISSN (2354-6026). https://iptek.its.ac.id/index.php/jps/article/view/6286/4122

Amin A.F (2018). Memperbaiki Purchase Effectiveness Rate untuk Meningkatkan efektivitas dan Efisiensi PT PJB Services. Research Gate https://www.researchgate.net/publication/352625069_Memperbaiki_Purchase_Effectiveness_Rate_Untuk_Meningkatkan_Efektivitas_Dan_Efisiensi_PT_PJB_Services

Armstrong M. (2006). Performance Management Key Strategies and Practical Guidelines. 3rd Edition. Kogan Page.

Armstrong M. (2017). Armstrong On Reinventing Performance Management: Building a cultural of Continuous Improvement. Kogan Page Limited.

Bailey, P., Farmer, D., Crocker, B., Jessop, D., Jones, D. (2015). Procurement Principles and Management. Eleventh Edition. Pearson Education Limited.

Bharath A.A., Shankar, M.G. (2020). Developing a framework for economically improving the quality of a construction process by Six Sigma. International journal of Six sigma and competitive advantage, Bol 12, No 2-3. Inder Science Online. https://www.inderscienceonline.com/doi/abs/10.1504/IJSSCA.2020.110978

Carroll, C.T. (2013) Six Sigma for Powerful Improvement A Green Belt DMAIC Training System with Software Tools and a 25-Lesson Course. CRC Press.

Cheshmberah, M., Nabavi, S. M. M. (2021). Journal An Application of Six Sigma DMAIC Methodology in Outsourcing Management Process Improvement. Research Gate. https://www.researchgate.net/publication/314832988_An_application_of_Six_Sigma_DMAIC_methodology_in_outsourcing_management_process_improvement

Costa J.P., Lopes I.S., Brito J.P. (2019). Six Sigma application for quality improvement of the pin insertion process. 29th International Conference on Flexible automation and Intelligent Manufacturing (FAIM2019), June 24-28,2019, Limerick, Ireland. Science direct. https://www.sciencedirect.com/science/article/pii/S235197892030127X

Eckerson, W.W. (2011). Performance Dashboard Measuring, Monitoring, And Managing Your Business. Second Edition. John Wiley & Sons, Inc.

Gaspersz, V. (2002). Pedoman Implementasi Program Six Sigma Terintegrasi Dengan ISO 9001:2000, MBNQA, Dan HACCP. Gramedia Pustaka Utama.

Gijo E.V., Sarkar A. (2013). Application of Six Sigma to improve the quality of the road for wind turbine installation. The TQM Journal ISSN: 1754-2731. Emerald Inside. https://www.emerald.com/insight/content/doi/10.1108/17542731311307438/full/html

Gupta, P. (2004). Six Sigma Business Scorecard Ensuring Performance for Profit. The McGraw-Hill Companies, Inc.

Hey, R.B. (2017). Performance Management for Oil, Gas, and process Industries A Systems Approach. Elsevier Inc.

Kieran M., Cleary M., Brun A., Igoe A. (2017). Supply and demand: application of Lean Six Sigma methods to improve drug round efficiency and release nursing time. National Library of Medicine. International Journal for Quality in Health Care, 2017, 1–7 https://pubmed.ncbi.nlm.nih.gov/29025066/

Knowles G., Whicker L., Femat J.H., Canales F.D.C. (2007). A conceptual model for the application of Six Sigma methodologies to supply chain improvement. Taylor & Francis Online. https://www.tandfonline.com/doi/abs/10.1080/13675560500067459?journalCode=cjol20

Kochov, A., Argilovski, A., (2021), Six Sigma Approach to Enhance Concurrency of the Procurement Process for Raw Materials, ISSN 1846-6168 (Print), ISSN 1848-5588 (Online). https://hrcak.srce.hr/265001

Kolibisky, M.M., Kucerova, M. (2020). Journal Improving Products Quality Applying Six Sigma. Research Papers Faculty of Materials Science and Technology in Tranava Slovak University of Technology in Bratislava. Research Gate https://www.researchgate.net/publication/342844096_Improving_Products_Quality_Applying_Six_Sigma

Mazumder Q.H. (2014). Applying Six Sigma in Higher Education Quality Improvement. Conference: 2014 ASEE Annual Conference & Exposition. Research Gate. https://www.researchgate.net/publication/344533498_Applying_Six_Sigma_in_Higher_Education_Quality_Improvement

Munro, R.A., Ramu, G., and Zrymiak. D.J. (2015). The Certified Six Sigma Green Belt Handbook. Second Edition. ASQ Quality Press.

Ottou, J.A., Baiden, B.K., Nani, G., (2020), Six Sigma Project Procurement application in public procurement. Research Gate. https://www.researchgate.net/publication/342734315_Six_Sigma_Project_Procurement_application_in_public_procurement

Pande, P. S., Neuman, R. P., & Cavanagh, R. R. (2000). The Six Sigma Way: How GE, Motorola, and Other Top Companies Are Honing Their Performance. McGraw-Hill.

Parmenter, D. (2020). Key Performance Indicators Developing, Implementing, and Using Winning KPIs. Fourth Edition. John Wiley & Sons, Inc.

Pyzdek, T. (2003). The Six Sigma Project Planner: A Step-by-Step Guide to Leading as Six Sigma Project Through DMAIC. McGraw-Hill, Ney York.

Rebull, M.V.S., Ninerola, A., Rullan, R.F. & Lara, A.B.H. (2020). Six Sigma for workplace safety improvement: Improving hazards and unsafe conditions in a metallic packaging manufacturing company. International Journal of Occupational Safety and Ergonomics. Taylor & Francis. https://www.tandfonline.com/doi/abs/10.1080/10803548.2020.1829318?journalCode=tose20

Rebull, M.V.S., Ninerola, A., Rullan, R.F. & Lara, A.B.H. (2020). Six Sigma for improving cash flow deficit: a case study in the food can manufacturing industry. International Journal of Lean Six Sigma. Volume 11 Issue 6. Emerald Insight. https://www.emerald.com/insight/content/doi/10.1108/IJLSS-12-2018-0137/full/html

Susetyo J. Winarni, Hartanto C. (2011). Aplikasi Six Sigma DMAIC dan Kaizen sebagai Metode Pengendalian dan Perbaikan Kualitas Produk. https://core.ac.uk/display/28362234

Stamatis, D.H. (2002). Six Sigma and Beyond Problem Solving and Basic Mathematics. St. Lucie Press The Council For Six Sigma Certification. CSSC. (2018). Six Sigma: A Complete Step-By-Step Guide. A Complete Training & Reference Guide for White Belts, Yellow Belts, Green Belts and Black Belts. Harmony Living, LLC.

Statham, G., Hackett, M. (2016). The Aqua Group Guide to Procurement, Tendering & Contract Administration. Second Edition. John Wiley & Sons Ltd & Blackwell Publishing.

Vanany I., Emilasari D. (2007). Aplikasi Six Sigma pada Produk Clear File di Perusahaan Stationary. Jurnal Teknik Industri ISSN 1411-2485 (print) / 2087-7439 (Online). https://jurnalindustri.petra.ac.id/index.php/ind/article/view/16616

Yang X., Gao S., He Z., Zang M. (2018). Application of Design for Six Sigma tools in telecom service improvement. Taylor & Francis Online. https://www.tandfonline.com/doi/abs/10.1080/09537287.2018.1486469?journalCode=tppc20

COMPETITIVE STRATEGY DEVELOPMENT WITH PERFORMANCE MANAGEMENT SYSTEM APPROACH BASED ON BALANCED SCORECARD PT XYZ

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ABSTRACT

A private owned company which runs business as manufacture and fabrication of steel structures, the main product of the company is a high voltage power transmission tower. In recent years the company's sales achievements have increased significantly, but the profit percentage has decreased. The company performance achievements are only assessed from the financial aspect because the company does not yet have a performance management system that can measure performance from other aspects; implementation of performance management system is needed to develop sustainable company. The research aims to create performance management system based on balanced scorecard, those appraisals from four perspectives: financial, customer perspective, internal process learning and growth. To design new performance management system, it is necessary to conduct a differentiation analysis with competitor using *Business Model Canvas* based on Blue Ocean Strategy approach. In determining the competitive position of the company, there are 10 competitive factors to determined company's positions in the strategy canvas. This research obtained a new *Business Model Canvas* based on differentiation analysis with Blue Ocean Strategy approach, which obtained a company strategy map with 14 strategic targets and 16 key performance indicators at the corporate level

Keywords: Balanced Scorecard, Blue Ocean Strategy, Business Model Canvas, Key Performance Indicator.

1. INTRODUCTION

The use of electricity as one of the main energy sources in the industrial and household sectors makes the construction of the electricity network increase from year to year, to achieve electrification levels and reliability of the electricity network. The Ministry of Energy and Mineral Resources (2020) report the electricity statistics that is the length of the transmission network has been installed at 61,454.20 kms and the distribution network is 1,006,265.15 kms. The development of the manufacturing industry in Indonesia is currently increasing to support domestic needs; products that were previously imported from abroad, now triggered to be produced domestically with the aim of reducing dependence on foreign products. To support this program, the government in this case is the Ministry of Industry making several regulations, one of which is the application of a minimum value of domestic component level for domestic products. The ministry of Industry of the Republic of Indonesia (2022) said that the government

continues to encourage the increase of domestic products and the level of domestic component level to realize the independence of the domestic industrial sectors.

The object of this research is one of manufacturing companies in East Java that is engaged in steel structures with the ability to produce voltage power transmission towers, communication towers, steel support HV equipment, bridges and steel frame buildings. The company has a vision to be the best manufacturing company in Indonesia by emphasizing sustainable growth and competency development through the development of human resources, management, technology and Good Corporate Governance (GCG). To achieve this vision, company continues to develop in every aspect, one of which is increasing the local content of each product in order to win the competition in the steel structure manufacturing industry. The local content level of products has an average of 53.01%, this is one of the factors driving the increase in the company's total revenue or sales.

The revenue of the company from 2017-2021 have increased from year to year, but management found several problems, that is decrease in net profit percentage. Operational constraints faced by the company are delays in the production process caused by limited facilities and production equipment as well as the number of qualified human resources to work on orders. This problem resulted in large production costs due to the need for subcontracting to other companies to meet the target for completion of the work, in addition to this problem due to limited land; the management company leases temporary warehouses to store production due to limited storage area. This problem made the increased of production costs due to the need for sub-contracting to other companies to achieve the target for completion of the order, in addition to this problem due to limited land, so the management company leased temporary warehouses to store production due to limited storage area.

This research produces a performance management system that can assist companies in preparing business strategies by creating innovations with the company's positioning and using the Blue Ocean Strategy (BOS) approach to create new business models that will have an impact on all aspects of the business (financial, customer, operational and HR). As well as creating a management system to control the achievement of targets by creating a Performance Management System using the Balanced Scorecard (BSC) and the company's action plan in order to achieve the targets set in BSC.

2. LITERATURE REVIEW

2.1. Business Model Canvas

Osterwalder & Pigneur (2010) said the Business Model Canvas or commonly called BMC is a strategy management in the form of a visual chart consisting of nine elements/blocks to assist business plan before it is formed. This business model changes the concept of a business that was complicated at first becomes simple. The nine elements are customer segment, value proposition, channel, customer relationship, revenue streams, key resources, key activities, key partners and cost structures.

2.2. Blue Ocean Strategy

Blue Ocean Strategy is the simultaneous pursuit of differentiation and low cost to open up a new market space and create new demand. It is about creating and capturing uncontested market space, thereby making the competition irrelevant. Chan Kim and Renee Mauborge (2005) tried to develop a proven analytical tool to analyze Blue Ocean Strategy, including: The Strategy Canvas and *Four Action Framework.* The strategy canvas is a framework for action as well as a diagnosis

to build a good BOS, has two functions: summarizing the situation of a known market spaceand encouraging to carry out activities with a focus oriented from competitors to alternative industries and from consumers to non-consumers. The Four Actions Framework are (1) eliminate – what factors should be eliminated from those that the industry has taken for granted?; (2) Reduce – what factors should be reduced to below industry standards; (3) Raise – what factors need to be raised above the industry standard; and (4) Create – what factors haven't been offered by the industry so they had to be created?.

2.3. Balanced Scorecard

David, Kaplan, Norton, & Robert (1996) the Balanced Scorecard is a method that can be used to measure the strategy implementation performance of a company, the aim is to make business strategies measurable and concrete. The Balanced Scorecard has four main perspectives; (1) Financial perspective, the perspective with the aim of satisfying the shareholders; (2) Customer perspective is the perspective to maintain relationships with customers; (3) Internal process describes any process that can be assessed as added company values; (4) Learning and growth perspective that describes how the company can continue to learn and grow (improvising employee performance).

2.4. Strategy Map

David, Kaplan, Norton, & Robert (2001) explain that strategy map is a diagram that describes the relationship between the four perspectives in the Balanced Scorecard. These four perspectives with their respective objectives have a causal relationship or cause – effect.

2.5. Translating BMC into BSC Framework

The author adopts the concept of an idea (Richardson, 2014) which provides an understanding of the translation of the Business Model Canvas into the Balanced Scorecard (BSC) performance measurement system. According to Richardsor (2014) a strategy map needs to be drawn up to bridge the gap between the realization of the company's achievements and the expected plans in the future through a synthesis between the nine blocks in the BMC with the BSC perspective as shown in Figure 1.

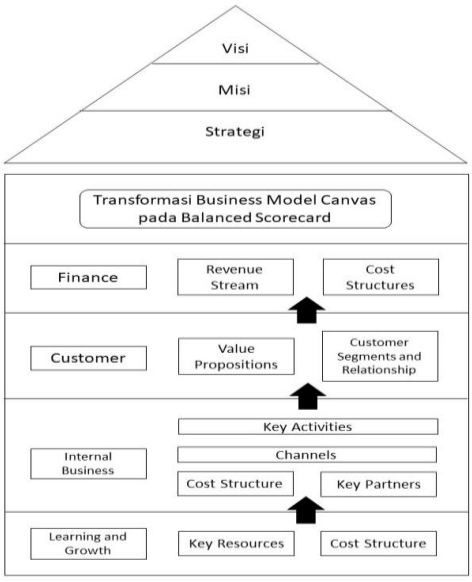


Figure 1. The Concept of Translating BMC into BSC Framework

2.6. Key Performance Indicator

Key Performance Indicator (KPI) is a variable that is used to shown quantitatively the effectiveness and efficiency of the process by referring to organizational targets and goals as a tool to assess the level of success in achieving organizational goals that are realized in certain measures. Parmenter (2007), KPI is an indicator used to measure the level of performance achievement against the strategic objectives that have been determined by the company.

3. METHODS

The research uses two method approaches; case study method at object and semi-structured interviews conducted with the middle to top level management level. There are five steps in this research; (1) Identification of potential issues with literature study method of company secondary data and interviews with several experts in the company; (2) Design the company's current business model; (3) Redesign the company's business model. In this step, an analysis of the company's positioning against competitors will be carried out by taking into account several aspects of the value owned by the company, while also using an innovation-based approach so that the company can create new market opportunities; (4) Translating the business model into a performance management system and determining strategic goals from each perspective using the expert judgment interview method; (5) Design KPIs and action plans for each strategic target. After determining the strategic targets, the next step is to create KPIs (Key Performance Indicators) and action plans to assist the company in achieving its goals.

4. RESULTS

4.1. Designing Current Business Model Canvas



Figure 2. Company Existing Business Model Canvas

4.2. Redesigning Business Model Canvas

The current PT XYZ's Business Model Canvas will be redesigned by analyzing the company's differentiation and positioning through the Blue Ocean Strategy approach with top management opinion data sources. The first is analyzed in terms of competitive factors from

aspects of product quality, market share, price, job completion time, human resources, work culture, job execution ability, marketing, bankability, and certification comparing PT XYZ with its competitors whose results will be displayed through a strategy canvas curve.

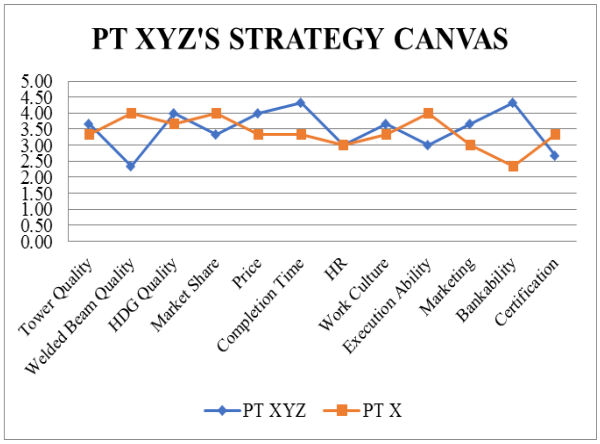


Figure 3. Company's Strategy Canvas

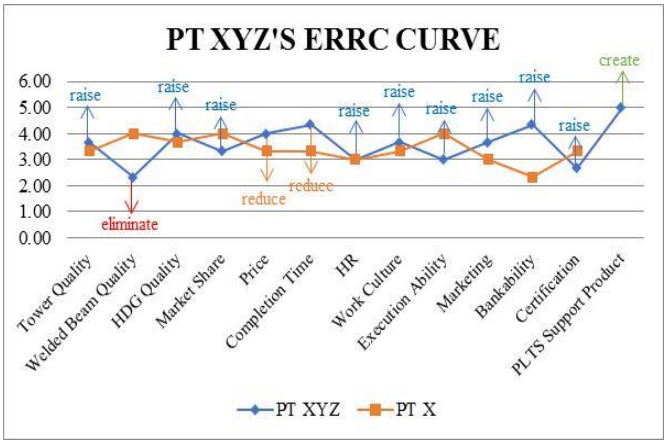


Figure 4. Company's ERRC Curve

The four action framework stages or Eliminate-Reduce-Raise-Create (ERRC) Grid are eliminating the competitive factor (eliminate), reducing the competitive factor (reduce), increasing the competitive factor (raise) and creating a competitive factor (create) to gain differentiation and cost cheap in the Blue Ocean Strategy approach. The company in terms of competition factors that need to be removed are welded beam products, reducing prices and work completion times, improving tower product quality and hot dip galvanization, market share, human resources, work culture, job execution capability, marketing, bankability and certification, as well as creating steel support products for solar power plants.

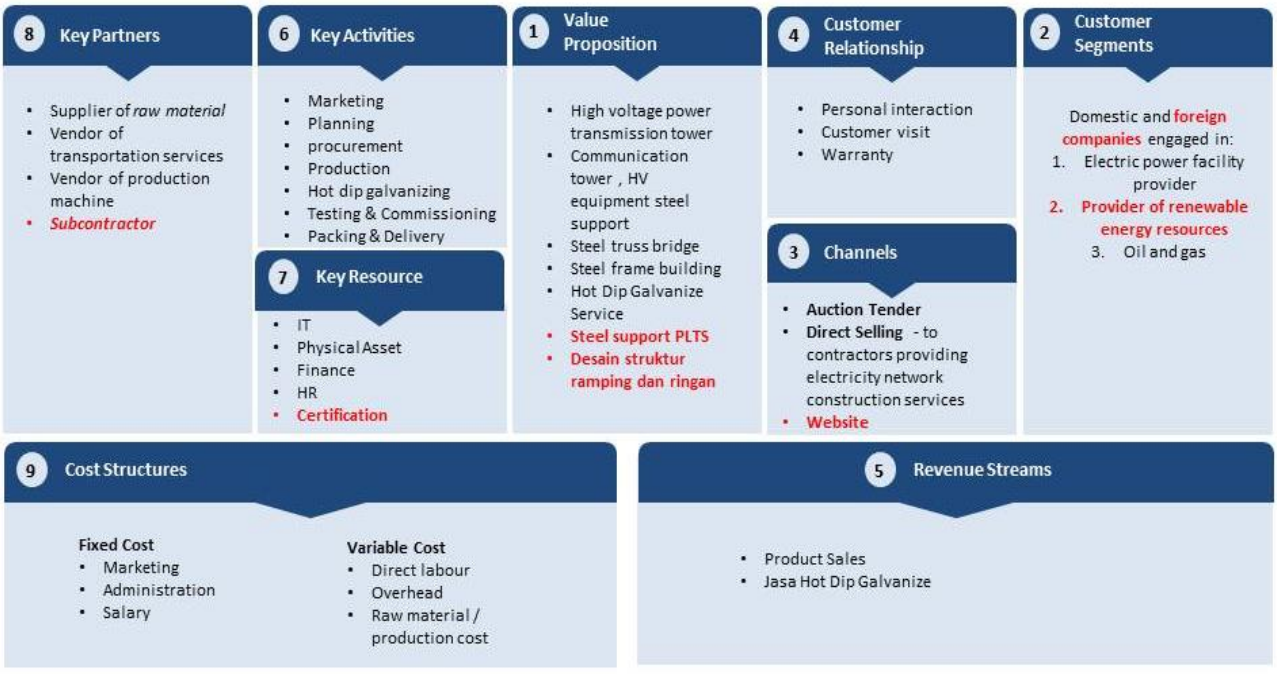


Figure 5. Redesign of Business Model Canvas

The redesign of the Business Model Canvas was formulated based on the results of interviews with expert judgment and the Blue Ocean Strategy approach. There are several changes to the company's BMC, namely in the value proposition, customer segments, channels, key resources, and key partners.

1. Value Propositions

In the redesign of BMC, the value propositions that will be offered to consumers are a slim and light structural design to meet consumer needs. With the green energy campaign, the company collaborates with companies providing solar power plants so that there is a new product, namely PLTS steel support. Meanwhile, high-voltage power transmission tower products, communication towers, HV equipment steel support, steel frame bridges, and steel frame buildings are still being produced because they are still the mainstay products.

2. Customer segment

There is a change in the redesign of the customer segment, namely domestic and foreign companies that are engaged in providing electric power facilities, renewable energy resources and companies in the oil and gas industry.

3. Channels

The company's channels are based on the redesign of the BMC to become a tender for the auction system, direct selling and through the website to reach foreign companies.

4. Customer Relationship

Customer relationships, namely conducting personal interactions, visiting customers and providing after-sales guarantees.

5. Revenue streams

Redesign Revenue streams have not changed, namely the source of income received is in the form of product sales and hot dip galvanizing service providers

6. Key Activities

Redesign Key activities namely marketing, planning (planning), procurement, production, hot dip galvanizing, testing & commissioning and packing & delivery

7. Key Resources

The company key resources are physical assets, IT systems, certificates, financial resources and skilled workers.

8. Key Partners

Key partner redesign has not changed, namely raw material suppliers, subcontractors, transportation service provider and production machine provider

9. Cost structure

The redesigned cost structure consists of fixed costs (marketing costs, administrative costs, and office employee salary costs) and variable costs (direct labor costs (factory), overhead costs, and raw material/production costs).

4.3. Translating the Business Model into A Performance Management System

The design of the Performance Management System in this study uses the grouping of nine blocks on the Business Model Canvas into four perspectives of the Balanced Scorecard Performance Management System (BSC).

Table 1. Strategic Objectives

Perspective	BMC's Block	Strategic Theme	Code	Strategic Objectives	Objectives
Finance	*Revenue Streams*	*Revenue Growth*	F1	Increase the continuous revenue	The company's revenue is increasing continuously
	Cost Structures	*Cost Efficiency*	F2	Increase cost efficiency	Production costs become more efficient
	Revenue Streams	*Margin Growth*	F3	Increase profit	The company's profit can increase from the previous year
Customer	*Customer Segments*	*Customer Satisfaction*	C1	Increase customer satisfaction	Customers will repeat orders
	Customer Relationship	*Customer Loyalty*	C2	Increase customer loyalty	Customers will increase product purchases
	Customer Segments	*New Customer*	C3	Increase amount of customers from different sectors	Amount of customers is increasing
Internal Business Process	*Value Proposition*	*Quality Product*	I1	Product quality improvement	Product quality according to the specifications requested by customers
	Key Activities	*Organization Development*	I2	Build R&D Department	Formation of R&D team for product development
	Cost Structure	*Productivity*	I3	Increase operational effectiveness and efficiency	Increased employee productivity
	Key Partners	*Quantity Partnership*	I4	Increase strategic partnership cooperation	There is a new strategic partnership
Learning and Growth	*Key Resources*	*Employee satisfaction*	L1	Increase employee satisfaction	Employee satisfaction increased from the previous year
	Key Resources & Cost Structure	*Learning & Development*	L2	Conducting training	Employee competence and expertise will increase
		Employee competencies	L3	Skill certification investment	The number of skill certifications will increase
		Business and technological concept	L4	IT and Information System Investment	There are additional IT assets and Information Systems

14 strategic goals based on each perspective of the Balanced Scorecard above and then each strategic theme is determined to facilitate the process of determining targets and KPI.

4.4. Strategy Map

The strategy map that has been prepared shows a comprehensive and coherent relationship between the strategic objectives of each BSC perspective. The end result of a cause-and-effect relationship is an increase in financial performance, namely being able to increase company profits which will also provide more value for shareholders. In achieving these main financial goals, support from a non-financial perspective is needed. The strategic objectives from each perspective in the strategy map depicted in Figure 6 are interrelated and have a clear causal relationship with each other that leads to an increase in the company's financial performance.

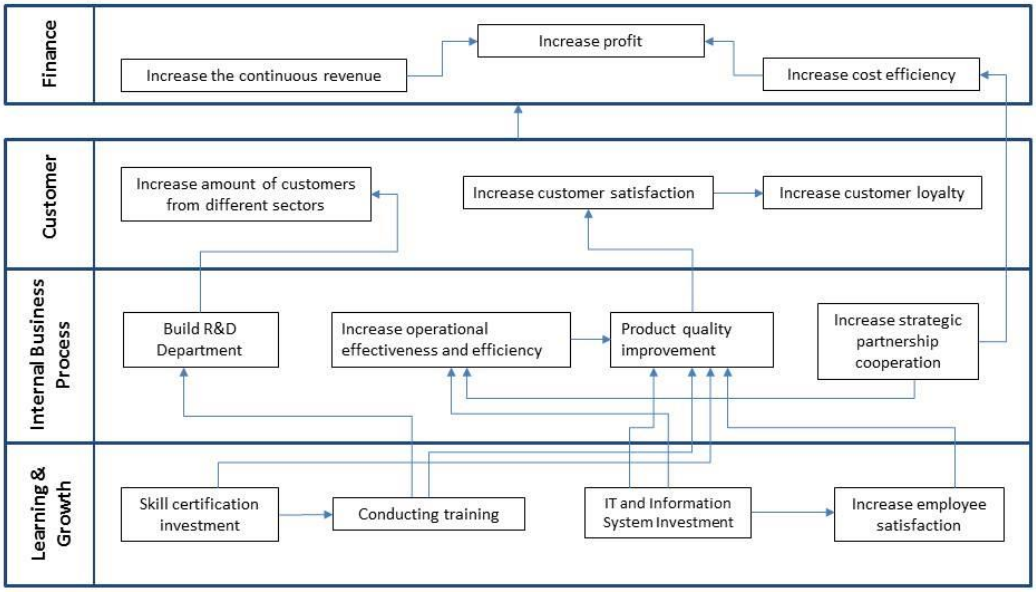


Figure 6. Company's Strategy Map

4.5. Key Performance Indicator

Table 2. Key Performance Indicator

Code	Strategic Objectives	KPI's Code	KPI	KPI's target	Pol.	Assessment period
F1	Increase the continuous revenue	F1.1	Percentage of increased revenue	20%	HB	Semester
F2	Increase cost efficiency	F2.1	Operating expense rate ratio	5%	LB	Semester
F3	Increase profit	F3.1	Percentage of increased profit	10%	HB	Semester
C1	Increase customer satisfaction	C1.1	Percentage of customer satisfaction	2%	HB	Annual
C2	Increase customer loyalty	C2.1	Percentage of customer retention	2%	HB	Annual
C3	Increase amount of customers from different sectors	C3.1	Amount of new customers	2 unit	HB	Annual
I1	Product quality improvement	I1.1	Percentage of decrease in the number of claims	20%	LB	Semester
		I1.2	The implementation of risk management	1 unit	MO	Semester
I2	Build R&D Department	I2.1	Realization of R&D Department	1 unit	MO	Annual
		I2.2	Amount of new products	1 unit	HB	Annual
I3	Increase operational effectiveness and efficiency	I3.1	Employee productivity level	700jt	HB	Annual
I4	Increase strategic partnership cooperation	I4.1	Increase in total contract value	20%	HB	Annual
L1	Increase employee satisfaction	L1.1	Increased of percentage of satisfied employees	5%	HB	Annual
L2	Conducting training	L2.1	Realization of training programs	40%	HB	Annual
L3	Skill certification investment	L3.1	Number of certifications /year	4 unit	HB	Annual
L4	IT and Information System Investment	L4.1	Implementation of the new computerized system	10%	HB	Annual

6. CONCLUSIONS

There are several conclusions from the results of the analysis that have been carried out, the following conclusions from this study are (1) Based on interviews and differentiation analysis using the Blue Ocean Strategy approach, it was found the company Redesign Business Model Canvas ; (2) From the translation of Business Model Canvas, a strategic map of the company is obtained, in the learning and growth perspective there are four strategic targets, in the internal business process perspective, there are four strategic targets, the customer perspective, there are three strategic objectives, and in financial perspective, there are 3 strategic targets; (3) So far, the company does not have a performance measurement so in this study a company performance measurement system was obtained to determine the company's performance to achieve the targets, in this study 16 KPIs were produced with an action plan with details of 3 financial perspectives, 3 customer perspectives, 6 internal business process perspectives, and 4 learning and growth perspectives.

REFERENCES

Applegate, L., Austin, R., & Soule, D. (2009). *Corporate Information Strategy and Management.* Singapore: McGraw Hill.

Bisnis.com. (2020, March). *Dampak-virus-corona-aktivitas-manufaktur-indonesia-anjlok-ke-453-pada-maret*. Retrieved from Bisnis.com: https://ekonomi.bisnis.com

Bititci, S., Anumba, C., & Thorpe, T. (1997). Integrated Performance Measurement Systems. *International Journal of Operations & Production*, 93-117.

Cross, Lynch, & Richard. (1993). *Performance Measurement System, Handbook of Cost Management.* New York: Warren GOrham Lamont.

David, P., Kaplan, Norton, & Robert , S. (1992). The Balanced Scorecard Measures That Drive Performance.

David, P., Kaplan, Norton, & Robert, S. (1996). *The Balanced Scorecard: Translating Strategy Indo Action.* Harvad Business Review.

David, P., Kaplan, Norton, & Robert, S. (2000). *Balanced Scorecard: Menciptakan Strategi Menjadi Aksi.* Jakarta: Erlangga.

David, P., Kaplan, Norton, & Robert, S. (2001). *The Strategy Focused Organization: How Balanced Scorecard Companies Thrive in the New Business Environment.* Massachusetts: Harvard Business Scholl Press.

Detikcom. (2022, March 16). *Industri-manufaktur-kena-dampak-pandemi-kemenperin-evaluasi-kebijakan*. Retrieved from Detikcom : https://finance.detik.com

Gaspersz, V. (2013). *All-In-One Integrated Total QUality Improvement* . Jakarta: PT Percetakan DKU.

Ministry of Energy and Mineral Resources Directorate General of Electricity. (2021). Electricity Statistics 2020. Jakarta: Ministry of Energy and Mineral Resources.

Ministry of Industry of the Republic of Indonesia. (2022, March 16). Kemenperin-Ajak-Pelaku-Industri-Tingkatkan-TKDN-dan-Sukseskan-Substitusi-Imporitle. Retrieved from https://kemenperin.go.id.

Kim, W. C., & Mauborgne, R. (2009). *Blue Ocen Strategy (Strategi Samudera Biru): Ciptakan Ruang Pasar Tanpa Pesaing dan Biarkan Kompetisi Tak Lagi relevan.* Jakarta: Serambi.

Kim, W., & Mauborgne. (2005). *Blue Ocean Strategy : Menciptakan Ruang Pasar Tanpa Pesaing dan Biarkan Kompetisi Tak Lagi Relevan.* Indonesia: Noura Books.

Kuncoro, M. (2003). *Metode Riset untuk Bisnis dan Ekonomi.* Jakarta: Erlangga.

Mainardes, E. F. (2014). Strategy and Strateguc Management Concepts: Are They Recognised by Management Students? . In *Business Administration and Management* (pp. 43-61).

Mainardes, E., Alves, H., & Raposo, M. (2011). Stakeholder Theory: Issues to Resolve. In *Management Decision* (pp. 226-252).

Makmur, & Thahier, R. (2015). *Inovasi dan Kreativitas Manusia dalam Administrasi dan Manajemen.* Bandung: Refika Aditama.

Malhotra, N. (2004). *Riset Pemasaran, Pendekatan Terapan.* Jakarta: PT Indeks Kelompok Gramedia.

Mulyadi. (2005). *Sistem Manejemen Strategik Berbasis Balanced Scorecard.* Yogyakarta: UPP AMP YKPN.

Nickols, F. (2016). *Strategy, Strategy Management, Strategic Planning, Strategic Thinking.* Retrieved from nickols.us: http://www.nickols.us/strategy_etc.pdf

Nitisemito, A. S. (2014). *Manajemen Personalia.* Jakarta: Ghalia Indonesia.

Osterwalder, A., & Pigneur, Y. (2010). *Business Model Canvas.* New Jersey: John Wiley & Sons, inc.

Parasuraman, A. (1990). *Delivering Quality Service.* New York: The Free Press.

Parmenter, D. (2007). *Key Performance Indikators.* Jakarta: PT Elex Media Komputindo.

Richardson, S. (2014, September 11). *Business Model Canvas and Strategy Map Fusion - Your Best Approach for Business Success*. Retrieved from Likedin: https://www.linkedin.com/pulse/20140911153223-3251275-business-model-canvas-and-strategy-map-fusion-your

Sedarmayanti. (2001). *Sumber Daya Manusia dan Produktivitas Kerja.* Bandung: Mandar Maju.

Suwignjo, P. (2000). Sistem Pengukuran Kinerja : Sejarah Perkembangan dan Agenda Penelitian ke Depan. Jakarta.

Tjiptono, F. (2000). *Manajemen Jasa.* Yogyakarta: Andy, Ghozali, Imam.

Tjiptono, F. (2004). *Manajemen Jasa.* Yogyakarta: Andi Offset.

LEAN IMPLEMENTATION FOR TENDER PROCESS ON PROCUREMENT DEPARTMENT IN A CEMENT COMPANY

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ABSTRACT

Global and highly competitive business environment makes every company to operate toward efficiency manner and continuously improve their operations. Tender process is one of operation on procurement department in a cement manufacturer in Indonesia, company ABC. Procurement department should ensure all purchasing process is running efficiently including tender. However, it is not the case for this company. There are many problems happened, such as lateness, which affects production and other related operations. The purpose of this research is to identify waste that leads to inefficiencies in tender process, identify the root causes of the waste, and formulate improvements to reduce waste. Several tools are utilized, they are Value Stream Mapping (VSM) and Process Activity Mapping (PAM) to assist in identifying waste. This study showed the waste in tender process are Delay/waiting, Excessive transportation or motion, lack of customer's focus, duplication, and lack of standardization. The critical waste is determined by using Borda Count Method (BCM). There are three critical waste they are: delay/waiting, excessive transport, and lack of customer's focus. Analysis of the root causes of critical waste is conducted using 5Whys. Then to determine the priority of the root causes of waste is determined by adopting risk analysis calculations. The improvement recommendation of this study is implementation of e-procurement system to minimize lead time the tender process.

Keywords: lead time, lean administration, procurement, tender, waste

1. INTRODUCTION

One way the manufacturing industry maintains its position in order to continue to be able to compete in the industrial world is to pay attention to the procurement system. According to Apriliana and Astuti (2018), procurement is an activity to obtain goods or services in a transparent, effective and efficient manner according to the needs and desires of users.

PT ABC is one of the manufacturing companies engaged in cement production where in general, the procurement tender process is carried out by bidding, technical evaluation, negotiation, and making engagement documents (Work Orders or SPK/contracts). This research focuses on the service procurement tender process because it is possible that there are indications of waste that occur in this process. In addition, in 2020, the realization of the KPI achieved by the operational procurement department is still below from the target. The purpose of the procurement of goods or services in the company, among others, is to provide goods or services needed in business processes in a timely, efficient and right price. However, PT ABC has not been able to achieve this goal.

This goal has not been achieved because there are indications of waste in the tender process, such as a delay. The lead time in tender process in department of operational procurement should be 50 days or less. In fact, there are some tender processes that take more than 50 days. As a result, the operational procurement KPIs in Q3 and Q4 2020 could not be achieved. In addition, there is waiting time between processes that occur in the procurement process, such as waiting for document approval, waiting for clarification by the user, waiting for a long technical evaluation. This is also exacerbated by Human Resources (HR) in the procurement department who tend to be less competent and lack coordination between teams. Officers who often delay work, resulting in the work being completed in a longer time. Another indication of waste that occurs in operational procurement is the officer takes longer to revise the document.

In addition to the procurement of goods, other losses can be experienced by the company due to delays in procuring maintenance and repair services for production machines. For example, the replacement of refractory stone furnace services. The delay in the provision of this service resulted in delays in factory operations so that they could suffer losses due to the cessation of several days of production.

One method that can help to reduce or eliminate waste is to apply the lean method. The Lean concept can also be applied in service-based fields. Lean in the service sector carries the same principles, namely 'Continuous Improvement' and 'Eliminating non-value-add or waste activities'. This method will analyze the waste that is in the process by assessing the existing process and comparing the existing process with the best goal (Womack & Jones, 2003).

Referring to the background above, the problems in this research can be formulated as follows: How to identify and reduce waste in the service procurement tender process?

2. LITERATURE REVIEW

The concept of lean manufacturing was first introduced by Ohno in 1988 from the Toyota Production System regarding continuous improvement with the aim of eliminating work activities that can reduce productivity levels in the company. According to Ohno in Kusuma (2010), lean manufacturing is all activities until the producer gets cash. The focus of lean manufacturing is to reduce the timeline by eliminating non-value added waste.

Bhasin & Burcher argues that Lean should be suitable for use in administration, because Lean is considered a way of thinking, a philosophy, and not a process. Maleyeff (2006) adds that means that all businesses, including the administration, create services to internal or external customers that affect the overall flow. Hicks (2007) believes that Lean can be implemented to create value in information-related processes. The main performance indicators in Lean administration include (Keyte & Locher, 2008): 1) processing time; 2) lead times; 3) value added time; 4) set-time; 5) speed of request; 6) percent complete and accurate; 7) reliability; 8) stock; 9) using IT systems; and 10) access time.

Waste is all activities that do not have added value in the transformation process from input to output along the value stream. Based on the lean perspective, all types of waste that exist along the value stream process, which transforms inputs into outputs must be eliminated in order to increase the value of the product (goods or services) and further increase customer value (Gaspersz, 2007). Bicheno & Holweg (in Wirasenjana, 2014) mentions that waste in lean administration is categorized into 7 types, including duplication, delay, lost opportunity to retain or win customers, unclear communication, movement, error, and incorrect inventory.

Value Stream Mapping (VSM) is one of the tools of lean services to identify value added and non-value added activities in the manufacturing industry, making it easier to find the root

cause of the process (McWilliams and Tetteh, 2008). Value Stream mapping consists of 2 types, namely the current state map and future state map (Daonil, 2012).

Process Activity Mapping (PAM) is a technical approach that can be used for activities on the production floor. The extension of this tool can be used to identify lead times and productivity for both physical product flows and information flows, not only within the company's scope but also in other areas of the supply chain. The basic concept of this tool is to map each stage of activity that occurs starting from operation, transportation, inspection, delay, and storage, then group into the types of existing activities starting from value adding activities, necessary non value adding activities, and non value adding activities.

The Borda Count Method, discovered by Jean Charles de Borda, is a direct technique for calculating the ranking of several alternative choices (Nash, Zhang, & Strawderman, 2011). Borda determines the winner by awarding a certain number of points to each candidate. Furthermore, the winner will be determined by the number of points collected by the candidate.

5-whys is the simplest method for structured root cause analysis. It is a method of asking questions used to explore the underlying causes of the relationship problem. Investigators keep asking the question "Why?" until a meaningful conclusion is reached and is repeated several times until the root of the problem is found.

Risk analysis is the stage of identifying and evaluating the existing controls at that time, determining the consequences and possibilities and causes of the level of risk (Anityasari and Aranti Wessiani, 2011). Risk can be analyzed by using an assessment of the probability of occurrence and the consequences if it occurs. When the opportunities (likelihoods) and impacts (consequences) have been identified, then an evaluation is carried out and prioritizing the most significant risks to be corrected first.

Benefit and Cost Ratio (BCR) is used to assess project feasibility which describes the magnitude of project risk. This risk or comparison must be greater than one. The greater the difference to one, the smaller the project risk/investment risk.

Tender can mean an auction or buying and selling system carried out by a party by inviting a vendor (seller or provider) to present the required price and quality. The winner of tender is determined by the best price and quality. The auction or tender system is very popular, especially by companies, considering the nominal amount of money and duration of contracts in an auction are varied.

3. METHODS

Waste Identification

At this stage the researchers identified activities that did not provide added value and waste in the procurement process at PT ABC. At this stage the researcher also collects data from the problems that exist in the company by means of field observations, interviews, and documentation. In this stage, Value Stream Mapping (VSM) and Process Activity Mapping (PAM) are also made.

Waste Determination

At this stage, the first thing the researcher did was grouping the waste. The purpose of this waste grouping is to be able to classify waste into the following categories: Overproduction, delay/waiting, unneeded transport or movement, duplication, lack of standardization, lack of customer's focus, underutilized employees, and manager's resistance to change. Furthermore, the researchers distributed questionnaires to respondents (8 people from the operational procurement team who carried out the service procurement tender process), to determine the priority scale of waste obtained from waste categorization. After the questionnaire is filled in, then the waste that

has been identified from the questionnaire results will be weighed using the Borda Count Method (BCM) to determine which waste has the highest weight and determine the ranking of the waste that is used as the dominant waste.

Determination of the Root Cause of Waste

The stage of determining the source of the causes of waste is carried out using the 5 whys method. The data needed are 3 types of critical waste and their activities (3 highest ranking from the borda count method) obtained by brainstorming. After obtaining the source of the causes of waste, then prioritize the root causes of waste with a risk analysis approach. Determining the priority of the root causes of this critical waste is done by calculating the multiplication between the probability value of the root cause of the problem (likelihood) and also the impact of the root cause (consequences). The likelihood and consequences data was carried out using a Focus Group Discussion (FGD) by discussing it with the operational procurement team. The output expected by the researcher is to get the priority of the root causes of which waste must be improved.

Conclusions and recommendations

At this stage, the activity carried out is drawing conclusions based on the results of research to answer the objectives that have been formulated. Furthermore, from the results that have been concluded, suggestions are given as input for the company in order to avoid the existing waste and suggestions for further research.

4. RESULTS

Waste Identification

Process Mapping with Value Stream Mapping (VSM)

Process mapping using Value Stream Mapping for the tender process in the operational procurement department of PT ABC includes 10 stages, namely the bidding stage, technical evaluation, price offer, negotiation 1, negotiation 2, price fairness, negotiation 3, PO and LP3, work supervision, and vendor letters lost. The Value Stream Mapping stage of the PT ABC tender process can be seen in Figure 1 as follows:

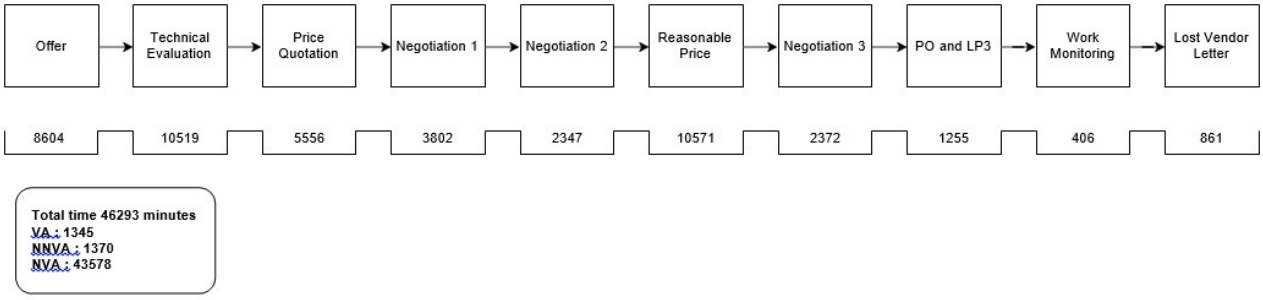


Figure 1. VSM Tender Process

Process Activity Mapping (PAM)

Processing time measurement data using time-measuring tools such as a stopwatch conducted in March 2021. In addition, an interview session was also conducted with procurement officers who carried out the tender process. After the activity data and processing time were obtained, the total time required for the tender process from start to finish was 46,293 minutes or 33 days. Most of the time required in the tender process is at the stage of waiting for the results of the technical evaluation and waiting for the results of the fairness of the price, each of which takes 10,080 minutes or the equivalent of 7 days.

Waste Determination

At this stage, waste is grouped from each non-value-added activity in the tender process in the operational procurement department of PT ABC. The grouping of types of waste in the tender process in the operational procurement department of PT ABC in this study consisted of five types of waste, namely:

1) Delay/waiting, namely the delay of employees or vendors waiting for information or service delivery
2) Unneeded transport or movement, namely the movement of unnecessary and value-added resources (people or goods), physical (from office to office) or virtual (methods, approaches, paths or tools to do the same work).
3) Lack of customer's focus, ie any aspect of service that fails to meet customer expectations or needs, resulting in miscommunication and/or missed opportunities.
4) Duplication, namely activities or processes that do not add value as perceived by the customer. These activities do not address real needs, adding more value to the service than customers are willing to pay.
5) Lack of standardization, namely the lack of standardization in bidding or processes, procedures, formats, including expiration or expiration without a specified standard time.

Determination of critical waste with Borda Count Method (BCM)

The use of the Borda Count Method (BCM) was carried out by distributing questionnaires to eight respondents to the operational procurement team that carried out the tender process, including one senior manager, two managers, and five supervisors. Based on the results of the questionnaire given to the respondents, the results of the critical waste ranking can be seen in Table 2.

Table 2. BCM

No	*Waste*	Rank	1	2	3	4	5	Last Score	Weight after normalization	Rank
		Weight	4	3	2	1	0			
1	Delay/waiting	W1	6	2	0	0	0	30	0,278	1
2	Uneeded transport or movement	W2	4	4	0	0	0	28	0,259	2
3	Lack of customer's focus	W3	0	4	2	2	0	18	0,167	3
4	Duplication	W4	0	3	3	2	0	17	0,157	4
5	Lack of Standarization	W5	0	3	1	4	0	15	0,139	5
Total								108		

Based on discussions with the respondents, the decision was taken that critical waste is waste with the top 3 rankings, namely, as follows:

1. *Delay/waiting*
2. *Uneeded transport or movement*
3. *Lack of customer's focus*

Determination of the root causes of waste with 5 Whys

The results of the focus group discussion in April 2021, which was attended by one senior manager, two managers, and five supervisors using the 5 Why's approach to find the root causes of waste delay/waiting, uneeded transport or movement, and lack of customer's focus is shown in Table 3.

Table 3. 5 Whys

No.	Waste	Activity	Why 1	Why 2	Why 3	Why 4	Why 5
1	Delay/ waiting	Waiting for documents to be signed	A lot of documents that need signatures pile up on the signing table	Signatories don't have time to sign documents			
2		Waiting for the results of technical evaluations from users	Officers who never remind users to immediately send technical evaluation results	Lack of responsiveness of officers in monitoring the extent of the tender process	Officers rarely update job monitoring	Monitoring is still manual	
3		Waiting for the results of the fairness of prices from the users	Officers who never remind users to immediately send the results of fairness of prices	officers are less responsive in monitoring the extent of the tender process	Officers rarely update job monitoring	Monitoring is still manual	
4		Queue scan/print documents	Limited printer				
5	Uneeded transport or movement	Scan/print documents Document	Delivery was still using email	The tender process is still manual The tender	Tender process system was not supported		
6		Copying documents for technical explanation purposes	Procurement officers distribute documents during technical explanation	Documents are still manual			
7		Resend offer invitations to vendors	Vendors have not received bid invitations when confirming bid acceptance to vendors	The email address listed in the system does not match the recipient (vendor contact person)	The vendor has never updated data on the system,	Lack of information regarding vendor data updates	
8		Requests for lack of technical offer documents to vendors	Technical offers sent by vendors are incomplete	Vendors do not understand the terms of the tender process	New vendors		
9	Lack of customer's focus	Revision of PO	There is a discrepancy between PO and procurement documents	Officers are not careful in making PO	HR who lack motivation		

Determining the Priority of the Root Causes of Waste by Adopting Risk Analysis Calculations

Table 4. Consequences (Impacts) Due to the Occurrence of the Root Causes of Waste

Score	Parameter	Waste		
		Uneeded transport or movement	**Lack of customer's focus**	**Delay/ Waiting**
1	*Not Significant*	Performed 1x	Financial loss very low	Processed at the same day
2	*Minor*	Performed 2x	Financial loss low	Delay for 1 day
3	*Moderate*	Performed 3x	Financial loss medium	Delay for 2 days

4	*Mayor*	Performed 4x	Financial loss high	Delay for 3 days
5	*Catastrophic*	Performed more than 4x	Financial loss very high	Delay more than 4 days

Table 5. Likelihood (Opportunity) Due to the Occurrence of the Root Causes of Waste

Score	Likelihood	Description
1	Rare	Possibility are less than 5%
2	Unlikely	Possibility between 6% - 25%
3	Moderate	Possibility between 26% - 50%
4	Likely	Possibility between 51% - 75%
5	Almost Certain	Possibility are more than 75%

From the results of the focus group discussion on waste risk, the likelihood and consequence values are summarized in Table 6.

Table 6. Calculation of the Amount / Score of the Root Cause of Waste

No.	Waste	Root Cause of the Waste	Code	Likelihood (L)	Consequence (C)	RRating (L x C)
1	Delay/ waiting	Signatories do not have time to sign documents	R1	4	4	16
2	Delay/ waiting	Monitoring is still manual	R2 & R3	5	5	25
3	Delay/ waiting	Limited printer	R4	3	1	3
4	Uneeded transport or movement	Tender process system was not supported	R5	4	5	20
5	Uneeded transport or movement	Documents are still manual	R6	4	3	12
6	Uneeded transport or movement	Lack of information regarding vendor data updates	R7	3	2	6
7	Uneeded transport or movement	New vendors	R8	2	2	4
8	Lack of customer's focus	Lack of motivation of human	R9	2	2	4

The root causes of waste along with the likelihood and consequence values are then mapped into the Assessment Matrix to map according to the values obtained during the FGD.

Table 7. Assessment Matrix

Likelihood	Almost Certain	5					R2, R3
	Likely	4			R6	R1	R5
	Moderate	3	R4	R7			
	Unlikely	2		R8, R9			
	Rare	1					
			1	2	3	4	5
			Insignificant	Minor	Moderate	Mayor	Catastrophic
			Consequence				

Keterangan:

Low
Moderate
High
Extreme

From Table 7 the priority root causes of waste above, there are 4 root causes of critical waste with the highest values, namely:

R1 : The signer does not have time to sign the document
R2 and R3 : Monitoring is still manual
R5 : No supporting tender process system

Improvement Plan Formulation

Based on the FGD that was held in May 2021, the improvement plans obtained from several previous journals to minimize critical waste were as follows:

Table 8. Improvement Formulation

Waste Code	Waste Causes	Plan Formulation
R1	The signatories do not have time to sign the document	Sign the document using an e-sign (Rahardja, Yusup, and Asmawati, 2013)
R2 & R3	Work monitoring is still manual	1. Tender process and monitoring using the eprocurement system (Banea, Saerang, and Warongan, 2020) 2. Adding an automatic email reminder to related users (Hermawati 2018)
R5	There is no tender process system that supports	1. The tender process uses the eprocurement system (Banea, Saerang, and Warongan, 2020 2. HR training (Yana, Astana, and Yuneta, 2022)

Future Value Stream Mapping (FVSM)

Tender process activities which previously took 46,293 minutes or the equivalent of 33 days, can be reduced to 34,549 minutes or the equivalent of 24 days. FVSM drawing can be done as follows:

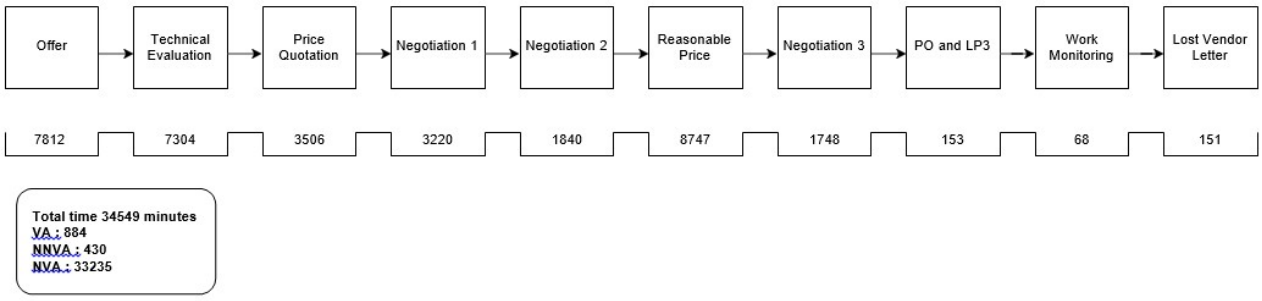


Figure 2. FVSM

6. CONCLUSIONS

Based on the results of calculations and analysis carried out in this study which discusses the minimization of 5 waste in the tender process at PT ABC by using value stream mapping and process activity mapping, therefore it can be concluded that the waste in the tender process includes delay/waiting, Unneeded transport or movement, Lack of customer's focus, duplication, and lack of standardization. The identified critical waste obtained 3 (three) highest rankings, namely delay/waiting, uneeded transport or movement, and lack of customer's focus. The root causes of critical waste for delay/waiting waste are signatories who do not have time to sign documents, monitoring is still manual, and printer limitations. Waste uneeded transport or movement, namely the absence of a supporting tender process system, documents are still manual, lack of information related to updating vendor data, and new vendors. Waste lack of customer's focus, namely human resources who lack motivation. The improvement recommendations to minimize lead time in tender process is using the eprocurement system.

For further lean administration research, it would be better to observe the non-procurement tenders that affect the tender process such as the administration/IT/PR because there are

indications that waste has appeared during the initial process in administration/IT/PR when publishing tenders to vendors. For an assessment of the alternative improvements that have been selected, it would be better if they were implemented in the company by considering the company's own internal conditions, both in terms of the budget and from the company's strategy, so that the improvements to be made are in line with the company's overall policies.

REFERENCES

Anityasari, M., Wessiani, A. (2011). *Analisa Kelayakan Usaha*, Guna Widya, Surabaya.

Apriliana, F.S., Astuti, R.D. (2018), Penerapan Value Stream Mapping (VSM) sebagai Upaya untuk Mengurangi Keterlambatan Proses Procurement di PT X. *Performa: Media Ilmiah Teknik Industri,* 17 (1), 61-70.

Daonil. (2012). Implementasi Lean Manufacturing untuk Eliminasi Waste pada Lini Produksi Machining Cast Wheel dengan Menggunakan Metode WAM dan VALSAT*, Tesis*, Magister, Universitas Indonesia (UI), Depok.

Gaspersz, V. (2007). *Lean Six Sigma for Manufacturing and Services Industries*, PT Gramedia Pustaka Utama, Jakarta.

Hicks, B. J. (2007). Lean Information Management: Understanding and Eliminating Waste. *International Journal of Information Management*, 27(4), 234-239.

Kusuma, S.A. (2010), Penerapan Lean Manufacturing dalam Mengidentifikasi dan Meminimasi Waste di PT. Hilton Surabaya*, Undergraduate Thesis*, UPN, Surabaya.

Maleyef, J. (2006). Exploration of Internal Service Systems Using Lean Principles, *Management Decision*, 44(5), 674-689.

McWilliams, D.L., Tetteh, E.G. (2008). Value-Stream Mapping to Improve Productivity in Transmission Case Machining, *Proceedings of the 2008 Industrial Engineering Research Conference.*

Nash, K., Zhang, H., Strawderman, L. (2011). Empirical Assessment of Decision Making Behavior in Multi-Criteria Scenarios. *Industrial Engineering Research Conference*, Mississippi.

Womack, J., Jones, D. (2003). *Lean Thinking*, Free Press Publishing Company, New York.

RISK ASSESSMENT OF SAFETY, OCCUPATIONAL HEALTH, AND ENVIRONMENT ON SHELL PLATE INSTALLATION WORK IN SULPHURIC ACID STORAGE TANK PROJECT

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ABSTRACT

The sulphuric acid storage tank is an important facility in the smelter industry, which store Sulphuric Acid as a by-product of a smelter, which is a raw material for other petrochemical industries. The potential hazards and risks in the Sulphuric Acid storage tank project are quite high, so it is necessary to control the hazards and risks to minimize their impact on safety, health, and the environment. The research data was obtained by questionnaires, interviews, and focus group discussion (FGD). This research aims to create integrated risk management in the Sulphuric Acid storage tank project by identifying hazards and risks and analyzing risks to obtain risk levels on shell plate installation. The risk assessment was carried out using the HIRARC (Hazard Identification, Risk Assessment & Risk Control). The risk assessment obtained that falling from height was categorized as the highest risk in this project.

Keywords: Hazard Identification, Risk Assessment, Sulphuric Acid Storage Tank, HIRARC and Falls from height.

1. INTRODUCTION

According to Guo et al. (2020), Storage tanks are essential facilities in the petrochemical industry, which store large volumes of flammable, explosive, toxic, and harmful materials. With the rapid development of the global economy and the strategic demand and production demand of energy reserves in the petrochemical industry, the volume and quantity of storage tanks are increasing. The potential hazard of the storage tank is relatively high such as fire, explosion, and toxic diffusion of the chemicals inside the tank. Once a fire, explosion, or poisonous diffusion occurs in the storage tank, it will not only affect the normal operation of the enterprise but also cause casualties, property losses, environmental pollution, and other serious consequences.

According to Chang & Lin (2006), 242 storage tank accidents occurred in industrial facilities over the last 40 years, including 114 cases in North America, 72 cases in Asia, 38 cases in Europe, 9 cases in South America, and 9 cases in Africa. Accidents occur more frequently at petroleum refineries with 116 cases (47.9%). The second most frequently involved place was terminals and pumping stations with 64 cases (26.4%) and only 62 cases (25.7%) of accidents that occurred in petrochemical plants.

Based on U.S. Chemical Safety and Hazard Investigation Board (2010), the CSB has identified over 60 fatalities since 1990 due to explosions and fires from hot work activities on

tanks that occurred in the United States. Hot work is defined as "work involving burning, welding, or a similar operation that is capable of initiating fires or explosions" (NFPA Standard 51B, 2009). Hot work also includes other activities with the potential to create a source of ignition such as cutting, brazing, grinding, and soldering.

The awareness of Occupational Safety and Health from the entire construction community still needs to be increased. Programmatic or systematic approaches to occupational safety and health (OSH) have long been acknowledged as essential to the prevention and control of occupational injury and illness. In the past two decades, OSH programs or management systems have emerged internationally as a major strategy for addressing workplace safety and health (LaMontagne et al., 2004).

Shell plate installation in the Sulfuric Acid Storage Tank project was one of the works with high potential risk. The risks included falling from a height, fire, explosion, electric shock, falling objects, pinched, bumping, and other threats.

Hazard identification, risk assessment, and risk control in this research were carried out using the HIRARC (Hazard Identification, Risk Assessment, and Risk Control). A common method widely used by the company in any field of industries and considered more precise and thorough where the hazards arise explained from each work activity.

2. LITERATURE REVIEW

2.1 Risk Management

Project Risk Management includes the processes of conducting risk management planning, identification, analysis, response planning, response implementation, and monitoring risk on a project. The objectives of project risk management are to increase the probability and/or impact of positive risks and to decrease the probability and/or impact of negative risks, in order to optimize the chances of project success (Project Management Institute, 2017). According to Cooper et al. (2019), risk management refers to the culture, processes and structures that are directed towards the effective management of potential opportunities and adverse effects. Risk management means minimising, controlling and sharing of risks rather than merely passing them on to another party. There are different types of risk management techniques, such as risk avoidance (prevention), risk retention, risk reduction (mitigation) and retention and risk transfer (Iqbal et al., 2015).

The likelihood of an event.

This value is based on the likelihood of an event occurring. The qualitative measurement of likelihood is based on worker experience, analysis, or measurement as shown in table 1.

Tabel 1. Qualitative Measures of Likelihood

Level	Descriptor	Description
5	*Almost Certain*	Is expected to occur in most circumstances
4	*Likely*	Will probably occur in most circumstances
3	*Possible*	Might occur at some time
2	*Unlikely*	Could occur at some time
1	*Rare*	May occur only in exceptional circumstances

Source: (AS ISO 31000, 2018)

The degree of consequence of the risk.

The level of consequence divided into five categories. Qualitative measurement of consequence is based on the increasing severity of the consequence on an individual's health, environment, or property as shown in table 2.

Tabel 2. Qualitative Measures of Consequence or Impact

Level	Descriptor	Description
1	*Insignificant*	No injuries, low financial loss
2	*Minor*	First aid treatment
3	*Moderate*	Medical treatment required
4	*Major*	Extensive injuries
5	*Catastrophic*	Death, toxic release off-site with detrimental effect

Source: (AS ISO 31000, 2018)

Risk Assessment

Risk can be presented in variety of ways to communicate the results of analysis to make decision on risk control. For risk analysis that uses likelihood and severity in qualitative method, presenting result in a risk matrix is a very effective way of communicating the distribution of the risk throughout a plant and area in a workplace as shown in table 3 (DOSH Malaysia, 2008).
Risk can be calculated using a formula as shown in equation 1 below:
L x S = Relative Risk…….....…….(equation 1)
L = Likelihood
S = Severity

Tabel 3. Risk Matrix

	SEVERITY (S)				
LIKELIHOOD (L)	**1**	**2**	**3**	**4**	**5**
5	5	10	15	20	25
4	4	8	12	16	20
3	3	6	9	12	15
2	2	4	6	8	10
1	1	2	3	4	5

Source: (DOSH Malaysia, 2008)

The relative risk value can be used to prioritize necessary actions to effectively manage work place hazards.

2.2 Occupational Health, Safety, and Enviroment Management

The Safety Management System was first introduced to the construction industry by the European Union in the 1980s, with the aim of reducing hazard and injury on construction sites (Vassie et al., 2000).

According to Sholihah & Kuncoro (2013), the occupational safety is process of planning and controlling situations that have the potential to cause the accidents through standard operating procedures. The safety program is a policy issued by the company to protect employees from the accidents.

Occupational health hazards are conditions or factors that arise from the workplace that have the possibility to affect the health of workers (Hassim & Hurme, 2010). Occupational health differs from occupational safety in terms of the duration of the impact, where occupational health involves long-term exposure (routine activities) to hazardous conditions while occupational safety relates to short-term exposure (accidents or routine activities) with acute effects on humans. (Hassim, 2010).

According to Sedarmayanti (2001), the work environment is the overall tools and materials encountered, the surrounding environment in which a person works, his work methods, and work arrangements both as individuals and as a group.

2.3 HIRARC (Hazard Identification, Risk Assessment and Risk Control)

According to Soehatman (2010), HIRARC is a process to identify hazards that can occur in routine or non-routine activities in the company then carry out a risk assessment of these hazards and then create a hazard control program so that the risk level can be minimized to a lower level with the aim to prevent the accidents.

Process of HIRARC requires 4 simple steps (DOSH Malaysia, 2008):

a. Classify work activities.
b. Identify hazard.
c. Conduct risk assessment (analyze and estimate risk from each hazard), by calculating or estimating:
   - Likelihood of occurrence, and.
   - Severity of hazard.
d. Decide if risk is tolerable and apply control measures (if necessary).

3. METHODS

This research is a case research to identify potential hazards and conduct a risk assessment of occupational health, safety, and environment using the HIRARC (Hazard Identification, Risk Assessment & Risk Control). The variables of this research are the potential hazards and risks that may occur during the construction of the Sulfuric Acid Storage Tank that can hinder the achievement of project objectives. Data collection was obtained from previous research, and job safety analysis then validated through interviews with the respondents. Respondents involved in this research are Project Manager, Engineering Manager, Mechanical Engineer, Civil Engineer, QC Engineer, HSE Coordinator, and HSE Officer. An assessment of likelihood and risk consequence was carried out through a questionnaire. The risk assessment carried out using the HIRARC to obtain the risk level of each variable by multiplying the likelihood and consequence levels. Risk response determined through focus group discussions (FGD), while the residual risk determined by expert judgment.

4. RESULTS

4.1 Risk Assessment using The HIRARC

In this research, the variables of hazard and risk are obtained from previous research and job safety analysis. Likelihood and consequence values for each variable were obtained from the average value given by the respondents. The risk assessment was carried out using the HIRARC to derive the risk level of each variable by multiplying the likelihood and consequence levels. Risk response is determined through focus group discussions (FGD), while the residual risk is determined by expert judgment. The result of risk assessment on shell plate installation can be seen in table 4.

Tabel 4. Risk Assessment on Shell Plate Installation

No	Work Process	Hazard	Risk ID	Risk	Consequence	Risk Assessment				Risk Response		Residual Risk			
						Likelihood	Consequence	Risk Value	Risk Level			Likelihood	Consequence	Risk Value	Risk Level
P.5	***Shell Plate Installation***	Lifting plate	R5.1	Hit by plate	Fracture, fatality	3	4	12	Medium	> Check the crane before used > Ensure the crane and rigger operators are competent and certified. > Install safety signs and barricades in the lifting area. > Use a double tag line to point the plate. > Use personal protective equipment.	Reduce	2	1	2	Low
			R5.2	Bumped by plate	Bruises, fatality	4	4	16	High	> Focus on working and stay away from lifting area > Install safety signs and barricades in the lifting area. > Use a double tag line to point the plate. > Use personal protective equipment.	Reduce	2	1	2	Low
			R5.3	Pinched by plate	Bruises	5	3	15	High	> Focus on working and stay away from lifting area > Install safety signs and barricades in the lifting area. > Use a double tag line to point the plate. > Use personal protective equipment.	Reduce	2	1	2	Low
		Covid-19 Virus	R5.4	Infected by Covid-19 virus	Infected, fatality	4	4	16	High	> Always wear a mask. > Checking body temperature before entering the work area. > Avoid crowds and maintain a minimum distance of 2 meters. > Always wash hands with soap or handsanitizer. > Vaccinate.	Reduce	3	2	6	Medium
		Working at height	R5.5	Fall	Fracture, fatality	5	5	25	High	> Apply a permit for working at height before work. > Install scaffolding and temporary platform. > Use a safety belt/body harness and hook it when performing working at height. > Use personal protective equipment.	Reduce	3	2	6	Medium

No	Work Process	Hazard	Risk ID	Risk	Consequence	Risk Assessment				Risk Response		Residual Risk			
						Likelihood	Consequence	Risk Value	Risk Level			Likelihood	Consequence	Risk Value	Risk Level
P.5	***Shell Plate Installation***	Working at height	R5.6	Slip	Abrasions	3	3	9	Medium	> Pay attention to the steps when walking and make sure the footing is in a safe condition. > Use a safety belt/body harness and hook it when performing working at height. > Use personal protective equipment.	Reduce	2	1	2	Low
			R5.7	Stumbling	Sprains, Abrasions	3	3	9	Medium	> Pay attention to the steps when walking and make sure the footing is in a safe condition. > Getting rid of equipment and materials on access road. > Use a safety belt/body harness and hook it when performing working at height. > Use personal protective equipment.	Reduce	2	1	2	Low
		Gas SO2	R5.8	Exposure to SO2 gas	Respiratory tract infection, eye irritation, poisoning	3	4	12	Medium	> Use a respirator and safety glass when working.	Reduce	2	1	2	Low
		Cutting plate with gas cutting	R5.9	Sparks	Burns, fires	5	4	20	High	> Apply a hot work permit before performing hot work. > Getting rid of flammable materials around the plate cutting area. > Use the apron when working. > Providing fire blankets and fire extinguishers at work location. > Use personal protective equipment.	Reduce	2	2	4	Low
			R5.10	Exposure to gas cutting fumes	Respiratory tract infection	3	2	6	Medium	> Use a respirator when performing gas cutting	Reduce	2	1	2	Low
			R5.11	Exposure to gas cutting rays	Eye irritation, visual impairment	3	2	6	Medium	> Use a welding shield when performing gas cutting	Reduce	2	1	2	Low

No	Work Process	Hazard	Risk ID	Risk	Consequence	Risk Assessment				Risk Response		Residual Risk			
						Likelihood	Consequence	Risk Value	Risk Level			Likelihood	Consequence	Risk Value	Risk Level
P.5	***Shell Plate Installation***	Welding of shell plate	R5.12	Got electric shock	Electric shock, burns, fatality	3	4	12	Medium	> Perform an inspection of electrical equipment and cables before used. > Perform grounding installation. > Use personal protective equipment.	Reduce	2	1	2	Low
			R5.13	Sparks	Burns, fires	5	4	20	High	> Apply a hot work permit before performing hot work. > Getting rid of flammable materials around the plate cutting area. > Use the apron when working. > Providing fire blankets and fire extinguishers at work location. > Use personal protective equipment.	Reduce	2	2	4	Low
			R5.14	Exposure to welding fumes	Respiratory tract infection	5	3	15	High	> Use a respirator when performing welding work.	Reduce	2	1	2	Low
			R5.15	Exposure to welding rays	Eye irritation, visual impairment	5	3	15	High	> Use a welding shield when performing welding work.	Reduce	2	1	2	Low
		Gas cylinder leaks	R5.16	Explosion	Fires, burns, fatality	3	4	12	Medium	> Check and perform leakage test of gas cylinders and hoses regularly every one week. > Keep flammable materials away from gas cylinders. > Providing fire blankets and fire extinguishers at work location. > Use personal protective equipment.	Reduce	2	2	4	Low
		Grinding	R5.17	Scratched by grinding stone	Cut wounds	3	3	9	Medium	> Make sure the position of the limbs is in a safe position during the grinding process. > Use a suitable grinding stone. > Make sure the grinding machine cover is installed properly and correctly. > Use personal protective equipment.	Reduce	2	1	2	Low
			R5.18	Got electric shock	Electric shock, burns, fatality	3	4	12	Medium	> Perform an inspection of electrical equipment and cables before used. > Perform grounding installation. > Use personal protective equipment.	Reduce	2	1	2	Low

No	Work Process	Hazard	Risk ID	Risk	Consequence	Risk Assessment				Risk Response		Residual Risk			
						Likelihood	Consequence	Risk Value	Risk Level			Likelihood	Consequence	Risk Value	Risk Level
P.5	***Shell Plate Installation***	Grinding	R5.19	Sparks	Burns, fires	5	4	20	High	> Make sure the grinding position is in the same direction as the splashing of fire. > Getting rid of flammable materials around the grinding area > Providing fire blankets and fire extinguishers at work location. > Use personal protective equipment.	Reduce	2	1	2	Low
			R5.20	Hit by a splash of grinding stones	Eye irritation, skin irritation	3	3	9	Medium	> Use a face shield when working. > Wear long sleeves when working. > Use personal protective equipment.	Reduce	2	1	2	Low
			R5.21	Exposure to noise	Hearing disorders	2	2	4	Rendah	> Use ear plugs when working.	Reduce	2	1	2	Low
		Sunlight	R5.22	Exposure to sunlight	Weak, faint, heat stroke	4	3	12	Medium	> Making a tent in the work area as a sun protection. > Take a rest and drink enough water.	Reduce	2	1	2	Low
			R5.23	Dehydration	Weak, faint	3	3	9	Medium	> Take a rest and drink plenty of water.	Reduce	2	1	2	Low
		Scrap material	R5.24	Metal waste	Skin irritation, polluted environment	4	2	8	Medium	> Collecting and sorting of waste according to waste handling procedure.	Accept	2	1	2	Low
		Inadequate lighting (works at night)	R5.25	Limited eyesight	Tired eyes, headache	3	3	9	Medium	> Add lighting lamps. > Use personal protective equipment.	Reduce	2	1	2	Low

The risk assessment on shell plate installation obtained 25 risks (9 high risks, 15 medium risks, and 1 low risk) as shown in the risk matrix in table 5. The highest risk on shell plate installation is falling from a height (R5.5).

Tabel 5. Risk Matrix on Shell Plate Installation

RISK MATRIX						
LIKELIHOOD	5			R5.3, R5.14, R5.15	R5.9, R5.13, R5.19	R5.5
	4		R5.24	R5.22	R5.2, R5.4	
	3		R5.10, R5.11	R5.6, R5.7, R5.17, R5.20, R5.23, R5.25	R5.1, R5.8, R5.12, R5.16, R5.18	
	2		R5.21			
	1					
		1	2	3	4	5
		CONSEQUENCE				

Based on the analysis, there was a risk in the high category, namely being bumped and pinched by the plate, infected by the Covid-19 virus, falling from a height, sparked by fire, and being exposed to welding fumes and welding light. The highest risk was fell from a height. Risk response planning is carried out on all risks to reduce exposure to the overall project risk. After the risk response was carried out, the residual risk was reduced to an acceptable level.

Considering the risk of falling from a height on shell plate installation, it is necessary to make procedures for working at heights that include the planning and execution stages. At the planning stage, it contains the identification of conditions which include determining what equipment will be installed, considering the safety system working at heights, and determine access plans for the evacuation process in the event of an accident. In addition, it must also consider the number of workers who will work at heights and conduct an evaluation of preventive actions. At the implementation stage, it contains procedures for work permits for working at heights.

6. CONCLUSIONS

In this research, we identified, conducted risk assessments, and provided recommendations for risk control related to safety, occupational health, and the environment on shell plate installation in the sulfuric acid storage tank project based on HIRARC (Hazard identification, risk assessment, and risk control). The level of risk obtained in this research was evaluated and divided into low, medium, and high. Based on risk assessment, falling from height was the highest risk in this project. The risk response has been recommended at all risk levels. Corrective action against the risk of falling from height was also recommended as risk control. The residual risk is reduced by risk response to an acceptable risk level.

REFERENCES

AS ISO 31000. (2018). *Australian Standard Risk Management - Guidelines*.

Chang, J. I., & Lin, C. C. (2006). A study of storage tank accidents. *Journal of Loss Prevention in the Process Industries*, *19*(1), 51–59. https://doi.org/10.1016/j.jlp.2005.05.015

DOSH Malaysia. (2008). *Guidlines for Hazard identification, Risk Assessment and Risk Control (HIRARC)*.

Guo, X., Ji, J., Khan, F., & Ding, L. (2020). Fuzzy bayesian network based on an improved similarity aggregation method for risk assessment of storage tank accident. *Process Safety and Environmental Protection*, *144*. https://doi.org/10.1016/j.psep.2020.07.030

Hassim, M. H., & Hurme, M. (2010). Inherent occupational health assessment during process research and development stage. *Journal of Loss Prevention in the Process Industries*, *23*(1). https://doi.org/10.1016/j.jlp.2009.06.009

Hassim, Mimi Haryani. (2010). *Inherent occupational health assessment in chemical process development and design*.

Iqbal, S., Choudhry, R. M., Holschemacher, K., Ali, A., & Tamošaitienė, J. (2015). Risk management in construction projects. *Technological and Economic Development of Economy*, *21*(1), 65–78. https://doi.org/10.3846/20294913.2014.994582

LaMontagne, A. D., Barbeau, E., Youngstrom, R. A., Lewiton, M., Stoddard, A. M., McLellan, D., Wallace, L. M., & Sorensen, G. (2004). Assessing and intervening on OSH programmes: Effectiveness evaluation of the Wellworks-2 intervention in 15 manufacturing worksites. *Occupational and Environmental Medicine*, *61*(8), 651–660. https://doi.org/10.1136/oem.2003.011718

NFPA Standard 51B. (2009). *Standard for Fire Prevention During Welding, Cutting, and Other Hot Work*.

Project Management Institute. (2017). PMBOK® Guide Sixth Edition (PMI, 2017). In *Project Management Institute* (Vol. 6).

Sedarmayanti. (2001). *Sumber Daya Manusia dan Produktivitas Kerja*. Mandar Maju.

Soehatman, R. (2010). *Sistem Manajemen Keselamatan dan Kesehatan Kerja OHSAS 18001 Seri Manajemen K3 001*. Dian Rakyat.

U.S. Chemical Safety and Hazard Investigation Board. (2010). Seven Key Lessons to Prevent Worker Deaths During Hot Work In and Around Tanks. *2009-01-SB*.

Vassie, L., Tomàs, J. M., & Oliver, A. (2000). Health and Safety Management in UK and Spanish SMEs: A Comparative Study. *Journal of Safety Research*, *31*(1).

INCREASING EFFICIENCY IN BREWING PROCESS BY APPLYING LEAN MANUFACTURING IN PT XYZ

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ABSTRACT

In order to conduct business in the "new normal" era due to the Covid-19 pandemic, companies face various challenges, one of them is strategies to reduce or eliminate potential waste from production, improve efficiency, and reduce production costs. The same happens with PT XYZ which is a beer production company located in East Java. According to preliminary observations, there are waste in the production line of the brewing process. This caused the company to suffer losses in the production line of brewing process approximately Rp.867.257.500,- in 2021. This research will help to solve these problems through lean manufacturing methods. First, various waste are identified through value stream mapping, process activity mapping (PAM), borda count method. Then use the root cause analysis (RCA) to find the cause of the waste that is taking place. Then make the recommendations to the company to avoid waste and optimize system performance in the brewing process. According to the research result, it was found that three critical wastes, namely overprocessing, inventory and movement. In order to reduce this critical wastes, recommendations are made which have several potential advantages such as potential water savings approximately 1,157 HL/year, extract losses savings around 3,066 kg extract/year, elimination of 4.7% of excess mature beer inventory from current planned inventory, and 14.5% reduction in necessary non-value added (NNVA) activities in the brewing process of PT XYZ.

Keywords: Lean manufacturing, value stream mapping, process activity mapping (PAM), borda count method (BCM), root cause analysis (RCA).

1. INTRODUCTION

In order to conduct business in the "new normal" era due to the Covid-19 pandemic, companies face various challenges, one of them is strategies to reduce or eliminate potential waste from production, improve efficiency, and reduce production costs. The same happens with PT XYZ. PT XYZ is one of the largest beer producers in Indonesia. PT XYZ already owns two factories, a brewery in West Java region (Plant A) and a brewery in East Java region (Plant B). PT XYZ, in particular Plant B, produces BTG beer in pint bottles (330ml), bremmer bottles (620ml) and kegs (40 litres). PT XYZ's production line includes a production line for brewing process, and a production line for packaging process. The production process of the brewery production line follows the principle of make-to-stock. Therefore, production plan (forecast) and the quantities produced during the brewing process must be align and accurate. This is to avoid overproduction in the brewing production process, thereby affecting the efficiency of the brewing process.

Table 1. Extract losses and total losses in PT XYZ area Plant B

Period	Extract Losses (kg extract)	Standard (kg extract)	Losses (kg extract)	Total Losses (In Rupiahs)
Semester 1	118.254	89.270	28.984	456.498.000
Semester 2	121.392	95.566	25.826	406.759.500
Total	239.646	184.836	54.810	863.257.500

Based on preliminary observations obtained in the brewing process line, several problems were identified, namely losses due to extract losses that occurs during the brewing process. Based on company's data in 2021 shows that extract losses was exceeded of specified standards that shown in Table 1. The greater the loss caused by extract losses, the higher the production cost of the brewing process line. In addition to losses from extract losses, there are other indications of waste that needs to be eliminated in the production line of brewing process at PT XYZ area Plant B. Therefore, in order to achieve a more effective and efficient production system, from this research is expected to eliminate part of the waste generated by the production line of brewing process and optimize the system and production process performance through the lean manufacturing method in PT XYZ area Plant B. The methodology used was lean Manufacturing and used one of the value stream analysis tools (VALSAT), process activity mapping (PAM) and root cause analysis (RCA), to reduce and eliminate waste in the process of beer production in PT XYZ area Plant B.

2. LITERATURE REVIEW

Lean is the continuous activity to eliminate waste and increase the value of a product or service in order to provide value to customers (Gaspersz, 2007). Lean is a concept that Japan adopted from the Toyota Production System to simplify production processes. Lean methods aim to eliminate waste in production systems. This waste elimination is carried out so that the production system can operate effectively and efficiently. The concept of lean manufacturing was first proposed by Akio Toyoda, Taiichi Ohno and Shigero Shingo (Juran & Godfrey, 1999). Lean can also be interpreted as a philosophy for optimizing manufacturing performance (Askin & Goldberg, 2001). Waste can be defined as any work activity that does not add value in the process of converting inputs into outputs in the value stream. According to Taiichi Ohno (Lonnie Wilson, 2010), there are seven types of waste, namely transportation, inventory, movement, waiting, overproduction, overprocessing, defects.

According to (Womack & Jones, 2003), a value stream is all the activities (which have added value or no added value) required to produce a product through the main production process. This value stream describes the product design, product flow, and information flows that support other activities. By using this VSM, we can easily spot waste in system processes. There are two types of VSMs, current state diagrams and future state diagrams. In addition, the conditions of the production system, such as the required lead time, can be described from the characteristics of each running process. Benefits VSM is a key lean tool that helps to view current business processes as a whole. So that it can visualize the expected business processes more efficiently and without waste. According to (Nash & Poling, 2008), the value stream map consists of three main components, namely material flow, information flow and time line.

Process activity mapping (PAM) is a tool for describing a production process that is carried out in stages. The purpose of using process activity mapping (PAM) is to identify and classify non-value added activities that can be reduced. Basically, process activity mapping (PAM) is used to capture all process activities and reduce unnecessary activities (non-value added) to reduce waste. The tool also makes it easy to view the process flow and identify waste in the value stream and see if the efficiency of the production process can be improved by eliminating unnecessary activities (non-value added). In PAM, activities are divided into categories, namely operation, transportation, inspection and storage. In addition to activities, process activity mapping (PAM) records the machines and areas used in operations, as well as the distance covered, the time required, and the number of operators. When using process activity mapping (PAM), the researcher must understand and examine the process flow, always think about identifying waste, and thinking simple, efficient, and smooth process flow, which can be achieved by changing the order of the processes or rearranging them (Hines & Rich, 2005).

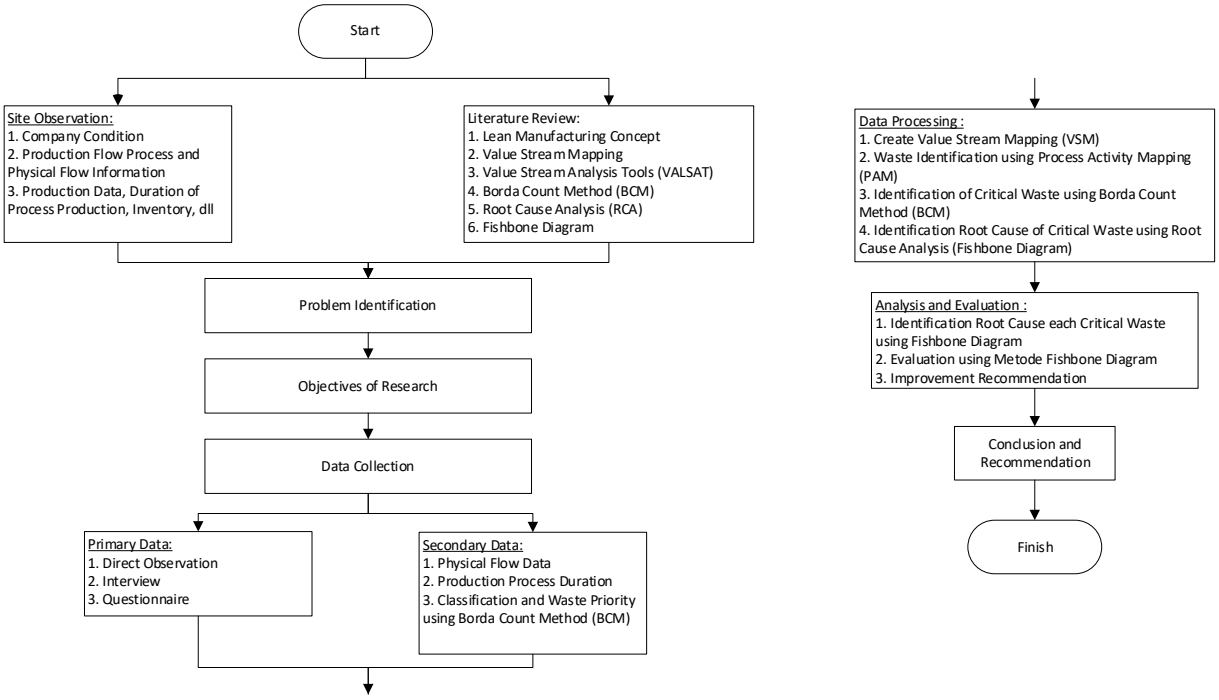
The borda count method (BCM) (Gavish, B., Gerdes, J.H., 1997), developed by its inventor Jean Charles de Borda in the 18th century, is one of the methods used to determine the best alternative from a variety of alternatives. Each decision alternative is ranked according to its weight. The largest weight is the best choice for the decision maker. This method can be used to determine which waste priority should be addressed first by sending a questionnaire to the relevant respondent or department.

A fishbone diagram is one of the tools used to find the root cause of a problem. The purpose of using fishbone diagrams in its application is to group possible causes of problems in a process and generate hypotheses by capturing all the causes and effects caused by the identified problems. The root cause of a problem in this fishbone diagram usually consists of multiple sets of causes. There are several factors that can be used to identify these causes, namely people, machines, methods and materials. (Spencer, 2015). The man variable identifies the cause of the event in terms of the worker or operator that is directly related to the event. The machine variable identifies the cause of the equipment and machines used. The material variable is seen from the supplier side, and the raw materials used in the production process. The method variable identifies the cause of the method used in the process.

3. METHODS

This research used lean manufacturing and used one of the value stream analysis tools (VALSAT) namely process activity mapping (PAM) and fishbone diagram, to find the root cause then reduce and eliminate waste in beer production process. The first step research conducted site observations, literature review, and collecting research data, including primary data (observations, interviews, questionnaires) and secondary data (physical flow data, production process duration). The second step research conducted data processing analysis and evaluation. Figure 1 shows the simulation step carried out from this research.

Figure 1. Value stream mapping (VSM) of brewing process in PT XYZ Plant B



4. RESULTS

4.1 Value Stream Mapping in PT XYZ

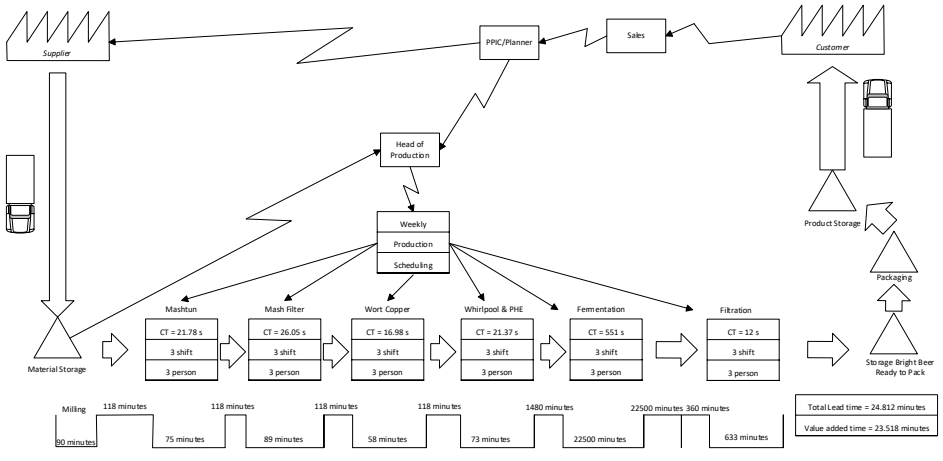


Figure 2. Value stream mapping (VSM) of brewing process in PT XYZ Plant B

A value stream mapping (VSM) was used to determine the physical process flow and information flow of brewing production process in PT XYZ area Plant B. Based on Figure 1, first sales department receive data demands from customers, and then the sales team sends the forecasts of customer demands for the next few months. Information from sales is passed to the PPIC and

planner to be submitted to the production department. The demands information is translated in the form of production plans, agreed at weekly production meetings between planners and production department. In terms of production, beer begins with the processes of malt milling, mashing, mash filtration, wort boiling, wort clarifying, wort cooling, fermentation and filtration.

Since the beer making process is characterized by a long fermentation process, the beer making process is carried out on make to stock. An efficient fermentation process takes about 15.5 days. So this week's production results are a good product in the next two weeks. Based on Figure 1 shows that the total value-added time (VA) for the PT XYZ beer production process was 23,518 minutes, producing 2,450 hl of young beer or 3,675 hl of bright beer. The total lead time was 24,812 minutes.

4.2 Process Activity Mapping of Brewing Production at PT XYZ

In process activity mapping there is a set of activities, divided into five activities, namely O (operation), T (transport), I (check), S (storage) and D (delay). It is also divided into three classification, namely value added (VA) activities, non-value added (NVA) activities and necessary non-value added (NNVA) activities. The results of process activity mapping are shown in Table 2. It was found that the brewing process has 23,518 minutes of value added (VA) activities, 60 minutes of non-value added (NVA) activities, and 2,956 minutes of necessary non-value added (NNVA).

Table 2. Process activity mapping (PAM)

No	Activity	Item	Duration (minutes)	Type of Activity					Classification		
				O	T	I	S	D	VA	NVA	NNVA
1	Milling	Malt milling process	90	x					x		
2	Mashing	Water pre run	15	x					x		
		Mashing in	20	x					x		
		Dosing enzymes dan CaCl2	5	x							x
		1st Rest	30	x					x		
		2nd Rest	10	x					x		
3	Mash Filtering	Filling mash filter	13	x					x		
		Main wort filtration	20	x					x		
		First sparging	16	x					x		
		Second sparging	40	x					x		
		Cleaning membrane after filtration during shifting process	10					x			x
4	Sugar dosing	Sugar transport from sugar warehouse to production area	150		x						x
		Sugar transport from 1st Floor to 2nd floor	150		x						x
		Open sugar sack and dosing sugar	120					x			x
5	Hop dosing	Open hop can	3	x							x
		Open and close hop dosing tank	3	x							x
6	Wort Boiling	Heating process	13	x					x		
		Boiling process	45	x					x		
7	Wort separation and wort cooling	Dosing Zn solution	10	x							x
		Rest at whirlpool	15	x					x		
		Wort cooling at PHE and aeration	58	x					x		
		Pre run wort cooling (total in 12 batch)	60	x						x	
		Post run wort cooling (total in 12	60	x							x

		batch)									
		Check wort concentration	25			x					x
8	Fermentation	Fermentation process	11700	x					x		
		Check apparent extract (AE)	25			x					x
		RUH process	5760	x					x		
		Yeast harvest process	150	x							x
		Check dead cell and yeast consistency after harvest	45			x					x
		Deep cooling process	720	x					x		
		Bubbling process	480	x							x
		Yeast purging gelaeger process	480	x							x
		Young beer storage	4320	x					x		
9	Filtration	Cleaning BBT tank	90					x			x
		Filtration	633	x					x		
		Check quality parameter of bright beer	60			x					x
		Filter preparation	270					x			x
		Cleaning line	100					x			x
		Bright beer storage	720	x							x

4.3 Identification Critical Waste Using Borda Count Method (BCM)

In the brewing process at PT XYZ, critical waste is determined using the borda count method (BCM). Focus group discussions (FGD) were conducted and questionnaires were distributed to respondents who were relevant and responsible for the production process, such as: production team leaders, technologist, and several operators who had become subject matter experts (SMEs), with a total of 6 respondents. When filling out the questionnaire, it was assumed that a value of 1 would be the highest value for waste that occurred frequently on site, and a value of 7 would be the lowest value for waste that occurred rarely on site. The results of rating critical waste are shown in Table 3.

Table 3. Critical waste rating

Critical Waste	Total Score	Rating
Transportation	24	4
Inventory	35	2
Movement	34	3
Waiting	10	7
Overproduction	14	5
Overprocessing	39	1
Defects	12	6

4.4 Identification Root Cause of Critical Waste Using Fishbone Diagram

The root cause of each critical waste identify by fishbone diagram, through focus group discussion (FGD). It was found that critical waste of overprocessing occurred due to the pre run step during wort transfer from the plate heat exchanger (PHE) to each fermenting tank, as shown in Figure 3. This happens because to minimize wastage of wort in the transfer line, which can lead to extract losses. However, this step is not necessary if there is a blocking valve in each tank, so the pre run step can be eliminated, residual wort left in the transfer line can be eliminated (zero loss), and no extract losses occurs in the wort transfer process.

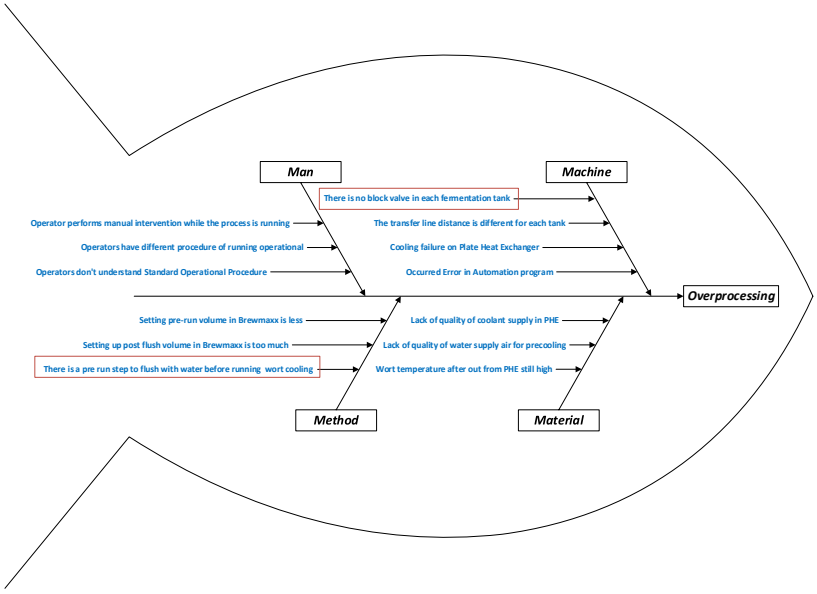


Figure 3. Fishbone diagram of waste overprocessing and root cause

Based on Figure 4, the root cause of waste of inventory occurred due to there are discrepancies in the information between planners and production department regarding the mature beer stock being converted to bright beer. This happens because a normal blending ratio change occurs, resulting in a larger number of bright beer than the planner. However, this can be avoided if the blending ratio is regularly monitored if the blending ratio changes during the filtration process due to recipe changes in the brewhouse, filtration and deviations from in-line flow meter in beer blender.

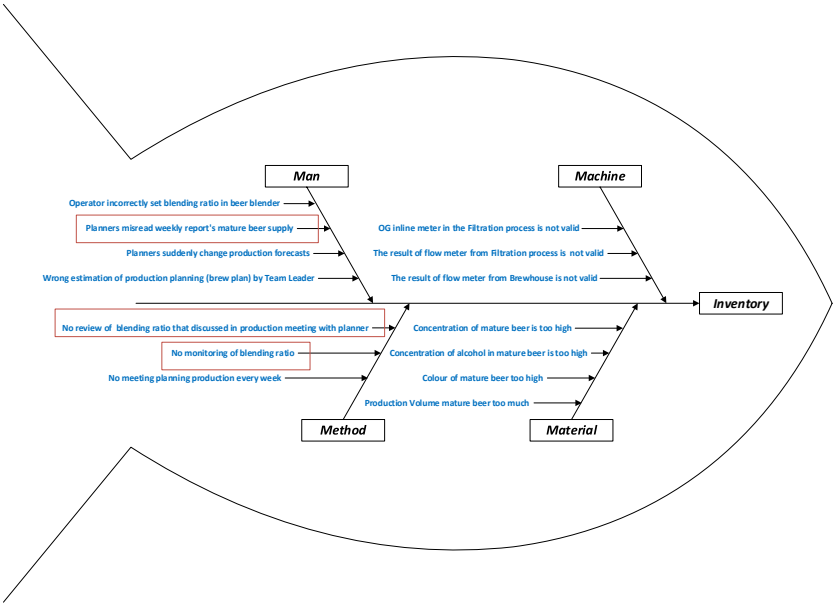


Figure 4. Fishbone diagram of waste inventory and root cause

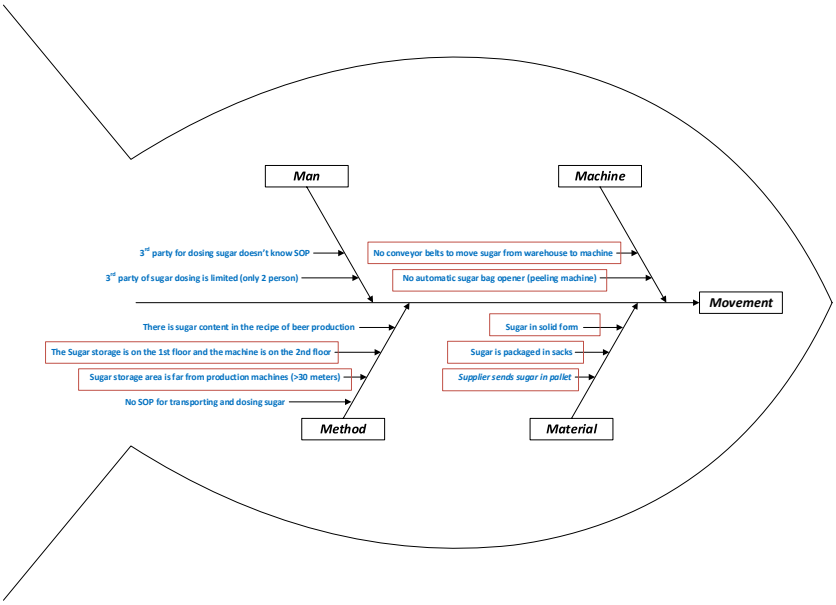


Figure 5. Fishbone diagram of waste movement and root cause

Based on Figure 5, the root cause of waste of movement occurred due to there is no automatic machine facility, so all sugar dosing activities are carried out manually by 3rd party resources. The material supplied by the supplier is in solid form, bagged and stacked on pallet, so some necessary non-value added (NNVA) activities are required to complete the process of dosing sugar to the wort copper machine.

4.5. Recommendation

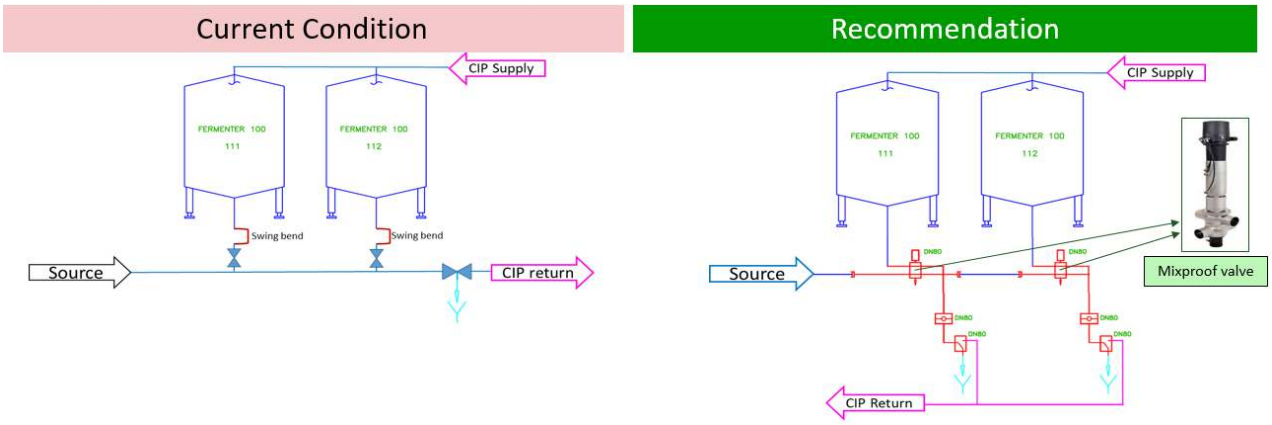


Figure 6. Current condition and recommendation of system for wort transfer with mixproof valve

A recommendation for waste overprocessing is to install a mixproof valve to eliminate a pre-run step during wort transfer from PHE to each fermenter. This will definitely have benefits in reducing the over-processing waste that occurs during the brewing process. In addition to reducing waste overprocessing, it will reduce and eliminate extract losses that occur during wort transfer and reduce process water consumption to fill the transfer line. The recommendation system of wort transfer to fermenter tank, it can be seen in Figure 6.

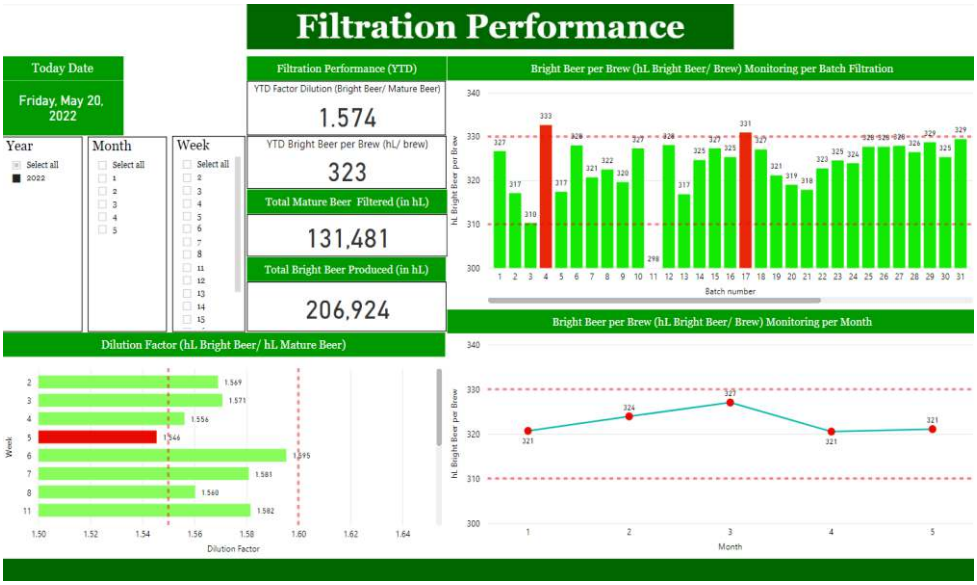


Figure 7. The real-time monitoring of blending ratios reporting with Power Bi

The recommendation for waste inventory is to create real time monitoring for blending ratio with Power Bi. This real-time monitoring system helps production department to monitor the performance of the filtration process and can more easily notify planners when the blending ratio changes during the filtration process. The implementation of recommendations aims to reduce of excess mature beer inventory approximately 4.7%. The recommendation of real time monitoring with Power Bi, it can be seen in Figure 7.

The recommendation for waste movement is to invest of liquid sugar dosing. First step, looking for a supplier who can provide liquid sugar with a 99.5% fermentable sugar content. When the sugar material changes from granular to liquid, the dosing process can be directly completed by transfer the liquid sugar from storage tank to the wort copper machine with a pump and line transfer. So, the waste of movement activity of sugar material from warehouse to the machine can be eliminate (zero loss).

6. CONCLUSIONS

The mapping of production flow of brewing process at PT XYZ area Plant B with value stream mapping (VSM) helped the study to identify some potential wastes (critical wastes). The results using the borda count Method (BCM) was identified critical wastes which are ranked in the top 3 for critical wastes, i.e. overprocessing, inventory and movement. The overprocessing waste that occurs is caused by step pre run at wort cooling process, non-value added (NVA) activities, and the source of the problem is the limited equipment and wort transfer system from the PHE to the fermenter. There are two main reasons for the waste inventory, the wrong way planners read the inventory, and the lack of real-time monitoring of blending ratios that can be read by both production workers and planners. The movement waste is due to limited machinery and the raw materials which are not easy to move.

The overprocessing waste recommendation is to install a blocking valve (mixproof valve) in each fermenting tank (FST), with the benefit of reduced non-value added activities (NVA), potential water savings of 1,157 HL/year, and extract losses savings around 3066 kg extract/year. The inventory waste recommendation is the implementation of production worker reporting

standards and real-time monitoring of blending ratios. The realized benefit was the elimination of 4.7% of excess mature beer inventory from current planned inventory. The recommendation of waste movement is replacing solid sugar with liquid sugar as raw material and preparing syrup sugar storage tank together with transfer lines. The benefit can be achieved is a 14.5% reduction in necessary non-value added (NNVA) activities in the brewing process at PT XYZ.

REFERENCES

Askin, R.G & Goldberg, J. B, (2001), Design and Analysis of Lean Production Systems, John Wiley & Sons, Inc, United States

Balamurugan, R., Kirubagharan, R., & Ramesh, C. (2020), "Implementation of lean tools and techniques in a connecting rod manufacturing industry", Materials Today: Proceedings, Vol. 33, pp. 3108-3113.

Barot, R. S., Raval, K., Berawala, H. S., & Patel, A. (2020), "Implementation of lean practices in water heater manufacturing industry", Materials Today: Proceedings, Vol. 38, pp. 2227-2234.

Boulton, Chris & David Quain, (2004), Brewing Yeast and Fermentation, Blackwell Science, Australia

Choomlucksana, J., Ongsaranakorn, M., & Suksabai, P. (2015), "Improving the Productivity of Sheet Metal Stamping Subassembly Area Using the Application of Lean Manufacturing Principles", Procedia Manufacturing, Vol. 2, pp. 102-107.

Deshkar, A., Kamle, S., Giri, J., & Korde, V. (2018), "Design and evaluation of a Lean Manufacturing framework using Value Stream Mapping (VSM) for a plastic bag manufacturing unit", In Materials Today: Proceedings, Vol. 5, pp. 2214-7853.

Edwin Joseph, R., Kanya, N., Bhaskar, K., Francis Xavier, J., Sendilvelan, S., Prabhahar, M., Kanimozhi, N., & Geetha, S. (2020), "Analysis on productivity improvement, using lean manufacturing concept", Materials Today: Proceedings, Vol. 45, pp. 717-7182.

Gaspersz, V, (2007), Lean Six Sigma for Manufacturing and Service Industries, Edisi 1, Gramedia Pustaka Utama, Jakarta.

Gavish, B. & Gerdes, J.H. (1997), Voting Mechanism and Their Implications in A GDSS Environment, Annals of operations Research Science Publisher.

Gunaki, P., Devaraj, S., & Patil, S. (2022), "Process optimization by value Stream Mapping", Materials Today: Proceedings, Vol. 54, pp. 251-254.

Hines, P. & Taylor, D., (2000), Going Lean, Lean Enterprise Research Center Cardiff Bussiness School, UK

Hines, Peter & Rich, Nick (2005), "The Seven Value Stream Mapping Tools", International Journal of Operation & Production Management, Vol. 17, No.1, pp. 46-04.

Hines, P. & Rich, N. (2001), The Seven Value Stream Mapping Tools Manufacturing Operation and Supply Chain Management, Thomas Learning, London.

Indrawati, S., & Ridwansyah, M. (2015), "Manufacturing Continuous Improvement Using Lean Six Sigma: An Iron Ores Industry Case Application", Procedia Manufacturing, Vol. 4, pp. 528-534.

Institute of Brewing and Distilling (IBD) (2014), Learning Material, London.

Juran, J. M., & Godfrey, A. B. (1999), Juran's Quality Handbook (5th edition).

Kumar, R., Chauhan, P. S., Kumar Dwivedi, R., Pratap Singh, A., & Prasad, J. (2022), "Design and development of ball dispenser Machine through lean manufacturing tool Poka-Yoke technique in automobile industries", Materials Today: Proceedings.

Linger, Hans Michael.ed. (2009), Handbook of Brewing: Processes, Technology, Markets, Wiley-VCH Verlag GmbH & Co. KgaA, Jerman

Liu, Q., & Yang, H. (2017), "Lean implementation through value stream mapping: A case study of a footwear manufacturer", Proceedings of the 29th Chinese Control and Decision Conference, pp. 3390-3395.

Mahajan, M., Chistopher, K. B., Harshan, & Shiva Prasad, H. C. (2019), "Implementation of lean techniques for sustainable workflow process in Indian motor manufacturing unit", Procedia Manufacturing, Vol. 35, pp. 1196–1204.

Modi, D. B., & Thakkar, H. (2014), "Lean Thinking: Reduction of Waste, Lead Time, Cost through Lean Manufacturing Tools and Technique", International Journal of Emerging Technology and Advanced Engineering, Vol. 4, No. 3, pp. 339-334.

Mohan Prasad, M., Dhiyaneswari, J. M., Ridzwanul Jamaan, J., Mythreyan, S., & Sutharsan, S. M. (2020), "A framework for lean manufacturing implementation in Indian textile industry", Materials Today: Proceedings, Vol. 33, pp. 2986-2995.

Narke, M. M., & Jayadeva, C. T. (2020), "Value Stream Mapping: Effective Lean Tool for SMEs", In Materials Today: Proceedings, Vol. 24.

Nash, Mark & Polling, Seila. (2008), Mapping the Total Value Stream, Taylor and Francis Group.

Ng, K. C., Lim, C. P., Chong, K. E., & Goh, G. G. G. (2014), "Elimination of waste through value Add/Non value add process analysis to improve cost productivity in manufacturing - A case study", IEEE International Conference on Industrial Engineering and Engineering Management, pp. 410-414.

Palange, A., & Dhatrak, P. (2021), "Lean manufacturing a vital tool to enhance productivity in manufacturing", Materials Today: Proceedings, Vol. 46, pp. 729-736.

Patil, M. B., Surange, V. G., Teli, S. N., & Bhushi, U. (2022), "Implementation of Lean Manufacturing Strategy in Label Printing Industry Using Value Stream Mapping", 2022 Advances in Science and Engineering Technology International Conferences.

Samuel, R., Rajesh, M., Rajanna, S., & Franklin, E. (2021), "Implementation of lean manufacturing with the notion of quality improvement in electronics repair industry", Materials Today: Proceedings, Vol. 47, pp. 2253-2257.

Sirajudeen, R. S., & Aravind Krishnan, K. (2022), "Application of lean manufacturing using value stream mapping (VSM) in precast component manufacturing: A case study", Materials Today: Proceedings.

Spencer, K. (2015), Getting the Root Cause. qualitymag.com.

Sundararajan, N., & Terkar, R. (2022), "Improving productivity in fastener manufacturing through the application of Lean-Kaizen principles", Materials Today: Proceedings.

Venkat Jayanth, B., Prathap, P., Sivaraman, P., Yogesh, S., & Madhu, S. (2020), "Implementation of lean manufacturing in electronics industry", Materials Today: Proceedings, Vol. 33, pp. 23-28.

Wilson, L. (2010), How to Implement Lean Manufacturing, the McGraw-Hill Companies, Inc., New York.

Womack, J.P. & Jones, D.T. (2003), Lean Thinking: Banish Waste and Create Wealth in Your Corporation, revised and updated, Free Press.

Zhang, L., Lv, H., & Xu, S. (2013), "Production process improvement based on Value Stream Mapping for CY company", Proceedings of 2013 6th International Conference on Information Management, Innovation Management and Industrial Engineering, ICIII 2013, Vol. 3, pp. 226-229.

MATURITY LEVEL OF PROJECT RISK MANAGEMENT IN OFFSHORE OIL AND GAS EPC INDUSTRY IN INDONESIA

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Abstract

For decades oil and gas industry has been developing facilities in all frontiers of Indonesia; onshore, offshore and subsea. In offshore fields, hundreds of platforms have been built and operated since 1970s. Most of those platforms are built and delivered by EPC (engineering, procurement, construction) contractors; foreign and locals alike - which making the EPC contractors as main contributor to the industry. Considering high risks involved in development stage, EPC contractors have been practicing project risk management (PRM) to some extents, to ensure business sustainability including protecting human life and customer satisfactions.

This thesis would be an exploratory and qualitative research, to measure the maturity level of PRM practice in some EPC contractors doing business in offshore oil and gas industry sector in Indonesia. Maturity model developed in this study based on framework and process suggested by ISO31000:2018. The purpose of this model is to provide an assessment tool for organization (within the scope of study) to assess their PRM benchmarked with the best practices from risk management standards.

This thesis would contribute to literature by providing snapshot of PRM practices at offshore oil and gas industry in Indonesia. The "interpretation" of ISO principles into oil and gas industry terms in its questionnaire could be used by any company for their self assessment of risk maturity level. It is also become a reference for engineers in risk management works and studies and hopefully to practice better PRM in their professional career.

Keywords: maturity level, assessment, management, project, risk, EPC, contractor, oil and gas, Indonesia, ISO31000.

1. INTRODUCTION

In oil and gas industry, the question of "does risk management contribute to project success", will be answered with a "yes". In a project that catastrophic events are obvious and could happened in a disaster form, risk mitigations are intrinsically performed since very early days of the business. Since then, catastrophic events are taking long list, billions of dollars of loss and hundreds of lives. **[Wikipedia, 2020].** Hence, this industry always tries to find "golden tools" to avoid project and operation failures, doing research in all disciplines and

applied the best practices along the way and risk management is one the important tool in this endeavor.

Hypothetically all EPC contractors practicing Project Risk Management (PRM). But how much, what extent, how they are doing it and so on; are interesting to find out. It is also assumed that the level of PRM practice is varied between organization. Not only interesting to see the maturity level of these practices, it is also important that organizations to see their management of risk status; to compare their current state with their ideal or targeted position, and to find out if their investment on RM practices are fruitful. **[Marks, 2020].**

So, to measure the level of maturity of these PRM practices we need to benchmarked the current PRM practices into something that could be considered as standard. This study reviewed and selected ISO31000:2018 edition as the evaluation tools to develop a model to measure maturity level of current PRM practices in some EPC contractors in Indonesia.

2. LITERATURE REVIEW

To provide the readers – assumed it is general audience in university level – of the O&G industry risks, we need to understand the complexities and the scope of business in oil and gas sector which could be grouped by some categories: by activities, by location of well and services on each field lifecycle phase.

In term of activities, oil and gas sector comprise three main group - upstream (exploration and production), midstream (transportation and processing) and downstream (distribution and sale to end users/consumers) **[Darko, 2014].** By location there are onshore, offshore, subsea and deepwater. By lifecycle phases there are five phases on life cycle of oil and gas industry **[Darko, 2014]:** exploration, appraisal, development, production and closing.

Few data from magazine articles and company websites some supermajors (have 2019 revenue more than 100 billion USD) companies are given also Indonesia oil companies which considered small.

Type of contracts that affecting the risk appetite of EPC contractors are studied: FIDIC, as a prominent institutes of contract management, defines type of contracts by eight categories [**Udom, 2014],** which the "Silver Book" is the most relevant type contract for EPC contractors. By using a lump sum contract, success criteria set by Owner is clear which is no escalation of price could be claimed by contractor. This is one of mitigation from Owner side on the price risk. However, on the other side, contractor would see this as a risk that should be absorbed into very early stage, even during bidding stage. And it is kind of complicated risk that needs to be handled carefully. Reimbursable type of contract would give less pressure to contractor but will give more uncertainties to Owner.

Definition of risk are given by many references. From **ISO (2009)** it stated as: "the effect this uncertainty has on an organization's objectives is risk". To manage the risk **ISO31000 (2018**) defines the "Risk management is coordinated activities to direct and control an organization with regard to risk."

There are many standards of risk management offered by institutions and companies. The study needs to select one that could be used for developing the maturity model. ISO31000 contributes significantly and indisputably to better risk management in the organization **[Ahmeti,2017].** And **Alijoyo (2021)** studied that ISO31000 standard has been well accepted and fairly adopted globally.

Project risk management has some differences with general or enterprise risk management in terms of scope, context and objectives, that make evaluating of maturity in a project organization would need specific and relevant tool to the purpose especially in oil and gas industry. The approach that risk management should be an important and integral part of project management and integral part of every project-driven organization **[Cano and Cruz, 2002**] is currently well and widely recognized by the leading project management institutions

(CII, PMI, ISO, IEC, IPMA, AEIPRO) and O&G companies as well. That makes risk management would be performed in early stage of project phases.

Project objectives in oil and gas could be varies from project to project and from organizations to another. However traditional criteria of project objectives are still valid nowadays that are: cost effective and lower than budget, completed on time and the facilities performed as promised **[Merrow, 2012]** which become also the objectives of risk management.

Risk contexts in oil and gas industry also determine the risk management. Although in general the contexts are very wide, for EPC contractors those are financial, legal, HSESS, engineering, procurement and supply chain, construction, marine transportation, offshore installation, commissioning and startup, brownfield and modification and interfaces.

3. METHODS

The methods employed to get the objective of the study is simple. Define the maturity model, create questionnaire that somehow could reflect the actual risk management status of the respondent's project risk management system and ask them to fill those with the simplest method for them.

To define the model, literature studies performed to find the best risk management system in the world and suitable for oil and gas offshore construction industry. Then to develop a tabulated maturity model as benchmark of "matured" state of risk management system. The model is developed into 1 to 4 scale with higher number as more matured status.



To create the questionnaire, each of the model item (there are 50) is given a question sentence. There would be four answers on each question that scored from 1 to 4. Each question would be factored based on priority. The weight factor is defined with Analytical Hierarchy Process (AHP) to make more objective weighing. Total score of the weighted results from each respondent will reflects their maturity level.

A website is developed to contains the questionnaire and provide interactive session with respondents. Its program is made as such to provide randomness of sequence between ISO31000 frameworks and processes, to increase the objectivity of answers even though the respondent well versed with ISO31000. Also, the software would generate random sequence of multiple-choice answers to provide more objective results. Immediate result of maturity level model would be reported to user / respondent screen after they completed the session.

4. RESULTS

After reviewing many maturity models, including the ones using ISO31000:2018 as basis, there is no suitable model available (at the time of research) for the oil and gas EPC contractor business. A new one to be developed. Literature also shown that maturity models are represented by numbers, either from 1-4 or 1-5, with various nomenclature for each level.

4.1 Selecting Risk Management Standard

Some risk management standard and guidelines are evaluated along with some project management standards dan guidelines. To avoid subjectivity on the selection process, a scoring system using Likert scales used and the results are tabulated.

AS/NZS 4360:2004
This guideline is the most comprehensive risk management system suggestions for general risk management system, when this discipline are still not embraced or adopted by many organizations. It was among the pioneer who promote risk management as good practices and necessary for businesses and organizations. As this guide is in very early stage of adoption of risk management by organizations, the authors put many practices in this guideline in "commentary" section only instead of as "formal" guidelines. Later (in the more recent revision), those suggestions are becoming "necessary" and put as formal guidelines (e.g management leadership, policy making, continous improvement etc).

COSO-ERM 2017
It's enterprise risk management system developed by financial organizations and heavily purposed and structured for their industry. As it is focusing on internal control and fraud deterrence, it is not suitable for construction industry in general nor the offshore construction.

ISO31000:2018, ISO/IEC 31010:2009, ISO Guide 73:2009
This set of latest development of risk management guidelines and best practices suggestions, taking some of its predecessors principles, commentaries (such as ISO31000:2009, AS/NZS 4360:2004) to become a more systematic guides on "principles, frameworks, processess". This is ISO style to put short gudielines yet comprehensive one, but make cross references to other documents for further details, so it would be easier to segregate between guidance and tools. This set could be applied to many type of organizations including offshore construction oil and gas.

APM-PRAM-2010
This is a project level implementation of APM Body of Knowledge risk management section that gives detailed tools and examples of "how" risk management to be performed. However this guidelines is not easy to follow, the format is awkward.

DWEA-2016
This Denmark standard is focusing on offshore health and safety (only) aspects of the risk management. While it is very suitable for offshore construction industry, however their coverage is very focused and limited to few risk contexts and identification. Limited suggestion of best practices.

PMI-PSPRM-2009
This is a project level implementation of PMI-PM Body of Knowledge risk management section that gives detailed tools, techniques and templates of "how" risk management to be performed.

OGC-PRINCE2-2009
It is a project management guidlines. Risk management section provided with some detailed procedure, tools, techniques in risk management.

IPMA-ICBPM-2019
It is a project management skills guidelines. Risk management section provided with some detailed procedure, tools, techniques in risk management.

ISO 21502-2020

ISO guidelines for Project, programme and portfolio management — Guidance on project management. The risk management section is too short and brief to provide meaninful risk management guidelines

Based on above analysis, it is found that ISO31000:2018 has the following advantages compare to other standards:

1. Issued in 2018 as the latest among the others – during the writing of this study. It is embraces erlier standards such as AS/NZS 4360:2004, ISO31000:2009 and blend it into an updated, better standard.
2. Covers tasks from top management down to project level implementation. Other standards mostly covers the working level only, which is found not sufficient anymore as corporate management involvement is required to fruit from risk management system implementation.
3. Suggest context identification in risk management, which is very important in offshore projects due to complexity and variety of issues in every project. Other standards not specifically asked to determine this factor and mostly leave it to user to do it.
4. Provide references to more detailed tasks (ISO/IEC 31010:2009, ISO Guide 73:2009) as part of document, giving comprehensive and detailed guidance for the users.
5. Presentation of the documents are systematic and easy to use along with comprehensible logic of thinking.

4.2 Proposed Maturity Level



Table 14: Proposed Maturity Model Level Description

Maturity Level	Characteristics
INFORMAL (Score: 1 to 2)	• Risk management is yet to be part of company policy. • Not all project perform risk management. • Project team will do risk management only if requested by contract. • No resources given from corporate for risk management, project to manage on its own and mostly done by Project manager. • Tools, personnel for risk management are upto project manager to choose and provide.
DEVELOPING (Score: 2 to 3)	• Risk management is already part of company policy. • However, project risk context is only internal and if requested by contract another context will be considered. • Risk Analysis mostly by qualitative method such as risk matrix. • No resources for risk management given from corporate, only project

Maturity Level	Characteristics
	to manage and it is part time. • Reporting and evaluation of implementation is not required by management.
MANAGED (Score 2 to 3)	• Risk management is established as company policy. • Project team must manage internal and external risk along with contractual context, with limited, manual tools and internal resource only. • Risk Analysis mostly by qualitative method such as risk matrix. • Resources are provided in corporate and project level. • Reporting is part of project documentation and submitted to corporate management
ASPIRATIONAL (Score: 3 to 4)	• Mandatory requirements to project team to manage all aspects of project risk context. • Resources are provided in corporate and project level. • Experts are sometimes used for risk assessment. • Comprehensive risk register template are provided. • Risk Analysis mostly by qualitative method such as risk matrix. • QRA are mandatory to be performed for extreme level risk. • Software and specific tools are used. • Evaluation and reporting for continous improvement is established.

4.3 Variables for Maturity Model Calculation

ISO31000:2018 outlined some "principles" as its philosophies of risk management. Further it suggests a "framework" consist of 6 significant activities and 10 "processes" that expanded into more detail to become 50 sub-categories; which reflecting those principles into actions in organization.

Each subcategory will have one question and 4 options of answers which reflecting the level of maturity from lowest (score 1) to highest (score 4). These questions would using terms and practices that familiar to oil and gas practitioners – while keeping the principles of the ISO frameworks and processes. These "interpretation" of ISO principles to the oil and gas industry terms is expected to be a contribution to the industry, for EPC company to use for their self assessment of risk maturity level in their organization.

The calculation of maturity level would be simply by multiplying weight factors in each category with the score of each answer. The variables and weight factors are given in the table below:

Table 16: ISO31000 Variables in Questionnaire and Weight factors

Framework	Category	Weight Factors (WF)	No. Of Questions	Each Question WF
1	Leadership and commitment	22.3%	9	2.482%
2	Integration	6.2%	3	2.070%
3	Design	9.6%	4	2.395%
4	Implementation	4.5%	2	2.234%

5	Evaluation	2.3%	1	2.272%
6	Improvement	2.3%	1	2.272%
Process	**Category**	**Weight Factors (WF)**	**No. Of Questions**	**Each Question WF**
1	Risk Management Scope	3.4%	5	0.676%
2	Risk Criteria	1.5%	1	1.533%
3	Risk Context	2.6%	4	0.638%
4	Risk Identification	20.5%	6	3.409%
5	Risk Analysis	6.2%	2	3.121%
6	Risk Evaluation	4.4%	1	4.393%
7	Risk treatment	6.0%	3	1.998%
8	Communication and consultation	3.1%	4	0.782%
9	Monitoring and review	2.8%	1	2.842%
10	Recording and reporting	2.3%	3	0.779%
	TOTAL	**47% + 53% = 100%**	**20 + 30 = 50**	

4.4 Maturity Level of Offshore Construction EPC Contractor in Indonesia

This is the main objective of this study. The results taken from 17 respondents who are currently working in EPC contractor companies. Corporate and project level risk management maturity having different figures which reflects the commitment of management leadership / board of directors toward risk management in their companies.

Table 22: Contractor Maturity Levels

Maturity Index	Maturity Level	n	%	Maturity Index Mean	Corporate Level Mean	Project Level Mean
1.00 – 2.00	Informal	0	-	-	-	-
2.01 - 3.00	Developing	5	25%	**2.56**	0.91	1.65
3.01 – 3.60	Managed	9	45%	**3.25**	1.29	1.95
3.61 – 4.00	Aspirational	3	15%	**3.72**	1.48	2.22
For comparison	Owner	3	15%	**3.35**	1.36	1.99

The data shows that in 45% of population, the risk management system maturity in a managed level. Only 15% in the highest level while the rest is on “developing” level. No respondent in the Informal level (the lowest level).

In general, these results reflect the actual conditions of how oil and gas EPC contractors in Indonesia handle risk management system. All respondents aware that risk factors should not be handled “informally” but need to be in a proper system. And show that adoption of risk management system into this business is ongoing and, on some contractors, have reach high level already.

Some reasons could contribute to this “good picture”. One factor is that proper risk management is required by many of oil and gas Owners (clients), not only from foreign investors but also Indonesian field operator like PERTAMINA, PGN, Medco. Other factor is many lessons have been learnt since 1980s of failures, fatalities and losses in EPC contractor businesses which due to improper or reckless handling of major risks, which avoidable if managed following these later risk management standards/guidelines.

Table 23: Respondents Statistics

Category	Subcategory	n	%	Maturity Index Mean (max 4.0)
1.Total respondents	Overall RM scope	20	100%	3.16
	Frameworks scope			1.23
	+ Process scope			1.92
2. Respondent's personal years of working experiences	> 30 years	7	35%	3.15
	20-30 years	6	25%	3.22
	10-20 years	5	30%	3.42
	< 10 years	2	10%	2.38
3. Respondent's Level in company management	Corporate	4	20%	2.91
	Project	16	80%	3.23
4. Respondent's Position / Title	Corporate Director	2	10%	3.08
	Corporate Manager	2	10%	2.87
	Project Manager, HSE Manager, Construction mgr	12	60%	3.38
	Construction Engineer, Project Engineer, Risk Eng.	4	20%	2.76
5. Side of Contract	Owner	3	10%	3.35
	Contractor	17	90%	3.14
	COMPANY PROFILES			
6. Major EPC Contract scope undertaken	Owner PMT	3	80%	3.35
	Main contractor (EPC)	13	75%	3.08
	Transportation & Installation	4	20%	3.34
7. Years in Business	**(contractors only**			
	> 50 years; Very established and experienced contractor	6	35%	3.15
	10-50 years; Established and experienced contractor	11	65%	3.15
	< 10 years Young and limited experiences contractor	0	-	n/a
8. Business Category				
OWNER	Oil and gas offshore field operator (Owners)	3	15%	3.35
EPC-1	EPC Contractor – local - has fabrication yard	3	15%	3.38
EPC-2	EPC Contractor – local – w/o fabrication yard	5	25%	2.85
EPC-3	EPC Contractor – foreign - has fabrication	1	5%	3.36

Category	Subcategory	n	%	Maturity Index Mean (max 4.0)
EPC-4	EPC Contractor – foreign – w/o fabrication	4	20%	3.09
EPC-5	T&I Contractor – local – has marine spread	4	20%	3.34

From item 2 above, respondents are "matured" in the ages and also working experience, as 90% of them have more than 10 years working, which give such a credibility to their opinion to questioner. It also shown that more senior respondents are working in more mature companies in risk management (index 3.21 to 3.28) compare to younger respondents. Item 3 shows more respondents handling management in project tasks (80%) compare to the rest that in corporate level. It would reflect that most of contractor project risk management system already in "managed" level (3.13). Item 4 shows more people in middle level of organization (75% as manager) consider their risk management is in "managed" level (3.19). Item 5 shows that Owner respondents in oil and gas business are having more mature risk management system in their organization. (3.35) compare to their contractor counterpart. (3.07). Item 6 shows that T&I contractors are more mature in risk management compare to EPC contractors or even to Owners (at least in the study population). From Item 7, it is shown that the duration of doing construction business affecting risk management maturity level. The longer it is, more mature risk management system they have. Item 8 shows contractor having fabrication yards are more mature in risk management compare to the ones having no yard. Also, the T&I specialist, having the marine spread, are more mature in risk management.

4.5 Data Analysis

The data shows that 80% of studied population has reached risk management system maturity in a "Managed" (60%) or higher "Aspirational" level (20%) while the rest (20%) is on "developing" level. No respondent in the Informal level (the lowest level).

In general, these results reflect the actual conditions of how oil and gas EPC contractors in Indonesia handle risk management system. All respondents aware that risk factors should not be handled "informaly" but need to be in a proper sytem. And show that adoption of risk management system into this business is ongoing and, on some contractors, have reach high level already.

Some reasons could contribute to this "good picture". One factor is that proper risk management is required by many of oil and gas Owners (clients), not only from foreign investors but also Indonesian field operator like PERTAMINA, PGN, Medco. Other factor is many lessons have been learnt since 1980s of failures, fatalities and losses in EPC contractor businesses which due to improper or reckless handling of major risks, which avoidable if managed following these later risk management standards/guidelines.

However, there is one important factor that could make differences between successful risk management that significantly impacting to project success; with Not-impacting risk management implementation, that is Leadership. Even with "managed" level maturity, if their leader do not have the same concerns to one project to another, the RM impacts are not automatically the same.

5. CONCLUSIONS

ISO31000:2018 has been found as comprehensive risk management guideline for project risk management and recommended also for implementation in offshore construction industry with additional tools for in depth safety and hazard risks management. Offshore construction industry in Indonesia, specifically the EPC contractors have achieved risk

management maturity level to a "managed" level. Even some achieved level where their practice could be "aspirations" to the others. Adoption of risk management system into this industry is continuing and getting better. Contractors aware that risk factors should not be handled "informaly" but need a proper risk management system. Leadership is important factor to successful implementation of risk management.

This maturity level measurement system could be implemented in the oil and gas industry as a tools for supply chain or procurement processes. Let say a new project would start a prequalification program to select EPC contractor candidates that will be invited to tender, if they asked to filled up this study questionnaire, the supply chain department could analyse and objectively getting picture whether the contractor is implementing good and sound risk management system in their organizations.

REFERENCES

AOGHS.org Editors. (2020)."First Oil Well Fire." Downloaded from: URL: https://aoghs.org/petroleum-pioneers/first-oil-well-fire. Last Updated: August 1, 2020. Original Published Date: April 29, 2013. American Oil & Gas Historical Society.

APM- Bartlett J. Chapman C., Close P. et al (editor), (2010), Project Risk Analysis and Management Guide, Association of Project Management, UK.

DWEA/Arbejdstilsynet (2016). Risk management in connection with offshore oiland gas operations. The Danish Working Environment Authority (WEA)

COSO (2017) - Enterprise Risk Management Integrating with Strategy and Performance-ERM-Presentation-September-2017

IPMA (2015). IPMA Individual competence baseline for project, programme and portfolio management. International Project Management Association. Available online at: http://products.ipma.world/wp-content/uploads/2016/03/IPMA_ICB_4_0_WEB.pdf

ISO (2018). Risk management – Guidelines. ISO 31000, International Organization for Standardization. Geneva, Switzerland.

ISO/IEC 31010 (2009) Risk management — Risk assessment techniques, International Organization for Standardization. Geneva, Switzerland.

ISO Guide 73 (2009), Risk management Vocabulary, International Organization for Standardization. Geneva, Switzerland

OECD (2021), Enterprise Risk Management Maturity Model Maturity Model, OECD Tax Administration Maturity Model Series, OECD, Paris. www.oecd.org/tax/forum-on-tax-administration/publications-and-products/enterprise-risk-management-maturity-model.htm.

OGC (2009). Managing successful projects with PRINCE2. Office of Government Commerce, London, UK.

PMI (2013). A guide to the project management body of knowledge (PMBOK Guide). Project Management Institute, Atlanta, USA. Available online at: https://www.pmi.org/ pmbok-guide-standards

Alexandrova M. and Ivanova, L., (2012). Critical success factors of project management: empirical evidence from projects supported by EU programmes. International ASECU Conference on Systematic Economics Crisis: Current Issues and Perspectives, Skopje, Macedonia, 2012.

Alijoyo A., Al Fattaah M., S. Fisabilillah (2021), Risk Management Implementation in Public Sector Organizations-Global Phenomena, International Journal of Current Science Research and Review ISSN: 2581-8341, Volume 04 Issue 03 March 2021

Baccarini, D., 1999. The logical framework method for defining project success. Project Management Journal , 30 (4), 25-32

Cobb, Michael. (2021), ISO 31000 vs. COSO: Comparing risk management standards, Article in https://www.techtarget.com/searchcio/feature/ISO-31000-vs-COSO-Comparing-risk-management-standards

Cano. A, Cruz M.P., (2002), Integrated Methodology for Project Risk Management, Journal of Construction engineering and management (Nov/Dec2002).

A P. Chan and A.P. Chan, (2004). Key performance indicators for measuring construction success, Benchmarking: an international journal, pp. 203-221, 2004

Chamoun E., Denewet N., Manzanera A. Matai1 S., (2019) Risk Management Maturity Assessment of Central Banks, IMF Working Paper Finance Department, December 2019

Darko E., (2014), Short guide summarizing the oil and gas industry lifecycle, Overseas Development Institute, EPS PEAKS, October 2014.

T. De Bruin, R. Freeze, U. Kaulkarni and M. Rosemann, "Understanding the Main Phases of Developing a Maturity Assessement Model," In Proceedings of the Australasian Conference on Information Systems (ACIS), 2005.

Dionne G., (2013), Risk Management: History, Definition and Critique,. Article. available at SSRN: https://ssrn.com/abstract=2231635

Ederstone, M.T. (2012), Risk Management of the Apple Company, Media Dialogues / Medijski dijalozi, Vol. 13, No. 3, pp. 35-43.

Fang H, Duan M, (2014), Chapter 7 - Safety System Engineering for Offshore Oil, part of Book Offshore Operation Facilities, Equipment and Procedures, , from Petroleum Industry Press.

Fiberesima D., Abdul Rani N.S, (2011). An evaluation of critical success factors in oil and gas project portfolio in Nigeria. African Journal of Business Management Vol.5 (6), pp. 2378-2395, 18 March, 2011

Govan P., Damnjanovic I., (2020), The Resource-Based-View on Project Risk Management, Journal of Construction Engineering and Management.

Hajiaga, SHR.,Shoukouhinia M, Hashemi S.S; (2016) Success Criteria in Oil, Gas and Petrochemical projects. International Conference on Electrical, Mechanical and Industrial Engineering (ICEMSE, 2016).

Hatmoko, J.U.D. and R.R. Khasani (2019), Mapping Delay Risks of EPC Projects: A Case Study of A Platform and Subsea Pipeline of An Oil and Gas Project, IOP Conf. Ser.: Mater. Sci. Eng. 598 012095

Kazimi MA ,, Grantham K., (2015), Investigating new risk reduction and mitigation in the oil and gas industry, Journal of Loss Prevention in the Process Industries 34 (2015) 196-208

Kurniawan, A., Wibowo A., (2017), Maturitas Enterprise Risk Management Kontraktor Besar di Indonesia dan Faktor-Faktor yang Mempengaruhinya, Jurnal Teknik Sipil ITB

Lenkova, O.V (2018), Risk management of oil and gas company in term of strategic transformation, Espacios, Vol. 39 (# 06) Year 2018. Page 30

Loan, C., (2012), Risk Management Practices in Six Organizations in the Government of Canada, Thesis , University of Ottawa

Merrow. EW., (2012). Oil and Gas Industry Megaprojects: Our Recent Track record, Independent Project Analysis, Inc., Oil and Gas Facilities Journal, April 2012

Mohan A, (2017), Risk management in offshore construction, International Journal of Engineering Technology Science and Research.

Nguyen V.T, Ogunlana S., Dey P.K, (2007). Risk management in oil and gas construction projects in Vietnam. International Journal of Energy Sector Management.

Ofori, DF., (2013). Project Management Practices and Critical Success Factors–A Developing Country Perspective. International Journal of Business and Management, Vol. 8, No. 21; 2013, 14-31.

Proenca, D. et al. (2017), Risk Management A Maturity Model based on ISO 31000, University of Lisbon Conference Paper · July 2017 DOI: 10.1109/CBI.2017.40

Rehacek, P., (2017. Risk Management Standards for Project Management. International Journal of Advanced and applied science.

Saaty, T.L., (1983). Decision Making For Leaders: The Analytical Hierarchy Process for Decision in Complex World. RWS Publication, Pittsburgh.

Tsiga. Z, Emes M, Smith A., (2017). Critical success factors for projects in the petroleum industry., International Conference on ENTERprise information System.

Wight A, Friestad H, Anderson I, Wicaksono P, Reminton CH, (1997). Exploration history of the offshore Southeast Sumatra PSC, Java Sea, Indonesia. Petroleum Geology of Southeast Asia, Geological Society Special Publication No. 126, pp. 121-142.

Zhao Xianbo; Bon-Gang Hwang; and Sui Pheng Low (2012), Developing a Fuzzy Enterprise Risk Management Maturity Model for Construction Firms, Journal of Construction Engineering and Management. Submitted October 16, 2012

P. Zou, Y. Chen, and T. Chan, (2010), "Understanding and Improving Your Risk Management Capability : Assessment Model for Construction Organizations," Journal of Construction Engineering and Management © ASCE / AUGUST 2010 pp. 854–864, 2010.

STRATEGY FOR INCREASING CUSTOMER SATISFACTION IN MAKING PAYMENT AT PLN MOBILE APPLICATION WITH USING EXTENDED TAM

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ABSTRACT

Currently, the development of information technology is increasing every year in Indonesia and is expected to improve company performance and customer satisfaction. PLN *Mobile* emerged as part of the digitalization transformation of PT PLN (Persero) based on *Customer-Focused* to make it easier for users to overcome electricity problems that are often faced. However, there are still many things that cause complaints from customers in its use, especially regarding payment, so it is necessary to identify the factors that affect customer satisfaction by using a technology acceptance model approach and beinh analyzed using the SmartPLS 3.0 application. The results of this study found that only four hypotheses were accepted from the eleven proposed hypotheses, namely based on a p-*value* of 0.046 < of 0.05. It found that *perceived ease of use* had a positive and significant effect on *behavioral intention to use*. In addition, *trust* has a positive and significant effect on *behavioral intention to use* as seen from the p-*value* of 0.010 < 0.05. *Compatibility* has a positive and significant effect on *behavioral intention to use* based on a p-*value* of 0.004 < 0.05. Finally, it was found that a p-*value* of 0.019 < 0.05, indicates that *compatibility* has a positive and significant effect on *customer satisfaction*. The strategy that is expected to increase customer satisfaction is to disseminate the PLN mobile further and further simplify existing features, especially payments. Companies can collaborate with more parties to provide more payment variations or can also build a special PLN *mobile* with a *top-up* and cheaper admin fees.

Keywords: Customer Satisfaction, Strategy, TAM

1. INTRODUCTION

Technological developments in the 4.0 revolution era can be a very big leap in the industrial sector to achieve efficiency, information and communication technology is utilized by almost all start-up companies, including PT. PLN (Persero). The use of information technology is also expected to improve the performance of this company to the stability of customer satisfaction with this company.

PT. PLN (Persero) as the only company in the electricity sector requires the company to always develop in all aspects of its business to maintain the availability of electricity and ensure the satisfaction of users of the company's products. This company on December 20, 2020, launched an application called New PLN Mobile with the aim of nothing more than realizing the digitalization transformation at PT. PLN (Persero) based on customer-focused. The features offered include

purchasing tokens and postpaid payments, submitting power changes, customer complaint services, and others. In collaboration with all National Banks in Indonesia, PLN Mobile is here to provide transaction convenience for 79 million customers of PT. PLN (Persero).

The existence of this application is expected to provide convenience by simply accessing the application and selecting the payment feature, all problems will become easier. Non-cash or online is now familiar and widely used by Indonesian people who use not only debit or credit cards but also use electronic money such as OVO, DANA, Shopeepay, or virtual accounts issued by banks that cooperate with the company. However, in the process, there are still frequent problems and this becomes one of the sources of complaints from customers to the company due to various reasons, one of which is the delay in confirmation given by third parties after the transaction. So it is necessary to have a strategy to overcome these problems so that customers remain satisfied with using the products and services offered by the company.

The technology acceptance method in this study analyzes strategies to increase customer satisfaction in making payments in the PLN Mobile. The model used to analyze these factors is the Technology Acceptance Model which was developed according to the problems in this study. The development of the TAM model is intended to add trust, compatibility, and mobility. The addition of this construct is expected to help in understanding user acceptance of the PLN Mobile, especially regarding the payment system in this application.

2. LITERATURE REVIEW

2.1 Technology Acceptance Model

Technology acceptance model is a model used by users or users in the process of accepting information technology systems (Davis, 1989). Perceived usefulness (PU) and perceived ease of use (PEOU) are the two beliefs used in determining technology acceptance (Fahmi, 2020). Perceived usefulness (PU) is a measure to assess people's beliefs that if someone uses a system in their activities, it will improve their performance. While perceived ease of use is how much a person's level of confidence that the time for the effort they are doing will be reduced if they use a system in doing their work (Davis, 1989).

2.2 Trust

Trust is a basic principle in every business relationship (Corbit et al., 2003). When transacting online, trust becomes very important because it reflects the user's positive assessment of the service provider. Therefore, building trust is important to increase user satisfaction (Chong et al., 2010; Wei et al., 2009; Zhou, 2011). Trust in the payment system provided online also one of the crucial things that affect the continuity of the business being carried out. Trust in the payment system is the willingness of users to make payment transactions via the internet and expect the platform to fulfill its obligations (Cao et al., 2017).

2.3 Mobility

The existence of information technology can help its users in terms of mobility of its use. They can access anywhere and anytime just by using the internet so they can connect and access as much as they want (Mallat et al., 2009; Marinkovic and Kalinic, 2016). The need for a product or service that can be accessed at any time has an impact not only on the desire to use it but also on user satisfaction. The increasing mobility of information technology will further increase user satisfaction (Marinkovic and Kalinic, 2016).

2.4 Compatibility

Compatibility is an important factor in the adoption of information technology. Compatibility means how consistent the new information technology is with past users' values, lifestyles, experiences, and needs (Bagla and Sancheti, 2018). Another definition put forward by Moore & Benbasat (1991) states that compatibility is the extent to which innovation from information technology is seen according to the needs and values that exist and is also based on the existing experience of potential users. compatibility indicates acceptance of better adoption or it can be interpreted that the more compatible an information technology is, it shows that more people accept the existence of the information technology (Lee et al., 2015).

2.5 Behavioral Intention to Use

Behavioral intention to use (BI) is the behavioral tendency of an individual or a person to use a technology (Davis et al., 1989). Another definition, namely, Schiffman and Kanuk (2010) define behavioral intention as the frequency of purchase or the proportion of total purchases of loyal buyers of a particular brand. Venkatesh and Davis (2000) define behavioral intention as the behavioral intention of a person when using certain technologies in their work. A person's attitude and attention to information systems can predict how big the level of use of information systems by users is, so that motivation to use will appear and invite other users to use it.

2.6 Customer Satisfaction

Consumer satisfaction is a feeling of pleasure to disappointment that is felt as a result of comparing the perceived service and product or perceived performance with the expectations of consumers (Kotler and Keller, 2016). If the customer is satisfied with the results obtained, a mutually beneficial relationship will be obtained between the consumer and the company and allow them to reuse it (Pitaloka et al., 2021). Customer satisfaction (customer satisfaction) is an evaluation of the overall level of pleasure felt by the customer based on the experience of the service that has been passed (Hellier et al. 2003). Research by Byamba and Chang (2012) results that satisfied customers have positive purchase intentions, such as repurchase intention, positive word of mouth, and long-term loyalty. Satisfaction felt by consumers describes the psychological process that consumers feel because their desires have been fulfilled so that the sense of satisfaction they feel will provide experience.

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3. METHODS

3.1 Research Model and Hypothesis The

The figure below is a research model that using the extended TAM model to analyze customer satisfaction in making payments in the PLN Mobile. The models that will be used in this study to prove the hypothesis are:

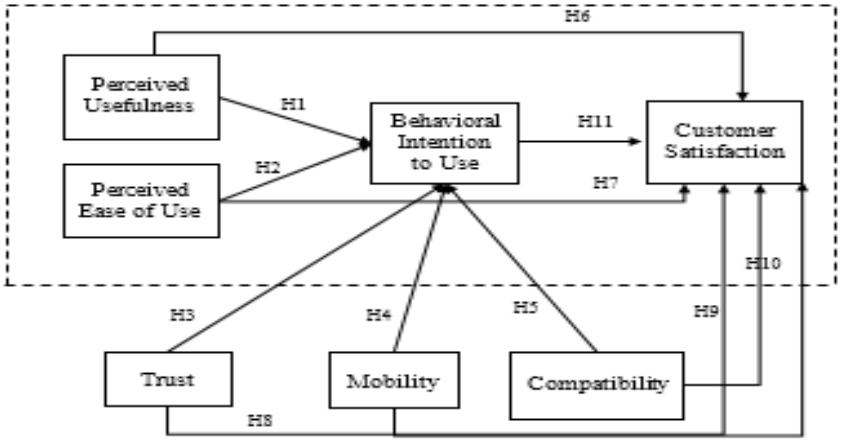


Figure 1. Conceptual Model of Proposed Research Extended TAM

This study uses primary data and secondary data. Primary data is obtained from the results of a questionnaire containing a list of statements that are systematically arranged and will be filled out by the respondents according to the actual situation. The questionnaire will be filled out by the respondent himself. Data collection was carried out by distributing online through google forms widely to the target respondents who were distributed based on the data and information they had. Secondary data on the research were obtained from journals, theses, scientific works, articles, and various related literature.

3.2 Sample and Data Analysis Methods

Sampling used voluntary sampling. Voluntary sampling is a sampling method that consists of people who self-select into a survey. According to Hair et al. (2006) recommend that in SEM analysis the minimum sample size used is around 100-300 samples. Therefore in this study for the sample size by combining the two statements, namely 150-300 samples for processing SEM analysis in this study.

The data processing and analysis technique in this study consisted of quantitative data research where the data was processed using the *Microsoft Excel* 2010 application by creating a frequency table to view the respondents' initial data and for each variable individually, then analyzing the PLS-SEM model using *software* SmartPLS 3.0.

4. RESULTS

4.1 Characteristics of Respondents

Table 1. Characteristics of Respondents

Characteristics	Category	Number (person)	Percentage (%)
Age (years)	≤25	18	9.94
	25-34	108	59.67
	35-44	39	21.55
	45-54	12	6.63
	>54	4	2.21
Gender	Male	158	87.29
	Female	23	12.71
Marriage Status	Not Married	25	13.81
	Married	156	86.19

Characteristics	Category	Number (person)	Percentage (%)
Education	Junior High School	3	1.66
	Senior High School	42	23.20
	Diploma	34	18.78
	Bachelor (S1)	91	50.28
	Postgraduate (S2)	11	6.08
Employment	Student	3	1.66
	Housewife	2	1.10
	PNS/Polri/TNI	30	16.57
	BUMN	88	48.62
	Pegawai Swasta	47	25.97
	Entrepreneur	11	6.08
Income in a month	< Rp 3 000 000	16	8.84
	Rp 3 000 001 - Rp 6 000 000	68	37.57
	Rp 6 000 001 - Rp 9 000 000	50	27.62
	> Rp 9 000 001	47	25.97
Expenditure in a month	< Rp 1 500 000	6	3.31
	Rp 1 500 001 - Rp 3 000 000	56	30.94
	Rp 3 000 001 - Rp 6 000 000	72	39.78
	> Rp 6 000 001	47	25.97

4.2 Payment Behavior in the PLN Mobile Application

Table 1. Payment Behavior in the PLN Mobile Application

Category	Information	Number (person)	Percentage (%)
Type of payments that are often did in PLN Mobile apps	Token puchases and postpaid payments	174	96.13
	Power Changes	6	3.31
	New installations	1	0.55
Frequency of payments in 3 months last time in the PLN Mobile application	1 – 2 times for 3 months	192	56.35
	3 – 4 times for 3 months	50	27.62
	5 – 6 times for 3 months	19	10.50
	7 – 8 times for 3 months	3	1.66
	> 8 times for 3 months	7	3.87
Average -average expenses made in the PLN Mobile application in the last 3 months	< Rp 200 000	43	23.76
	Rp 200 001 - Rp 500 000	97	53.59
	Rp 500 001 - Rp 1 000 000	30	16.57
	> Rp 1 000 001	11	6.08
Sources of information on the PLN Mobile application	Social media ads	99	54.70
	Friends/Family	57	31.49
	Ads on Google	3	1.66
	Conversations on online forum	12	6.63
	TV	2	1.10
	Banners/bilboard	8	4.42
Reasons for choosing the PLN Mobile application	Ease of transaction	106	58.56
	Ease of refill	11	6.08
	Convenience of using the PLN application Mobile	44	24.31
	Security	5	2.76
	Promo and cashback that provided	10	5.52
	Merchant that collab with PLN Mobile apps	5	2.76

4.3 Hypothesis Testing Hypothesis

The decisions are obtained by comparing the t-count value with the t-table or *probability value* (*p-value*) by taking into account the level of confidence. The criteria stating the hypothesis

can be accepted if the probability value of the path coefficient is < 0.05 with a t-count value > 1.96, and vice versa the hypothesis is said to be rejected or not accepted if the probability value of the path coefficient is > 0.05 with a t-count value <1.96. The results of testing the hypothesis of this study are based on Table 3 as follows.

Table 2. Hypothesis Test Results

Hypothesis	Original Sample	t-statistics	p-values	Conclusion
PU → BI	0.111	1.006	0.315	H1 Rejected
PEOU → BI	0.217	1.997	0.046	H2 Accepted
TRU → BI	0.251	2.570	0.010	H3 Accepted
MOB → BI	-0.088	0.912	0.362	H4 Rejected
COM → BI	0.385	2.927	0.004	H5 Accepted
PU → CS	0.113	1.458	0.146	H6 Rejected
PEOU → CS	0.170	1.872	0.062	H7 Rejected
TRU → CS	0.176	1.721	0.086	H8 Rejected
MOB → CS	0.080	0.766	0.444	H9 Rejected
COM → CS	0.312	2.346	0.019	H10 Accepted
BI → CS	0.117	1.389	0.165	H11 Rejected

Based on Table 3, it is known that of the 11 proposed hypotheses, only four were accepted, namely:

a. H2 or the second hypothesis in this study states that perceived ease of use has a positive and significant effect on behavioral intention to use, this statement is supported by the results of this study. Based on Table 3, the results show that there is a positive relationship shown by the original sample value of 0.217 and there is an influence on behavioral intention to use based on the pvalue < 0.05 which is 0.046, and the t-count value > 1.96 which is worth 1.997. Based on these results, it can be concluded that the second hypothesis in this study is accepted. This means that the higher the perceived ease of use, the higher the behavioral intention to use customers in making payments on the PLN mobile. The results of this study are following the results of research conducted by Fahresi (2021) and Afifah and Widyanesti (2017) who found that perceived ease of use had a positive and significant effect on behavioral intention to use.
b. The third hypothesis in this study states that trust has a positive and significant effect on behavioral intention to use, this statement is supported by the results of this study. Based on Table 3, the results show that there is a positive relationship shown by the original sample value of 0.251 and there is an influence on behavioral intention to use based on the pvalue < 0.05 which is 0.010, and the t-count value > 1.96 which is worth 2.570. Based on these results, it can be concluded that the third hypothesis in this study is accepted. This means that if customer trust increases, their intention to make payments on the PLN mobile. The results of the study are following the research conducted by Fahresi (2021) and Sadiyoko et al. (2019) found that trust had a positive and significant effect on behavioral intention to use.
c. The fifth hypothesis in this study states that compatibility has a positive and significant effect on behavioral intention to use, this statement is supported by the results of this study. Based on Table 3, the results show that there is a positive relationship indicated by the original sample value of 0.385 and there is an influence on behavioral intention to use based on the pvalue <

0.05, which is 0.004, and the t-count value > 1.96 which is 2,927. Based on these results, it can be concluded that the fifth hypothesis in this study is accepted. This means that the more compatible payments on the PLN mobile, the higher the customer's intention to make payments on the PLN mobile. The results of this study are following Mallat et al.(2009) found that compatibility has a positive and significant effect on behavioral intention to use.

d. The tenth hypothesis in this study states that compatibility has a positive and significant effect on customer satisfaction, this statement is supported by the results of this study. Based on Table 3, the results show that there is a positive relationship indicated by the original sample value of 0.312 and there is an influence on behavioral intention to use based on the pvalue < 0.05 which is 0.019, and the t-count value > 1.96 which is worth 2.346. Based on these results, it can be concluded that the tenth hypothesis in this study is accepted. This means that the more compatible payments in the PLN mobile, the higher customer satisfaction in making payments in the PLN mobile. The results of this study are following Hariansyah et al. (2019) who found that compatibility had a positive and significant effect on customer satisfaction.

4.4 Strategies to Increase Customer Satisfaction in Making Payments in the PLN Mobile Application

This study found that there were four variables whose hypothesis was accepted, namely H2, H3, H5, and H10. In determining the strategy that is expected to further increase customer satisfaction who makes payments in the PLN Mobile referring to the influential hypothesis and also combined with suggestions submitted by customers through questionnaires that have been distributed to further strengthen and increase customer satisfaction. Based on this, the strategies that can be suggested are:

a. Company, in this case, to maintain the satisfaction and sustainability of the use of this application, it is better to continue to improve the quality of the application because there are still complaints from consumers about the reliability of the application. In addition, there is a need to simplify existing features, especially payments that are friendly for customer because there are still many people who are not responsive to technology.
b. The company is maintaining the trust of its customers to continue to be satisfied transacting in this application can guarantee that the data provided by the customer is guaranteed confidentiality, especially if the payment method uses a debit/credit card.
c. There are still complaints from customers due to the use of virtual accounts and there are still many merchants who have not joined this application, demanding the developer to want to increase cooperation with more merchants or by building a special PLN Mobile with a top-up and lower admin fees.

Table 4. Number Transaction and Admin Fee Total in June 2022

UNIT	TRANSACTION AMOUNT (Times)			ADMIN FEE TOTAL (Rupiah)		
	Prepaid	Postpaid	TOTAL	Prepaid	Postpaid	TOTAL
BJM	815.813	337.286	1.153.099	2.409.035.000	1.005.808.000	3.414.843.000
BRB	388.407	226.448	614.855	1.199.855.500	675.960.000	1.875.815.500
PKY	830.383	122.679	953.062	2.433.496.000	363.563.000	2.797.059.000
KPS	316.598	92.018	408.616	902.766.000	268.028.000	1.170.794.000
KTB	274.741	82.237	356.978	781.102.500	241.113.500	1.022.216.000
UIW KSKT	2.625.942	860.668	**3.486.610**	7.726.255.000	2.554.472.500	**10.280.727.500**

From five UP3 that below PLN UIW Kalimantan Selatan and Kalimantan Tengah, the number of transaction of prepaid transaction are 2 625 942 times, whereas for postpaid are 860 668 times. Because the prepaid and postpaid transaction, the admin fee total will receive 10 280 727 500 rupiah. If the fee received by the company and can be utilized in system development within the corporation. If the company can develop a payment system in the form e-wallet, it is hoped that these admin fees can be converted into new income for the company.

d. Provide attractive promos such as discount discounts, cashback, and other promos that suit customer needs.

5. CONCLUSIONS

Based on the results of research on strategies to increase customer satisfaction in making payments in the PLN mobile application, it can be concluded that the types of payments that are often made by customers in the PLN mobile are token purchases and postpaid payments, and the reason they choose this PLN mobile is because of the ease of transactions. In other words, customers use the PLN mobile because it makes it easier for customers to purchase tokens and make postpaid payments for electricity services.

In addition, based on the results of the study, four hypotheses were accepted from the eleven proposed hypotheses, namely perceived ease of use and a significant positive effect on behavioral intention to use (H2); trust has a positive and significant effect on behavioral intention to use (H3); compatibility has a positive and significant effect on behavioral intention to use (H5), and compatibility has a positive and significant effect on customer satisfaction (H10).

The strategy that is expected to increase customer satisfaction is to further disseminate the PLN mobile, further simplify existing features, especially payments, collaborate with more parties to provide more variety of payments, or be able to build a special PLN mobile with a top-up that easier and cheaper admin fees. If the company can carry out this strategy well, it will achieve satisfaction from customers who make payments on this PLN mobile.

REFERENCES

Afifah, F., Widyanesti, S. (2017). Analisis Penggunaan Mobile Banking dengan Mengadopsi Technology Acceptance Model (TAM). *e-Proceeding of Management* 4 (1), 46-52.

Bagla, R.K., Sancheti, V. (2018). Gaps in Customer Satisfaction with Digital Wallets: Challenge for Sustainability. *Journal of Management Development* 37 (6), 442-451.

Cao, X., Yu, L., Liu, Z., Gong, M., Adeel, L. (2017). Understanding mobile payment users' continuance intention: a trust transfer perspective. *Internet Research* 28 (2), 456-476.

Chong, A.Y.-L., Ooi, K.-B., Lin, B., Tan, B.I. (2010). Online banking adoption: an empirical analysis. *International Journal of Bank Marketing* 28 (4), 267-287.

Corbit, B.J., Thanasankit, T., Yi, H. (2003). Trust and e-commerce: a study of consumer perceptions. *Electronic Commerce Research and Applications* 2 (3), 203-215.

Davis, F. D., Bagozzi R. P., Warshaw P. R. (1989). User Acceptance of Computer Technology: A Comparison of Two Theoretical Models. *Management Sci* 35, 982–1002.

Davis, F. D. (1989). Perceived Usefulness, Perceived Ease of Use, and User Acceptance of Information Technology. *MIS Quarterly* 13 (3), 319-40.

Fahmi, M. A. (2021). *Analisis Penerimaan Implementasi Erp Di Perum Bulog Dengan Pendekatan Extended TAM 3 (Extended Technology Acceptance Model 3),* Masters Thesis, Institut Teknologi Sepuluh Nopember, Surabaya, ID.

Fahresi, F. (2021). *Analisis Minat Penggunaan Aplikasi PLN Mobile Dengan Menggunakan Modifikasi Model TAM.* Master Thesis, Institut Teknologi Sepuluh Nopember, Surabaya ID.

Hair, R., Black, W., Babin, B., Anderson, R., Tarham, R. (2006). *Multivariate Data Analysis,* Ed ke-6, Pearson Prentice Hall, New Jersey.

Hariansyah, F.A., Wardani, N. H., Herlambang, A. D. (2019). Analisis pengaruh kualitas layanan mobile banking terhadap kepuasan dan loyalitas nasabah pada pengguna layanan BRI Mobile Bank Rakyat Indonesia di Kantor Cabang Cirebon. *Jurnal Pengembangan Teknologi Informasi dan Ilmu Komputer* 3 (5), 4267-4275.

Hellier, P.K., Geursen, G.M., Carr, R.A., Rickard, J.A. (2003). Customer Repurchase Intention. *European Journal of Marketing* 37 (11/12), 1762-1800.

Kotler, P., Keller, K.L. (2016). *Marketing Management*, 15th Edition, Pearson Education, New York.

Lee, C., Tsao, C., Chang, W. (2015). The relationship between attitude toward using and customer satisfaction with mobile application services: an empirical study from the life insurance industry. *Journal of Enterprise Information Mangement* 28 (5), 690-697.

Mallat, N., Rossi, M., Tuunainen, V.K., Oorni, A. (2008). An empirical investigation of mobile ticketing service adoption in public transportation. *Personal and Ubiquitous Computing* 12 (1), 57-65.

Marinkovic, V., Kalinic, Z. (2016). Antecedents of customer satisfaction in mobile commerce. *Online Information Review* 41 (2), 138-154.

Moore, G. C., Benbasat, I. (1991). Development of an Instrumentt to Measure the Perceptions of Adopting an Information Technology Innovation. *Information Systems Research* 2 (3)*,* 192-222.

Pitaloka, A. D., Hartoyo, Ali, M. M. (2021). *Faktor-Faktor yang Memengaruhi Niat Beli Ulang Sayuran Melalui Platform E-commerce di Jabodetabek*. Master Thesis, Institut Pertanian Bogor, Bogor, ID.

Sadiyoko, A., Tesavtira, C., Kurniawan, R. (2019). Increasing The Acceptance and On-line Transaction of an e-Commerce Site Using Technology Acceptance Model. *Proceedings of National Seminar on Applied Technology, Sciences, and Arts*, 216 – 220.

Schiffman L.G, Kanuk L.L. (2010). *Consumer Behavior Tenth Edition.* Prestice Hall, England, UK.

Venkatesh, V., Davis, F.D. (2000). A Theoretical Extension of the Technology Acceptance Model: Four Longitudinal Field Studies. *Management Science* 46 (2), 186–204.

Wei, T.T., Marthandan, G., Chong, A.Y.L., Ooi, K.B., Arumugam, S. (2009). What drives Malaysian m-commerce? An empirical analysis. *Industrial Management & Data Systems* 109 (3), 370-388.

Zhou, T. (2011). Examining the critical success factors of mobile website adoption. *Online Information Review* 35 (4), 636-652.

SERVICE DESIGN STRATEGY FOR INDONESIAN FOOTWEAR NETWORK PLATFORM DEVELOPMENT

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ABSTRACT

Indonesia Footwear Network, or IFN, is a community network platform for the footwear industry aimed at strengthening supply chains from upstream to downstream. IFN's mission is to collect, connect, and collaborate as one of the realizations of national partnership programs to strengthen the industrial ecosystem. Currently, the IFN platform is still at the stage of collecting, so this platform is still only a directory of the footwear industry and other related industries. There has been no intense interaction or engagement since the industry joined the platform. This study aims to increase the intensity of interaction between the footwear industry and its stakeholders to form a conducive and productive industrial ecosystem. This research is expected to provide system recommendations for partnership programs mandated by Government Regulation No. 29 of 2018 concerning industrial empowerment. The approach used in this research is Design Thinking, especially Service Design. The Design Thinking approach is intended so that the IFN platform is in accordance with the needs of its users, namely IFN members, and even the needs of the footwear industry players who are members of other related industries. This study involved several relevant stakeholders and resulted in a service design for IFN according to user needs, namely partners of the month, collect and go, and IFN labs.

Keywords: Service Design, Indonesia Footwear Network, Design Thinking, Community Network Platform

1. INTRODUCTION

The footwear industry is a potential industry to support Indonesia's economic growth significantly. Based on the performance data of the Indonesian footwear industry from 2018 to 2020, the export value of Indonesian footwear is in the 3rd position (APICCAPS, 2020). From the beginning of 2020 until 2021, the footwear industry runs into challenges due to the Covid-19 pandemic. Global export performance was also oppressed because of the disruption in the supply of the substance and materials. The disruption of the material supply chain during the pandemic provides important lessons for the continued growth of the component, substance, and material. The footwear industry can grow better by supplying their needs. On the side of the upstream industry (raw materials), with increasing domestic demand, it is expected that it will meet the substitution of raw material for footwear both in quality and price so that the competitiveness of the upstream industry is better than before. To cope with the problems that occurred, government organization A initiated the formation of a digital platform, namely Indonesia Footwear Network.

The development of digital platforms is an effective and efficient solution for supply chain application in varied products and manufacturing system domains (Aguila & ElMaraghy, 2020). The performance of a platform can be increased with efficient control, both formal control and informal control. In the information technology platform, control is the highest priority. The platform's reputation and government's rules positively affect participation in platform governance through formal and informal control. (Jiang & et al, 2021). The important points in information technology are perceived benefits, perceived ease of use, aesthetics, and homophiles. IFN is a digital platform to bridge and resolve footwear's national dynamic during the pandemic. IFN aims to answer the supply and demand needs of the footwear industry more easily and flexibly.

In the second year since the IFN platform was created, this platform had only succeeded to collect the tree diagram of the footwear industry, with the industry database collection which is categorized into raw materials industry, manufacture, brand owners, service, and association/community. But, the members of each category are still not complete. The members' needs could not be fulfilled optimally on this platform. Because there has not been a significant benefit to the industry, IFN has not been able to bind the industry to join. The research on the development of IFN is done to increase IFN's service and goal so it can be more useful, desired by clients, efficient, and effective to the organization. Indonesia Footwear Network has not answered the desired industrial ecosystem, until now the platform had only collected the industry and then entered the platform, so it's merely a directory. How to increase the users' interaction in the IFN platform becomes an important thing to solve in this research. To clarify the formulated problem statement in more detail, the research questions for this research are as follows:

- How does the footwear industry respond to the existence of IFN?
- What are the problems faced by the footwear industry while using IFN?
- How are the recommendations for IFN digital platform development that is suitable to the users' needs?

2. LITERATURE REVIEW

2.1 Indonesia Footwear Network

Indonesia Footwear Network as a new community platform to the industry is expected to give relevant information to potential global and domestic markets about the potency of the footwear industry from the raw materials industry to the finished product industry. In accordance with the goal of organization A as the industry's facilitator, IFN will be encouraged to complete and gather industrial information that currently exists in each community. As one of the biggest global footwear manufacturing companies, Indonesia feels the need to take an initiative to take the role to integrate information about producers, suppliers, material sources, local brands, and organizations that run in the footwear industry sector (BPIPI, 2020)

2.2 Ecosystem

An ecosystem platform becomes the solution to connect one stakeholder to another so that a synergistic relationship can be formed. There are several ecosystem platforms similar to IFN (Indonesia Footwear Network) but with different specifications, like PaDI UMKM, Agree Ekosistem, Pilar, and Data Jabar. PaDI UMKM is an ecosystem platform for agriculture in which Micro, Small, and Medium Enterprises (MSME) partner with the state-owned corporation, with MSME as the supplier. Agree Ekosistem is an agricultural platform with a concept that the agricultural partner is the supplier and distributor and then connected with companies to be

partners. The Data Jabar application is an ecosystem in the form of data about public information disclosure in West Java Province.

2.3 The Footwear Industry

Footwear is one of Indonesia's flagship products. The footwear industry has been proven to contribute a large amount of foreign exchange for the country, besides the fact that they also have a large workforce. Indonesia's footwear industry has good potential. It can be seen from the global footwear that Indonesia is in fourth place in world production, fourth place in world consumption, and third place in footwear exports. Indonesia's largest footwear export is to America at 95,7 million pairs. The next largest exports are China, Germany, Belgium, and Japan. There are 18,657 footwear industries in Indonesia, which are consisted of small, medium, and big enterprises. There are 18,091 small footwear enterprises, 411 medium footwear industries, and 155 big footwear industries. The majority of these industries are located in Java, particularly in the provinces of DKI, DIY, Banten, and Bali (BPIPI, 2018).

2.4 Design Thinking

Design thinking is a comprehensive customer-oriented innovation approach that aims to generate and develop creative business ideas or overall business models. Basically, design thinking tries to project a designer's approaches and methods to the business process. This approach will eventually be applied to all kinds of business ideas, whether they have product characters or services (Roterberg, 2018). According to (Plattner, Meinel, & Ulrich, 2019) design thinking process consists of six steps with iteration loop: understand, empathize, define, ideation, prototype, and test.

2.5 Design Service

Design service and service innovation must play a key role in advancing service research and practice. Design and innovation service can be the base to strengthen the impact of service research. Some of the research trends in design and innovation service are as follows (Patrcio & et al, 2018):

1. Service design and innovation research recognize the need for multidisciplinary integration towards the development of interdisciplinary fields.
2. Service design and innovation are moving from a traditional customer-centered view to a broader human-centered view.
3. Service design and innovation handle a higher level of complexity by broadening its scope from developing new solutions for the customers and organizations to creating transformative services and encouraging societal changes.

3. METHODS

` The methods used in this research are literature study to apply existing theories, then proceed with the design thinking method, and then analyze the result. The principle used in this project is design service. The sample for this project design is representative of each category, such as brand, raw materials, manufacture, association, and service. The data collection for this project is through questionnaires, Focus Group Discussions (FGD), and In-Depth interviews. The questionnaire was sent to IFN's partners in February. The FGD was held in February and was attended by the representatives of each category. The In-Depth-Interview was conducted by involving each persona representative from the category. The people who will be the samples here are the owners of the industry that has influential power in the business and strong networking

with other business entities. The analysis carried out in this project uses a User Persona, Empathy Map, and User Journey Map, in which there are seven personas, namely three local brand owner personas, one factory owner persona, one footwear service business owner persona, one association representative persona, and one raw material entrepreneur.

4. RESULTS

Indonesia Footwear Network (IFN) has a final purpose: to connect industries from upstream to downstream and collaborate in building the footwear industry's ecosystem. Now, IFN is still in the 'collect' step, which means it has not answered IFN's initial purpose, which is collect - connect - collaboration. The need for development that every business entity would have an engagement and the requirements of Indonesian footwear business entities are met through the platform. This research uses the design thinking approach through empathy, definition, ideating, prototype, and testing stages.

At the empathy stage, the writer distributes an initial questionnaire to be aware of IFN's partners and stakeholders' current behaviors to obtain a reasonably accurate picture for future research decisions. From the initial questionnaire, several descriptions of IFN's partners and stakeholders have been received, which include the following: The average intensity of gadget usage at work is within the following parameters: the use of gadgets for more than 15 minutes, the use of devices during spare times, the use of devices for internet surfing for 2 hours per day, the use of the device for social media, the use of gadgets for browsing is on average above 20%. This means that the IFN's partners and stakeholders have high intensity on gadget usage; devices used for work are personal smartphones, laptops, and computers. Promotion channels used for marketing purposes are social media (Instagram and Facebook) as much as 88,9%, marketplace as much as 77,8%, and friends recommendations as much as 55,6%. In IFN, business entities with close connections are 51,9% raw materials providers, 44,4% local brand owners, 37% manufacturers, and 37% service providers. The variety of raw materials is limited to as much as 33,3%. As many as 33% mentioned they have never joined the footwear ecosystem community. Almost 74,1% of people said joining the ecosystem/footwear community is essential. The next stage is stakeholder mapping identification which has an impact on the development of the footwear industry on the IFN platform. From the stakeholder mapping in the quadrant key player and meeting their needs, interviews were conducted with each stakeholder representative from the raw material industry, manufacturing industry, brand, association, and service. From the empathy map, the results are as follows:

1. Raw material industry, there are three industries where the needs of raw materials for each region are different, which makes it difficult for the production process. They have to set the minimum purchase order of raw materials to close the production, build connections with other materials, share the knowledge of the raw materials with other brands, examine the government's policy about minimizing imports, and think about how the sales can always grow.
2. Brand owners: on four brands of different types of footwear, the need for cheap but high-quality vendors, stock, raw materials with minimal order, updated knowledge about footwears technology, learning about quality, promotions, and government's policy about standards adjusted to the industry, purchasing the suitable raw materials, and photography and designer services.
3. Association: 2 associations, where the minimum standard is that a brand must have Intellectual Property Rights, difficulties in exports, overlapping government regulations,

policy about domestic level components that burden the small industry, and decreasing marketing support from the government.

4. Manufacture to 2 companies, when in pandemic the demand is low, the minimum purchase order is set to cover the operational costs, the development of attractive designs, connection to the customers, and domestic raw materials is not variative.
5. Services: designer, the need for active social media, standardization for competence, clear links for sales, and technical instructions.

Then the define stage. Making HMW questions to each persona and some conclusions are obtained as follows:

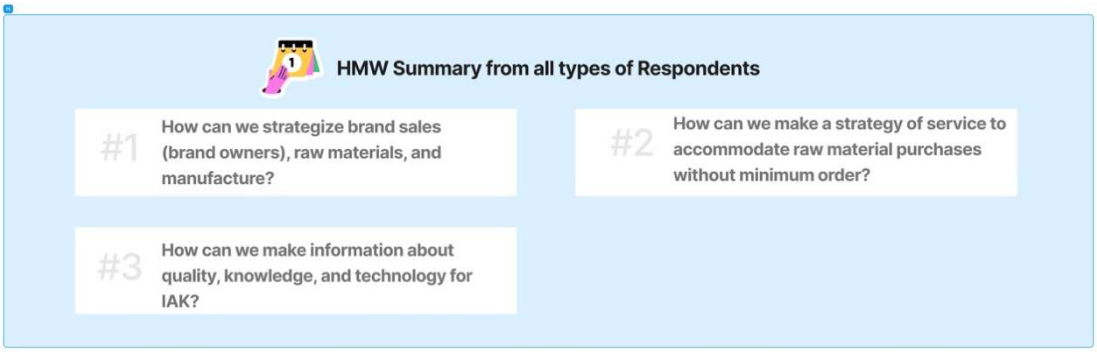


Figure 4.1 Summary of the Respondents' HMW

Figure 4.1 is the How Might We summary from PoV Madlib and How Might WE (HMW) Questions for each stakeholder. After defining the problems, the next step of the research is ideation by team brainstorming to obtain ideas that can be implemented on this platform, as follows:

Table 4.1 Brainstorming Ideas Summary

No	*How Might We (HMW) Question*	Brainstorming Ideas Summary
1.	How can we strategize brand sales (brand owners), raw materials, and manufacture?	1. Highlight the unique selling point of each products 2. Present the product with a story telling 3. Inform the product availability 4. Display various and trending articles 5. Make the transaction convenient 6. Show the products in the form of videos or pictures 7. Make material center 8. Keep the product ratings good for brands, raw materials and manufacturing
2	How can we make a strategy of service to accommodate raw material purchases without minimum order?	1. Gather the industry/relevant stakeholders who have the same needs 2. Gather the data of industrial capacity of each vendor 3. Gather the data of raw materials specifications that will be ordered 4. Create a specific page on the IFN platform for minimum order terms and conditions 5. Advertise to distribute the same raw material needs
3	How can we make information about quality, knowledge, and technology for IAK?	1. Make a communication forum about knowledge and technology 2. Give information about the latest technology and knowledge 3. Give information about the current trends of the footwear industry 4. Ask each stakeholders to spread about the knowledge and technology 5. Build a digital Library 6. Invite relevant stakeholders to share knowledge

Table 4.1 explains the summary of the brainstorming idea from the interviews at the empathy stage and then defines it at the define stage. From the ideation process, the results of the development are obtained and made into prototypes to explain the following:

1. A specific feed for Partner of the Month contains videos of the Partner who fulfilled the Partner of the Month criteria. Creative display page feeds consist of more interactive profiles, including product descriptions with storytelling, various contents, and all Partner's product highlights.
2. Collect and go page collects raw material needs to meet minimum orders by producers. It is where producers or IFN partners will upload their needs and invite all partners with the exact requirements to unite and buy together as producers so that the minimum order target can be reached.
3. IFN lab is where each Partner can upload the knowledge, technology, and regulatory contents. In the IFN lab, there is a discussion room for the topics discussed. The facilitator will reward every Partner who shares their knowledge.

After the prototype stage, the testing stage is conducted on IFN platform users, where this stage is held out into some steps. The first stage is testing the valuation expert, who is the official who initiates the formation of the IFN, then proceeding to the IFN platform users. The results of the testing phase are as follows:

1. Valuation Expert
   The test results for Partner of the Month and Creative Display are 5 (strongly agree), with the main feedback that must be developed are the need for rewards for active partners and ease of transaction. On Collect and Go, the expert also answered 5 (strongly agree) with some feedback: that the payment mechanism must be developed for ease of transaction. Last, at the IFN lab, the expert answered 5 (strongly agree) with some input, including collaboration with academics or R&D agencies to enrich the knowledge.
2. IFN Partners
   Test results on IFN partners for Partner of the Month and Creative Display as the solution is 5 (strongly agree) with some feedback to increase partners to be more diverse and activate IFN. IFN must promote through other channels and facilitate transaction features. In the Collect and Go, partners rate 5 (strongly agree) with feedback requiring Customer Service or Request boxes for raw materials that are not yet available. And in the IFN Lab, partners rated 5 (strongly agree) with feedback, namely information and technology updates, discussions on domicile to get to know them better, and easy access to needed information. With the percentage of partners answered in each development, 71.4% Partner of the Month and Creative Display, 78.6% Collect and Go, and 71.4% IFN Lab.

The testing stage presented in stage 4.2 shows the testing results on experts and IFN partners, answering 5 (strongly agree) with the order based on its percentage: Collect and Go, IFN Lab, Partner of the Month, and Creative Display. After the testing stage is done, the development stage is being held out as follows:

1. Collect and Go



Figure 4.2 Collect and Go Landing Page

Figure 4.2 shows the development of the IFN platform on the home page, where partners will easily collect raw material needs and fulfill raw material purchases without minimum order. Features added based on testing results are product profiles offered on the first page, PO button, brief product information, specific price information, quota, offer period, remind me button, pre-order join button, product description information, product specifications, information of produced by, the switch to visit the partner as the producer, customer service/chat, social media share button, and the profile information of the partner who uploads the pre-order.

2. IFN Lab

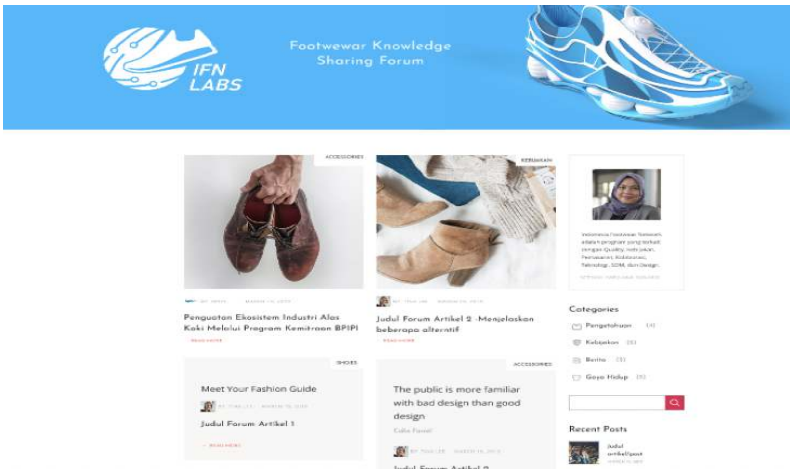


Figure 4.3 IFN Lab Landing Page

Figure 4.3 is an image of the IFN Lab landing page as a tool for sharing knowledge between partners. Based on the results of testing, the features added to this development are the knowledge page from IFN Lab, a button to read other articles, quotes from partners, category buttons (knowledge, policies, news, lifestyle), recent posts, gallery, space for advertising, hashtags for related words, articles/news, author information, and time, social

media share button, visit buttons for writing partners, previous or next news buttons, related post for related news, comments, reply, submit comment button.

3. Partner of the month and Creative Display

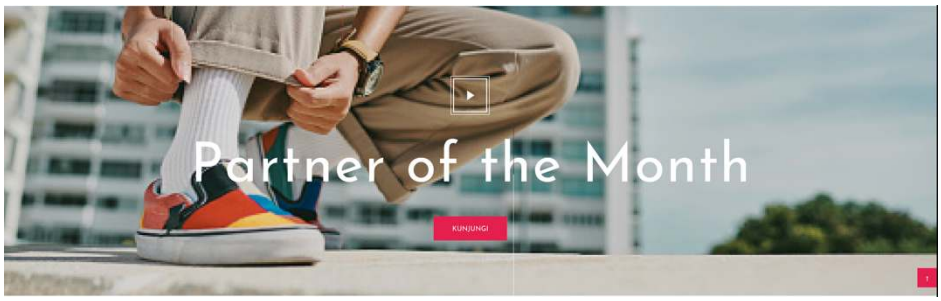


Figure 4.4 Partner of the Month Landing Page

Figure 4.4 is the Partner of the Month landing page for displaying products from partners. Based on the test results, the features added to the innovation development are the Partner of the Month page, the title of the story displayed by the Partner, the name of the Partner, the read more button, the process, and product description, the related partner menu, the comment display leave a reply (Reply). Then in the Creative Display, the development features added are partner pages, a menu of all categories, industry size, information tags, partner profiles, partner information, share buttons to other social media, partner descriptions, and partner reviews.

6. CONCLUSIONS

Indonesia Footwear Network or IFN is a digital platform to build a footwear ecosystem from the upstream industry to the downstream sector. IFN's mission is collect-connect-collaboration, where the IFN platform is still limited to collect, other missions have not been achieved, and there is no attachment if partners join the platform. The method used in this research is design thinking. The results of this study showed that IFN's presence is beneficial for the footwear industry with the evidence from the interviews with partners as 75% of them need an industrial ecosystem, one of which is the Indonesia Footwear Network. The results of the empathy stage show that there are several problems faced by partners, which in this study are grouped into marketing and promotion, collaboration/networking, human resources, design, technology, knowledge, finance, raw materials, and policies/regulations. So from the brainstorming stage to the testing stage, the results are recommendations for developing the IFN platform based on the priority order: Collect and Go, IFN Lab, Partner of the Month, and Creative Display.

REFERENCES

Aguila, J. O., & ElMaraghy, H. (2020). Co-development of product and supplier platform. *Journal of Manufacturing Systems , 372 - 385*, 54.

APICCAPS. (2020). *World Footwear Yearbook.* Portuguese : Portuguese : worldfootwear.

BPIPI. (2020). Indonesia Footwear Network . Sidoarjo: BPIPI.

Jiang, G., Zhang, M., Cai, X., & Feng, X. (6 September , 2021). Collaborative governance in shared accommodation platform: Moderating role of perceived risk. *Journal of Hospitality and Tourism Management, 49*, 112 - 128.

Lievens, A., & Blazevíc, V. (2021). A service design perspective on the stakeholder engagement journey during B2B innovation: Challenges and future research agenda. *Elsevier Inc* , 128 - 141.

Magistretti, S., Tu Anh Pham, C., & Dell'Era, C. (30 Juni, 2021). Enlightening the dynamic capabilities of design thinking in fostering digital transformation. *Industrial Marketing Management, 97*, 59 - 70.

Patrcio, L., Gustafsson, A., & Fisk, R. (2018). Upframing Service Design and Innovation for Research Impact. *Service Research, 21 (1)* , 3 - 16.

Plattner, H., Meinel, C., & Ulrich, W. (20019). *Design-Thinking.* Munchen: mi-Wirtschaftsbuch.

Roterberg, C. (2018). *Handbook of Design Thinking.* researchgate.net.

Shan, X., Yu Neo, X. z., & Yang, E.-H. (28 July, 2021). Mobile app-aided design thinking approach to promote upcycling in Singapore. *Journal of Cleaner Production, 317*.

Stanford Design School. (2008). *An introduction to design thinking—Process guide. In Hasso Plattner Institute of Design at Stanford University.* Retrieved 10 12, 2021, from https://dschoolold.stanford.edu/sandbox/groups/designresources/wiki/36873/attachments/7 4b3d/ModeGuideBOOTCAMP2010L.pdf

Stickdorn, M., & Jakob Schneider, e. (2010). *This Is Service Design Thinking.* Amsterdam, the Netherlands: BIS Publishers.

MODELING OF THE RELATIONSHIP BETWEEN WORKPLACE CONFLICT AND THE SUCCESS OF HIGH-RISE BUILDING CONSTRUCTION PROJECT IN SURABAYA

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ABSTRACT

Human resources is the most dominant resource in determining the success of a construction project. Problems can arise in the project due to human resource factors. The interaction between human resources can make a difference, this triggers workplace conflict. Workplace conflicts that are not properly resolved will have an impact on many things, especially on the level of trust and team performance, consequently, it can affect the success of the project. This study aimed to determine the relationship model between workplace conflict and the success of high-rise building construction projects in Surabaya. This research steps was literature review from previous studies to obtain variables that had a relationship with the success project. The conclusion was variables of workplace conflict, level of trust, and team performance related to the success project. Furthermore, workplace conflict is related to the level of trust and team performance, while the level of trust is also related to team performance. This study requires further analysis of the model to determine the effect and relationship of each variable to the success of the construction project.

Keywords: Human resources, workplace conflict, trust level, team performance, project success, building construction.

1. INTRODUCTION

The development of the construction industry in East Java shows a significant increase. According to the Central Statistics Agency (East Java Central Statistics Agency, 2020), the construction sector ranks fifth out of nine sectors that contribute to GRDP, with the construction category in 2020 growing by 5.83% BPSJT (2020). This is supported by various construction project development activities such as the construction of high-rise buildings and infrastructure. This increasing job demand growth is in contrast to another problem in construction projects, namely delays in completion times. According to Santoso et al. (2021) conditions in East Java Province, especially Surabaya City, often occur delays in building construction projects caused by several variables and affect project costs. All parties involved in the implementation of the project hope to meet the expected goals, namely the success of the project. The expected goals include, among other things, that the project is completed on time, does not exceed the set budget and is met with quality Ervanto (2002).

The identification of variables inhibiting project success should receive more attention, considering that the construction industry is known as an industry full of task pressure, limited time and complicated working group relationships. The results of research conducted by Aderiani et al. (2005) on the implementation of construction projects explained that the technical influence of work, and time, work environment, and human resources can explained and have an impact on conflict in project implementation. Meanwhile, according to Alfiah (2013), explained that there is a conflict relationship to the variable level of worker trust, which concludes that the higher the conflict, the lower the level of trust between co-workers. The level of trust is an important thing in interpersonal relationships and confidence in one's ability to carry out tasks. Based on trust, the relationship between workers in the organization will result in the ability to work together in carrying out tasks and be able to produce good quality and quality work, thus job satisfaction and team performance will be fulfilled. This is in line with Colquitt's (2007) statement that employees will work well with their co-workers if the foundation of their relationship is mutual trust based on shared goals and close friendships over a long period of time so that it will have an impact on improving team performance. It is also reinforced by the results of the research by Praningrum & Febrianto (2019) which conclud that the level of trust has a positive and significant effect on performance. This result means that if the level of trust among workers increases, it will be able to improve team performance in a company.

Based on the causes, the success of the project there are three dominant variables in influencing the success of a construction project, namely the influence of work conflict, the level of trust workers and team performance. This study builds on previous research looking at variables such as work conflict, level of trust, team performance and project success. This study wants to see another model of the relationship between these variables, considering that the relationship between each variable is very closely related in influencing the success of the project.

2. LITERATURE REVIEW

There are several previous studies conducted on work conflict. From the research conducted by Alfiah (2013) and Yun et al. (2020) which is the purpose were determine the effect of conflict through the level of trust in the working relationship. In this study, it was found that conflict had a significant and negative effect on trust. Thus, the higher conflict, the lower employee's trust. Conflicts that often occur in an organization are relationship conflicts and task conflicts. Relationship conflicts occur when personal problems are brought into the work routine at the company. This is indicated if there is tension, hostility, irritability and emotions with work partners. While task conflict is an awareness for work team members that there is a discrepancy about the task being carried out with the goals and objectives and the division of tasks that have been made previously. This is marked if there is awareness of discrepancies, disagreements on ideas, views, thoughts and disagreements on the content of decisions with work partners. Relationship conflicts and task conflicts that occur in the organization will reduce trust both in organizational trust, trust in superiors, and trust in co-workers Alfiah (2013). The research also has been conducted by Giovanni et al. (2015) and Yofandi et al. (2017), the aimed of this research is to find out the effect of conflict on performance. In this study, it was found that one of the causes of low employee performance was caused by the problem of employee work conflicts in the

company. Negative work conflicts are still common. So it can be concluded that if work conflict increases, then employee performance will decrease.

Subsequent research has also been carried out by Susila & Handoyo (2015), Rinaldy et al.(2017), and Jnana, et al.(2020) whose aim is to determine the effect of conflict on the success of construction projects. In the study, it was found that one of the causes of not achieving project success was caused by conflicts that occurred within the company. So it can be concluded that if work conflict increases, it can have a negative effect on the success of a construction project company. The relationship model of work conflict can be seen in figure 1.

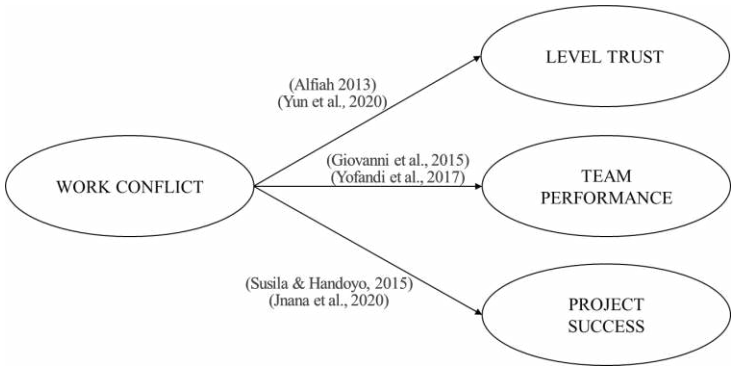


Figure 1. The relationship between work conflict variables on the variables of trust level, team performance, and project success

There are several previous studies conducted on trust. From the research conducted by Praningrum & Febrianto (2019), the purpose of this research is to determine the effect of trust on employee performance. In this study, it was found that trust has a positive and significant effect on employee performance. This result means that if trust among employees increases, it will also increase employee performance. Trust affects all relationships between individuals and groups of individuals, and is key to team performance in an organization because trust enables voluntary collaboration Mathis & Jackson (2006). Research has also been carried out by Annalin (2020), the purpose of this research is to find out the relationship between trust and project success. In this study, it was found that the level of employee trust had a significant effect on the success of project management.

Trust is a human attitude variable that implies an emotional bond that links emotional intelligence and project success. Thus, emotionally intelligent project managers develop trust with their work teams by creating emotional bonds with their work team members, and this relationship is then reflected in the success variables in a project, including communication, mission clarity, and problem solving. Calculative beliefs are based on human resource rationality that considers how the behavior of others will benefit self-interest. Relational trust is the result of the virtue of working together i.e., interpersonal relationships that make project progress smoother. So it can be concluded that trust is positively related to the success of the relationship model project from the level of trust can be seen in figure 2.

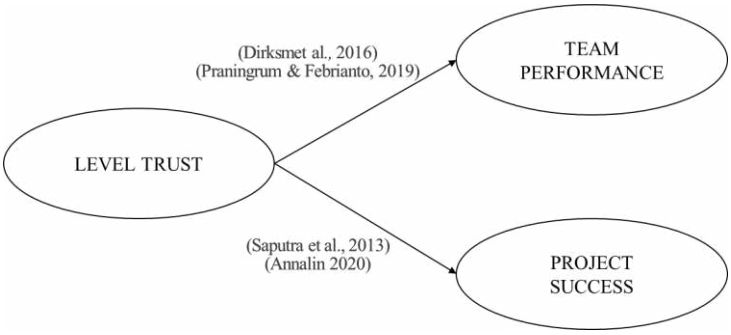


Figure 2. The relationship between the variable level of trust on the variable team performance and project success

There are several previous studies conducted on team performance. From the research conducted by Hidayat (2013), the purpose of this research was to determined the effect of team performance on project success. In this study, the results showed that there was a significant relationship between the variables that influenced the team's performance on the success of the project. These variables are the ability of members to solve problems, the ability to work together, the enthusiasm and commitment of team members, the team successfully completes the work according to quality, on time. So it can be concluded that team performance greatly affects the success of a project. The relationship model of team performance can be seen in figure 3.

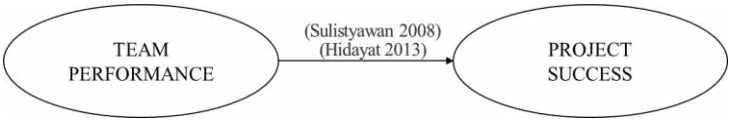


Figure 3. The relationship between team performance variables on project success variables

3. METHODS

The research was conducted by identifying knowledge gaps from previous research. Previous studies have examined the relationship between work conflict and project success, the relationship between project success and the level of trust and the relationship between team performance and project success. Based on the variables that have been obtained from previous studies with a combination of variable modifications that have never been presented in previous studies as hypothesis testing by knowing the relationship between variables. Research by exploring the relationship between variables can be known through the theories put forward in previous studies about work conflict, the level of trust in team performance and project success. The objectives of the literature study include Soeyandono (2021):

1. Identify previous research related to variables that affect project success.
2. Literature review for indicators that match to the variables and see the relationship between indicators for each variable
3. Model formulation based on the theory that has been developed in previous research by looking at the variables and indicators that have been found.

4. RESULTS

Based on previous research, indicators of work conflict include differences in goals, human ego, feelings of loss, miscommunication, work pressure and work injustice. Then indicators of the level of trust include reputation, work experience, competence, openness, loyalty and integrity. Furthermore, the indicators of team performance are teamwork, organizational structure, organizational culture, leadership and individual skills. The next indicators of project success consist of cost, quality and time. The identification of indicators of each latent variable based on previous research can be seen in table 1.

Table 1. Identification of indicators of each latent variable

Variable	Indicator	Journal Source
Work Conflict	Goal Difference Human Ego Feeling Hurt Miscommunication Working Pressure Work Injustice	(Putri, 2017), (Waruwu, 2018), (Dewi, et al., 2020), (Suryani & Yoga, 2018), (Yuliawan, 2012), (Fatikhin, et al., 2017).
Level Trust	Reputation Work experience Competence Openness Faithfulness Integrity	(Lendra & Andi, 2006), (Sari, 2017), (Alfiah, 2013), (Saputra, et al., 2013), (Robbin & Judge, 2008).
Team Performance	Teamwork Organizational structure Organizational culture Leadership Communication Individual skills	(Simatupang, 2019), (Taufik, 2017), (Imron, 2019), (Sulistyawan, 2008), (Muspah et al., 2021), (Sinuhaji, 2020).
Project Success	Cost Quality Time	(Setiawan & Ariadi, 2012), (Sufa, 2012), (Saputra, et al., 2013), (Syaranamual, 2014).

After previous research review and the relationship between each variable, a new model was formed to find the relationship of each variable. While the pattern of relationships between variables is formed based on the results of previous studies as well as research by Alfiah (2013) explained that work conflict will greatly affect the level of trust. The higher of the conflict, the lower employee's level of trust. While Yun et al. (2020) found that work conflict will affect trust. Therefore, it can be concluded that work conflict will have an influence on the level of trust. Giovanni et al. (2015) founded a relationship that conflicts occur in the work process can cause a decrease in performance. The same thing was also stated by Yofandi et al. (2017) that there is a work conflict relationship that is not immediately addressed properly and affects the decline in work team performance. Therefore, it can be concluded that conflict at work can affect team

performance. Susila & Handoyo (2015) explained that work conflict can reduce the success of a project. The higher the conflict will have an impact on cost, quality and time. Rinaldy et al. (2017), also stated that effective conflict management can have a good impact on the project sustainability time. Jnana et al. (2020) stated that success in managing construction projects is one result of handling work conflicts appropriately. Therefore, it can be concluded that work conflict can affect the success of construction projects. In the research of Dirks et al. (2016) stated that team performance is influenced by the level of trust that has been formed. Praningrum & Febrianto (2019) found that the level of trust affects team performance. Therefore it can be concluded that the level of trust can affect team performance. Saputra et al. (2013) found a relationship that the trust of human resources in the project team can affect the success of the project. Annalin (2020) also stated that there is a relationship between the level of trust and the success of the project. Therefore it can be concluded that the level of trust can affect the success of a construction project. Sulistyawan (2008) explained that the performance resulting from a good work team can have a positive influence on project success. Hidayat (2013) also states that performance has a relationship to project success. Therefore, it can be concluded that team performance can affect the success of a construction project. There are several differences between previous research and this research. The final result of this research will focus on knowing the work conflict relationship model, level of trust, team performance and the success of construction projects. The concept of modeling this relationship was formed based on the theory of substance based on the opinion of previous research regarding the patterns of relationships in each variable. The conclusions obtained from the modeling concept in this study can be seen in figure 3.

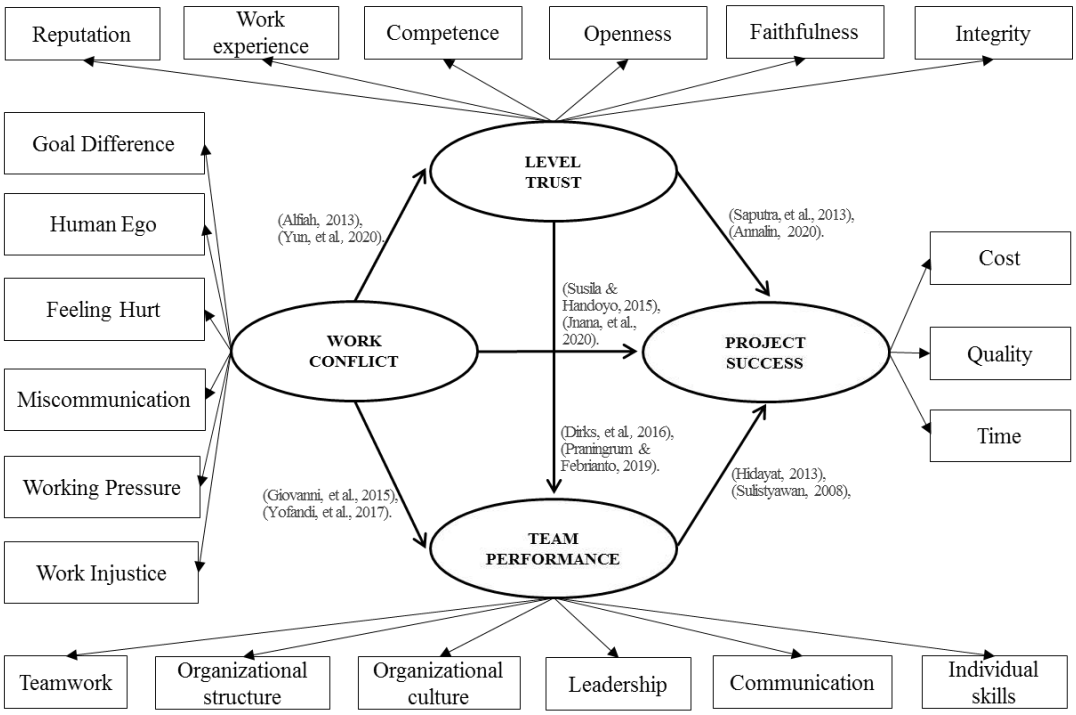


Figure 4. Modeling the relationship between work conflict variables, level of trust, team performance and project success

6. CONCLUSIONS

This study found the final result, namely the concept of framework model about relationship between work conflict variables and the success variable of a building construction project in Surabaya. There were also intermediate variables, namely the level of trust and team performance variables. The conclusion was variables of workplace conflict, level of trust, and team performance related to the success project. The level of trust variable has a relationship with the variables of team performance and project success. And the team performance variable has a relationship with the project success variable. This modeling concept is based on the results of a literature review from previous research to obtain variables and indicators that have a relationship with the success of a construction project. This study recommends further research to collect data and measurements from this model by analyzing each variable and its indicators, then analyzing its relationship with existing methods so that it can be seen how much influence each variable has.

REFERENCES

Aderiani, R., & Adi, T. J. W. (2005), "Identification of Conflicts that Occur in the Implementation of Building Construction Projects",*In Prosiding Seminar Nasional Manajemen Teknologi I,* (25) 26.

Alfiah, J. (2013), "The Effect of Conflict on Job Satisfaction Through Trust", *Jurnal Ilmu Manajemen*, 1 (1), 197-208.

Annalin, A. (2020), "Analysis of the Effect of Trust Level on the Success of Project Management Through Mediation Level of Collaboration at Developer Companies in Batam", Doctoral dissertation, Universitas Internasional Batam, Batam.

Badan Pusat Statistik Propinsi Jawa Timur, 2020. Produk Domestik Regional Bruto Jawa Timur Tahun 2020. Surabaya : Badan Pusat Statistik.

Colquitt, J. A., Scott, B. A., and LePine, J. A. (2007), " Trust, Trustworthiness, and Trust propensity: a meta analytic test of their unique relationships with rist taking and job performance". *The Journal of Applied Psychology*, (92) 4.

Dirks, K. T., DeJong, B. A., & Gillespie, N. (2016), "Trust And Team Performance: A Meta Analysis Of Main Effects, Moderators, And Covariates", *Journal Of Applied Psychology*, 101 (8), 11-34.

Ervanto, I Wulfram, 2002. "Construction Project Management", Penerbit Andi Yogyakarta.

Giovanni, T. M., Kojo, C., & Lengkong, V. P. (2015), "The Effect of Role Conflict, Work Conflict and Work Stress on Employee Performance at PT. Manado Water", *Jurnal Riset Ekonomi, Manajemen, Bisnis dan Akuntansi*, 3 (3), 90-98.

Hidayat, A. (2013), "Project Team Performance Analysis on Project Success", *Jurnal Aplikasi Teknologi,* 5 (1), 1-8.

Jnana, I.B.A.S., Bintana, I.BP., & Ardika, I.W.D. (2020), "Analysis of the Effect of Conflict on the Successful Implementation of Construction Projects in Bandung Regency (Case Study in South Kuta District)", *In Proceedings*, 1 (1), 233-236.

Mathis, R.L. & J.H. Jackson. 2006. "Human Resource Management". Jakarta: Salemba Empat.

Praningrum, P., & Febrianto, F. (2019), "The Effect of Knowledge Sharing and Trust on Employee Performance at PT. Shoots Dwipa Matra Bitterness", *Jurnal Bisnis dan Manajemen*, 13 (3),166-171.

Rinaldy, R., Aulia, T. B., & Rauzana, A. (2017), "Factor Analysis of Conflict Influence on the Success of Construction Projects in Aceh Province", *Jurnal Teknik Sipil*, 6 (2), 149-158.

Santoso, K. J., Wijaya, K. A., & Chandra, H. P. (2021), "Portrait of the Construction Industry in Surabaya During the Covid-19 Pandemic", Jurnal Dimensi Pratama Teknik Sipil 10 (1), 57-64.

Saputra, A.A.I., Wiguna, I.P.A., & Nurcahyo, C.B. (2013), "The Influence of Communication, Trust and Commitment to the Success of Project Work", Prosiding Seminar Nasional Manajemen Teknologi XVIII, Ed. Nurcahyo, C.B., Institut Teknologi Sepuluh Nopember, Surabaya, 18-26.

Soeyandono, J. R. (2021). Influence of Certified Professional Verbal Safety on Safety Performance in Building Construction Projects in East Java. (Doctoral dissertation, Institut Teknologi Sepuluh

Nopember).

Susila, H., & Handoyo, S. (2015), "Analysis of the Effect of Conflict in Construction Implementation on Project Success", *Jurnal Teknik Sipil Dan Arsitektur*, 16 (20), 1-14.

Sulistyawan, A. (2008), "Influence of Project Team Performance on Project Success", Doctoral Dissertation*, Universitas Diponegoro Semarang*, Semarang.

Yofandi, A., Nuryanti, N., & Wasnury, R. (2017), "*The Influence of Work Conflict, Work Stress, and Work Morale on Employee Performance At PT. Perkebunan Nusantara V (Persero) Pekanbaru,* Doctoral Dissertation, Riau University, Pekanbaru.

Yun, Y., Tham, J., & Azam, S. F. (2020), "Conflicts On Team Trust And Team Performance At The University Scientific Research Teams In Jiangsu Province", *European Journal of Management and Marketing studies,* 6 (1), 23-39.

A COMPARATIVE STUDY OF PROJECT COST PERFORMANCE AT PT XYZ USING DEMATEL AND ANP METHODS

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ABSTRACT

PT XYZ is a company engaged in the construction sector, where PT XYZ is the contractor of the West Tarum Project (river rehabilitation), the LRT Diversion Project (Highrise), Cipamingkis Project (Roads & Bridges), and the River Diversion Project (river relocation). In carrying out a construction project, PT XYZ is always limited by costs, quality, and time that vary in each project, therefore the cost component is the most important factor in the project implementation process. The type of research used in this study uses a combination of DEMATEL and ANP methods. The DEMATEL method is useful for knowing the relationship between criteria and each other, while the ANP method is used to obtain expert judgments and obtain priority weights that will be used to evaluate achievement/implementation. The research output based on the results of DEMATEL and ANP processing shows that the cost performance of the four tested projects has results that are quite different from the actual margin validation data produced, where the Tarum Barat project is the project that has the most efficient cost performance compared to the LRT Diversion project which has the highest cost performance. the largest margin value. These results can be used as a reference for PT XYZ in conducting additional tool evaluations for each of its projects to determine its cost performance using a combined of DEMATEL and ANP.

Keywords: Project Cost, DEMATEL, Analytical Network Process (ANP)

1. INDUCTION

Large projects have a dependence between work on each other that is very complex, so controlling is complicated. In the implementation of a project, it is very rare to encounter a project that goes right according to the plan. Generally, there are delays in the form of time, costs, and work progress. Therefore, a control method is needed so that the project can run according to plan.

A project is said to be successful if the scope of work is carried out on time, with human resources working effectively and efficiently, and the use of the minimum possible costs. Therefore, careful planning is needed before the project is implemented. In the fourth point above, project cost can contain many definitions depending on which point of view we define it. Do we look at it from the point of view of an owner, contractor, or consultant.

Construction can be considered a dynamic industry, which constantly faces uncertainty. This uncertainty makes it difficult for management to calculate costs which sometimes leads to excessive costs. Success from a management point of view can be seen from the completion of a project with the smallest possible cost,

as quickly as possible, high quality, without accidents, and so on. But sometimes something accident occurs that can result in the overcharge of the project. This can happen due to the result of many factors such as inexperienced estimators, insufficient contractor knowledge of the project site, incorrect use of materials, incorrect provision of data, and many others.

2. METHOD

The research method is observations, interviews, questionnaires, and literature studies. The results of the data obtained will then be processed using the DEMATEL and ANP methods. The research flow chart is summarized in Figure 2.

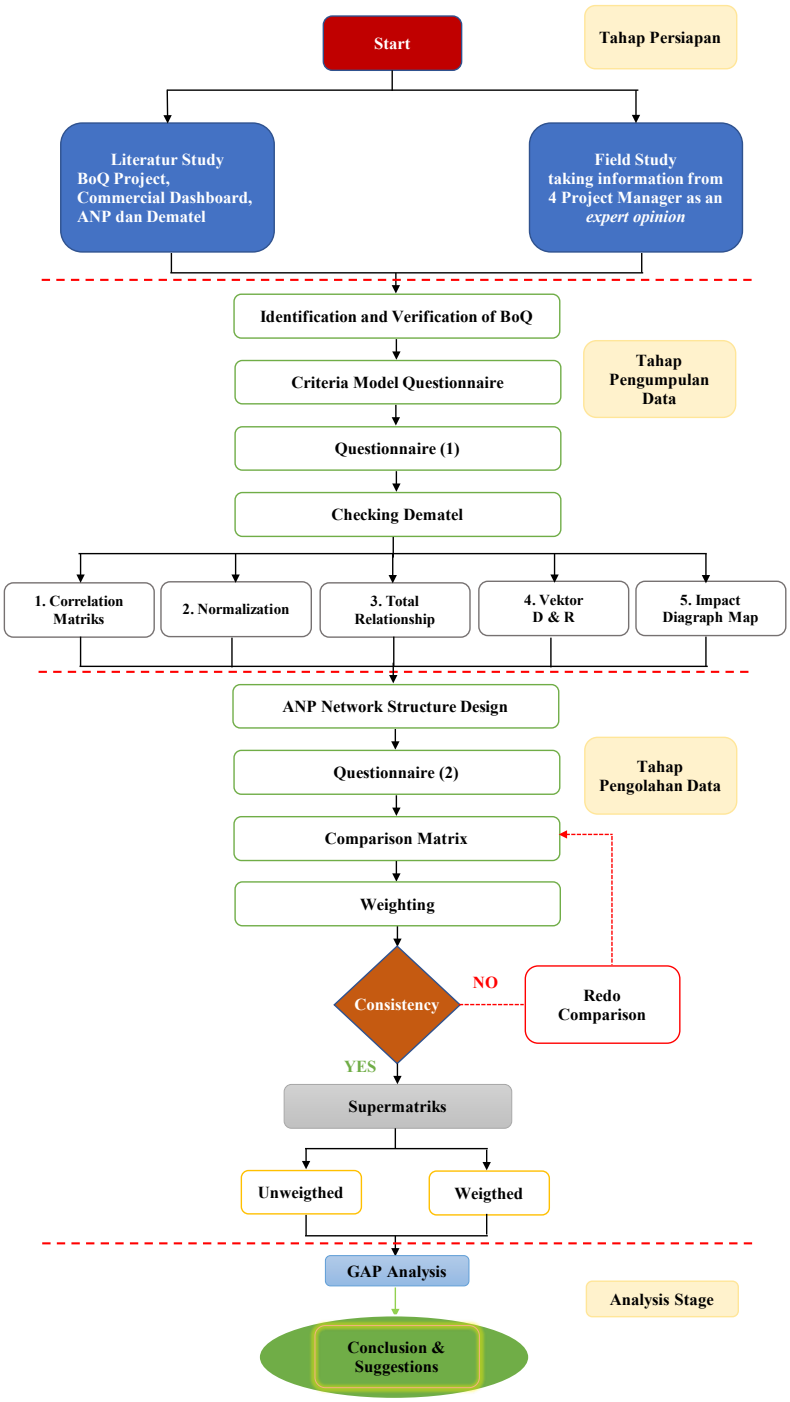


Figure 2. The Proposed research flowchart

The data collected in this study are the opinions of five experts who meet the following
requirements **:**

a. Work on the construction project.
b. the experts in this study were directly involved and understood the plans and realization of costs for each of these projects.

The five experts were selected to represent all stakeholders in determining the assessment of the construction project, namely 4 Project Managers from the four projects tested, and 4 heads of the commercial procurement section of the four projects.

According to Büyüközkan (2016), DEMATEL is able to complement the Analytic Network Process (ANP) method because DEMATEL can determine the interdependence relationship between criteria from several factors more objectively, even though DEMATEL cannot determine the weight of the criteria. The combination of the two methods, the Analytic Network Process (ANP) and DEMATEL, is very helpful for solving decision-making problems with criteria having dependence and feedback more accurately. Büyüközkan (2016) explains that the Decision-making trial and evaluation laboratory (DEMATEL) method has five main stages, including the following:

Stage 2.1: Conducting a survey of the relationship between the criteria and sub-criteria then creating a direct relationship matrix
Stage 2.2: Normalization of the relationship matrix directly
Stage 2.3: Obtaining the total relationship matrix
Stage 2.4: Calculating the vector D (dispatcher) and the vector R (receiver)
Stage 2.5: Obtain an impact-digraph map and analyze the relationship between criteria

According to Varma (2012), the threshold value is obtained from the average of all values from the T matrix (Total Relation Matrix). The threshold value determines the relationship between the criteria / sub-criteria, If the cell value in the T matrix is higher than the threshold value, then the two sub-criteria are related, for this decision. The results of the DEMATEL method are used to determine the relationship between criteria / sub-criteria in the Analytic Networking Process (ANP) method with Super Decision software. According to Büyüközkan (2016) and Kheybari (2020), how to make decisions using the Analytic Network Process (ANP) can be simplified into the following steps:

Stage 3.1: Building the model, transforming the problem into a network structure as shown in Figure 3, making a pairwise comparative survey
Stage 3.2: Determine the relative weights of each criteria and create a pairwise comparison matrix.
Stage 3.3: Calculate the Eigenvalues and Eigenvectors from the comparison matrix from step 2
Stage 3.4: Check consistency test: Consistency index (C.I) and consistency ratio (C.R) are used to estimate the consistency of pairwise comparisons
Stage 3.5: Creating a super-matrix
Stage 3.6: Creating a super-matrix weight
Stage 3.7: Creating super-matrix limiting
Stage 3.8: Obtain criteria and sub-criteria weight.

Step 4 surveys the experts to get their views about the weight of each alternative according to each criteria / sub-criteria. Step 5 synthesis of the results of the project selection ranking, is obtained from multiply criteria and sub-criteria weight (obtained in stage 3 of ANP process) with the weight of each alternative according to each criteria / sub-criteria (obtained in stage 4).

3. RESULT AND DISCUSSION

The measurement of the relationship between criteria and sub-criteria was carried out using the DEMATEL questionnaire. The following is a description of the criteria and sub-criteria as in Table 1.

Tabel 1. Description of Criteria and Sub-criteria

No	Criteria	Subcriteria
1	Cost Of Material(A)	1. Material Quality (A1) 2. Material Pricing (A2) 3. Material Type (A3)
2	Cost Of Labour (B)	1. Labor Skills (B1) 2. Total Manpower (B2)
3	Cost Of Heavy Equipment (C)	1. Equipment Productivity (C1) 2. Type Of Equipment (C2) 3. Equipment Rental Price (C3) 4. Administrative requirements (C4)
4	Cost of Vendor (D)	1. Vendor Classification (D1) 2. Quality of Work (D2) 3. Competitive Price (D3)
5	Cost Of Safety Equipment (E)	1. Type Of Safety Euipment (E1) 2. Price of Safety Equipment (E2) 3. Occupational Risk Level (E3)
6	Indirect Cost (F)	1. Salary (F1) 2. Capability (F2) 3. Working Duration (F3) 4. Supporting Tools (F4)

The questionnaire was filled in with a scale of 0, 1, 2, 3, and 4, representing no influence, less influence, moderate influence, strong influence, and very influential. The score given by the respondent is formed into a direct-relation matrix nxn as shown in the table below

Table 2. Correspondence Direct Relation Matrix

Koresponden 3 (P.Harry)		A			B		C				D			E			F1			
		A1	A2	A3	B1	B2	C1	C2	C3	C4	D1	D2	D3	E1	E2	E3	F1	F2	F3	F4
A	A1		3	4	1	1	1	1	1	2	1	4	1	1	1	1	1	1	1	1
	A2	3		3	3	2	2	4	3	3	3	2	4	1	1	1	1	1	1	1
	A3	4	3		1	1	1	1	1	1	1	4	1	1	1	1	1	1	1	1
B	B1	1	3	1		3	3	1	1	3	4	4	2	3	1	4	4	4	4	2
	B2	1	2	1	3		1	3	1	3	2	2	1	3	3	3	4	4	1	1
C	C1	1	2	1	3	1		4	4	1	3	2	1	1	1	3	1	1	3	2
	C2	1	4	1	1	3	4		4	3	4	3	1	4	1	3	1	1	3	1
	C3	1	3	1	1	1	4	4		1	4	1	4	2	2	1	1	1	1	1
	C4	2	3	1	3	3	1	3	1		4	1	1	1	1	1	1	1	1	1
D	D1	1	3	1	4	2	3	4	4	4		4	3	4	1	4	3	4	3	3
	D2	4	2	4	4	2	2	3	1	1	4		4	1	1	4	2	4	4	4
	D3	1	4	1	2	1	1	1	4	1	3	4		1	1	2	2	3	3	3
E	E1	1	1	1	3	3	1	4	2	1	4	1	1		4	4	1	1	1	1
	E2	1	1	1	1	3	1	1	2	1	1	1	1	4		2	1	1	1	1
	E3	1	1	1	4	3	3	3	1	1	4	4	2	4	2		1	1	1	3
F	F1	1	1	1	4	4	1	1	1	1	3	2	2	1	1	1		4	3	1
	F2	1	1	1	4	4	1	1	1	1	4	4	3	1	1	1	4		4	3
	F3	1	1	1	4	1	3	3	1	1	3	4	3	1	1	1	3	4		2
	F4	1	1	1	2	1	2	1	1	1	3	4	3	1	1	3	1	3	2	

Table 3. Influence Matrix

		A			B		C				D			E			F1			
		A1	A2	A3	B1	B2	C1	C2	C3	C4	D1	D2	D3	E1	E2	E3	F1	F2	F3	F4
A	A1	0,000000	0,000000	0,000000	0,000000	0,000000	0,000000	0,000000	0,000000	0,000000	0,000000	0,195384	0,000000	0,000000	0,000000	0,000000	0,000000	0,000000	0,000000	0,000000
	A2	0,000000	0,000000	0,000000	0,000000	0,000000	0,000000	0,000000	0,000000	0,000000	0,199388	0,214877	0,196721	0,000000	0,000000	0,000000	0,000000	0,000000	0,000000	0,000000
	A3	0,000000	0,000000	0,000000	0,000000	0,000000	0,000000	0,000000	0,000000	0,000000	0,000000	0,229279	0,190301	0,000000	0,000000	0,000000	0,000000	0,000000	0,000000	0,000000
B	B1	0,000000	0,000000	0,000000	0,186960	0,218552	0,212335	0,215870	0,000000	0,000000	0,261040	0,285242	0,231875	0,000000	0,000000	0,244618	0,216416	0,265370	0,239462	0,213490
	B2	0,000000	0,000000	0,000000	0,215726	0,000000	0,191446	0,187073	0,000000	0,000000	0,221698	0,236391	0,191068	0,000000	0,000000	0,208446	0,000000	0,225599	0,000000	0,000000
C	C1	0,000000	0,000000	0,000000	0,210548	0,195458	0,000000	0,229756	0,199669	0,000000	0,226363	0,263781	0,212974	0,000000	0,000000	0,228228	0,186764	0,239637	0,212441	0,199083
	C2	0,000000	0,188836	0,000000	0,226295	0,199302	0,234229	0,187712	0,217791	0,208329	0,266133	0,278275	0,240691	0,205816	0,000000	0,253540	0,203938	0,242491	0,227058	0,210283
	C3	0,000000	0,000000	0,000000	0,189012	0,000000	0,209572	0,227999	0,000000	0,000000	0,237618	0,241552	0,231977	0,000000	0,000000	0,211706	0,000000	0,218110	0,198636	0,189833
	C4	0,000000	0,000000	0,000000	0,192407	0,000000	0,000000	0,212449	0,000000	0,000000	0,239823	0,229374	0,206540	0,000000	0,000000	0,203598	0,000000	0,206386	0,000000	0,000000
D	D1	0,000000	0,208357	0,191135	0,269711	0,232464	0,238925	0,259464	0,227019	0,227843	0,229608	0,313261	0,279161	0,214053	0,000000	0,281455	0,226368	0,290280	0,251251	0,239585
	D2	0,189951	0,200618	0,208306	0,266176	0,221888	0,239513	0,246750	0,205691	0,196331	0,286465	0,236627	0,268035	0,000000	0,000000	0,264779	0,219579	0,282401	0,254783	0,239988
	D3	0,000000	0,204094	0,186769	0,236954	0,202541	0,212009	0,230357	0,208872	0,189387	0,268171	0,278567	0,191405	0,000000	0,000000	0,247422	0,203271	0,259155	0,222862	0,213336
E	E1	0,000000	0,000000	0,000000	0,000000	0,000000	0,000000	0,195584	0,000000	0,000000	0,195472	0,000000	0,000000	0,000000	0,000000	0,215960	0,000000	0,000000	0,000000	0,000000
	E2	0,000000	0,000000	0,000000	0,000000	0,000000	0,000000	0,000000	0,000000	0,000000	0,000000	0,000000	0,000000	0,000000	0,000000	0,000000	0,000000	0,000000	0,000000	0,000000
	E3	0,000000	0,000000	0,000000	0,233348	0,203700	0,223143	0,239026	0,195920	0,193783	0,261520	0,269886	0,242980	0,210634	0,000000	0,190771	0,200758	0,249316	0,213087	0,206534
F	F1	0,000000	0,000000	0,000000	0,215569	0,000000	0,000000	0,189036	0,000000	0,000000	0,209757	0,227943	0,196651	0,000000	0,000000	0,195150	0,000000	0,236460	0,211189	0,000000
	F2	0,000000	0,000000	0,000000	0,247692	0,213174	0,218476	0,224861	0,193591	0,000000	0,248118	0,264907	0,222543	0,000000	0,000000	0,231775	0,219611	0,193589	0,242242	0,201010
	F3	0,000000	0,000000	0,000000	0,225989	0,000000	0,194191	0,206612	0,000000	0,000000	0,224528	0,243611	0,204072	0,000000	0,000000	0,199096	0,200105	0,240549	0,000000	0,000000
	F4	0,000000	0,000000	0,000000	0,195159	0,000000	0,000000	0,000000	0,000000	0,000000	0,207993	0,226033	0,189770	0,000000	0,000000	0,000000	0,000000	0,200556	0,000000	0,000000

The results of the DEMATEL method in this study can be seen in Table 4. The threshold value is determined by the average value of the Total Influenced Matrix column value, which is 0.1862. Matrix column values that are equal to or greater than the threshold value are colored green, while smaller values are not colored. A value below 0.1862 means that the two criteria / sub-criteria are not related.
The pairwise comparison value can be determined between criteria/sub-criteria and between alternatives. The pairwise comparison value was obtained by using an expert questionnaire. The value of pairwise comparison will be processed by ANP using Super decision software. The weighting of each sub-criteria is obtained in table 4.

Table 4. Weight sub-criteria results from the ANP process

Name	Normalized By Cluster	Limiting	Percentage
Occupational Risk Level (E3)	0.12953	0,129531	12,95%
Quality of Work (D2)	0.11636	0,116362	11,64%
Material Quality (A1)	0.09183	0,091833	9,18%
Equipment Rental Price (C3)	0.08828	0,088282	8,83%
Equipment Productivity (C1)	0.08089	0,080886	8,09%
Vendor Classification (D1)	0.06039	0,060395	6,04%
Competitive Price (D3)	0.06015	0,060151	6,02%
Material Pricing (A2)	0.05595	0,055953	5,60%
Capability (F2)	0.05013	0,050129	5,01%
Labor Skills (B1)	0.04994	0,049937	4,99%
Administrative requirements (C4)	0.03684	0,036841	3,68%
Type Of Equipment (C2)	0.03140	0,031403	3,14%
Material Type (A3)	0.03005	0,030054	3,01%
Supporting Tools (F4)	0.02641	0,02641	2,64%
Total Manpower (B2)	0.02466	0,024665	2,47%
Working Duration (F3)	0.02207	0,022067	2,21%
Salary (F1)	0.01600	0,016004	1,60%
Type Of Safety Euipment (E1)	0.01580	0,015798	1,58%
Price of Safety Equipment (E2)	0.01330	0,013299	1,33%

The criteria that have the highest weight are the Occupational Risk Level with a value of (0.1295), followed by Work Quality (0.1164) and Material Quality (0.0918).
And from super decision software analysis the results of the best alternative project with the highest weight, the Tarum Barat Project with a value of (0.3494), followed by the Cipamingkis Project (0.3118), and the LRT Diversion Project (0.2219). Therefore, from the results of data processing, the Tarum Barat Project is the most effective and efficient project in terms of cost performance. As shown in table 5.

Table 5. global weight criteria

Name	Normalized By Cluster	Limiting	Percentage
Tarum Barat	0.34940	0,349395	34,94%
Cipamingkis	0.31175	0,311752	31,18%
LRT Divertion	0.22190	0,2219	22,19%
River Divertion	0.11695	0,116953	11,70%

4. CONCLUSIONS

Based on the results of the research and analysis and interpretation of the data carried out, it can be concluded that:

1. Performance measurement in the 4 projects namely Cipamingkis, Tarum Barat, LRT Diversion, and River Diversion using 6 criteria, namely Material, Wages, Tools, Subcontractors, Safety, and Indirect Costs, where the 6 criteria are further detailed in 19 sub-criteria.

2. The most dominant sub-criteria that affect the performance of a project based on the integration method of the DEMATEL and ANP methods are the first sub-criteria of Occupational Risk Level (0.1295), followed by Quality of Work (0.1163), Quality of Materials (0.0918) and weight the lowest is the purchase price of APD (0.0132).

3. The best project that meets the goal of cost-efficient project performance is Tarum Barat with a weight of 0.3494, followed by Cipamingkis, LRT Diversion, and finally River Diversion.

Suggestions that can be given to the company according to the results of the thesis carried out are as follows.

1. The company can pay attention to and add several other criteria and sub-criteria according to the results of the research, in order to make a project that is implemented in accordance with the company's plan, namely a project with efficient cost performance results.

2. The company can maintain and make improvements to the performance of a project in collaboration with subcontractors and vendors/suppliers because subcontractors and vendors/suppliers are criteria that make projects efficient or not. Therefore, the company should prioritize subcontractors and the best vendors/suppliers so that it can make it easier for companies to monitor the performance of a project according to the plan.

REFERENCES

Cleland, D. L , 1995 . Project Management Strategic Design and Implementation, Singapore : Mc. Graw-Hill, Inc

Fajrin, Muhammad Reza, dan Nofie Iman Vidya Kemal, (2018), Penerapan metode DEMATEL dan ANP untuk membangun basis pasokan pada pemilihan pemasok bahan baku susu bubuk studi pada PT XYZ, Universitas Gadjah Mada

Hatefi, S. M., & Tamošaitienė, J. (2018). An integrated fuzzy DEMATEL-fuzzy ANP model for evaluating construction projects by considering interrelationships among risk factors. *Journal of Civil Engineering and Management,* 25(2), 114–131. https://doi.org/10.3846/jcem.2019.8280

Muhendra, H., Hasibuan, S., & Buana, U. M. (2018). Seleksi Sub-Kontraktor Proyek Konstruksi Jalan Layang The Sub-Contractor Selection of Fly Over Construction Project. *Jurnal Manajemen Transportasi Dan Logistik, 05*(01), 43–54.

Maromi, Muhammad Izeul, (2015), Analisa kinerja biaya dan waktu pelaksanaan pada proyek pembangunan Condotel de vasa Surabaya menggunakan metode earned value, Institut Teknologi Surabaya

Novianto, Rista Dwi, dan Suparno, (2015), Evaluasi kinerja supplier dengan integrasi metode DEMATEL, ANP dan TOPSIS (Studi Kasus: PT. XYZ), Prosiding Seminar Nasional Manajemen Teknologi XXIII

Pambudi, A. S. (2018). Pemilihan Engineering Contractor Proyek Dana Hibah Energi Terbarukan Dengan Metode Dematel Dan Anp. *Bisma, 12*(2), 145. https://doi.org/10.19184/bisma.v12i2.7878

PMBOK guide (A Guide to the Project Management Body of Knowledge), 2004, Third Edition.

Soeharto, Iman , 1995. Manajemen Proyek Dari Konseptual Sampai Operasional, Jakarta : Penerbit Erlangga

Tamura, H. (2008). Pengukuran kinerja. Journal of Chemical Information and Modeling, 53(9), 287.

Trenggonowati, D. L., & Nurdiana, L. (2021*). Analisis Faktor Prioritas Penilaian Kinerja Internal dan Eksternal Divisi C & SBU di PT XYZ Menggunakan Metode Analytical Network Process (ANP)*. 6(2).

Yanuarni, Nurlita, (2021), Manajemen proyek : Studi kasus implementasi proyek fiberisasi oleh PT. XYZ, Universitas Indonesia

Gülçin Büyüközkan, Sezin Güleryüz. (2016), An integrated DEMATEL-ANP approach for renewable energy resources selection in Turkey. int. J. *Production Economics 182*, 435–448.

Varma, K., & Kumar, K. S. (2012), Criteria analysis aiding portfolio selection using DEMATEL. *Procedia Engineering 38*, 3649-3661.

Siamak Kheybari, Fariba Mahdi Rezaie, Hadis Farazmand. (2020), Analytic network process: An overview of applications. *Applied Mathematics and Computation Vol. 367*, 124780.

ANALYSIS OF THE INFLUENCE OF CELEBRITY ENDORSEMENT ON PURCHASE INTENTION ON SOCIAL MEDIA WITH PLS-SEM APPROACH ON THE SALES OF FASHION ACCESSORIES

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ABSTRACT

Celebrity advertising or also called as endorsement has become a trend in business field. It is very likely that someone would be influenced to buy an item because of advertising on social media especially by someone they like. This research analyses the influence of endorsement perception on purchase intention on social media. To evaluate and validate the result, this study adopted higher order (reflective-formative) using Partial Least Square-Structural Equation Modelling. This study used primary data from questionnaire and collected 165 respondents. The aim of this study is to be able to identify the influence of celebrity endorsement perception on social media along with celebrity endorsement value, on purchase intention and to analyze the variables that have direct and indirect effect on purchase intention. The finding suggests all hypothesis in this study are significantly supported by data collected. Celebrity endorsement perception has an impact on purchase intention and celebrity endorsement value; celebrity endorsement value has an impact on purchase intention; and celebrity endorsement perception are transmitted indirectly through celebrity endorsement value to purchase intention.

Keywords: Celebrity advertising perception, Purchase intention, PLS-SEM.

1. INTRODUCTION

Nowadays, Internet is an opportunity for business people because the internet could broaden the market to reach buyers who are not in the same city or country with seller and also save times for buyers who could not went to the store. The owner of the business could save on the cost of renting places for offline stores so small business have the easiness to build their business (Rudansky-Kloppers, 2016). A product is known by the public through promotion or advertising. It is most likely that someone would be influenced to buy an item because of a promotion on social media especially carried out by celebrities they like (Hani, et al., 2018). A promotion by celebrities of someone famous is called as endorsement. In the ease of accessing the internet there are various kinds of sales tools such as the one that is currently booming, namely social media. Social media is one of the tools that most of business people would use to developed their business. Social media that is often used nowadays in celebrity endorsement is Instagram. Endorsement is a form of advertising that involves a well-known public figure or celebrity (Times, 2022). Endorsement is one of the marketing strategies, namely advertising (Times, 2022). Today's

technological advances, business people not only endorse top celebrities but also endorse famous celebrities through social media Instagram, commonly known in Indonesia as *selebgram*.

This study focuses on the effect of social media Instagram celebrity endorsement on purchase intention. Instagram is a free photo and video sharing application that allows users to publish and share their creations with their friends or followers (Instagram, n.d.). The celebrities used in this research are Instagram celebrities or celebrities who are in the macro influencer level. A macro influencer is an influencer who has a following on social media around 40,000 to one million (Redcomm, 2021). This research focused on the market of fashion jewelry accessories from Alloy.

In this research, the framework of this research is adapting from the framework proposed by (Sharma, et al., 2021). In the research of (Sharma, et al., 2021), they proposed a framework of SMS advertising which has five elements in it which are credibility, entertainment, informativeness, irritation and message relevance. The research question of this research is to understand the influence of social media celebrity endorsement on purchase intention. The aim of this study is to identify the celebrity endorsement in social media, analyzing the influence of celebrity endorsement on purchase intention. The data in this study acquired from data primer which is questionnaire and were analyzed using Structural Equation Modeling (SEM). The limitation of this study is the data used is a questionnaire filled out by customers who had purchased fashion accessories online on Instagram and customers who had seen advertisements/endorsements of fashion accessories made from Alloy from Instagram celebrities with number of followers less than one million.

2. LITERATURE REVIEW

This chapter describes the theoretical basis as a supporter in the analysis of this study. Purchase intention is a target after advertising by endorsement. This study investigated the influenced of celebrity endorsement perception on purchase intention mediated with celebrity endorsement value.

2.1 Celebrity Endorsement Perception

Consumer perception of endorsement have a crucial factor in building positive attitudes towards brands and could lead to a desire to buy (Akkaya, et al., 2017). This research uses a research model based on Stimulus-Organism-Response where perception is a stimulus and there are five factors that could influence a person's perception namely credibility, entertainment, informativeness, irritation, and message relevance (Sharma, et al., 2021).

Based on previous research, one of the important factors in celebrity endorsement is credibility (Weismueller, et al., 2020). The credibility of a celebrity refers to the extent to which the source is considered to have expertise and can be trusted to provide an objective opinion on the subject (Goldsmith, et al., 2000). In this study, the credibility factor is used as one of the measurements of celebrity endorsement perception. In measuring credibility, it is seen from how much consumers believe in the advertisements displayed with the celebrity. So far, the credibility of a celebrity can be seen through the way they endorse a product or service. As stated by (Wang & Scheinbaum, 2018), when consumers believe in a celebrity, they will see the celebrity as a credible person.

Entertainment in endorsement is one of important thing because watching an interesting and entertaining advertisements could increase consumer loyalty and easily to be remembered. Moreover, the positive value would be higher if the advertisement entertains the audience (Liu, et al., 2012).

Information is considered as valuable thing in online marketing because it is received positively by the audience (Liu, et al., 2012). The informative aspect is the ability of advertisements to display information that is up-to-date, timely, and easily accessible. Informative features of advertisements influence consumer satisfaction and consumer purchasing decisions, besides that it is also considered a major factor in consumer acceptance of advertisements (Akkaya, et al., 2017).

In a study of American consumers, Bauer and Greyser (1968) showed that the main reason people criticize advertising is related to the disturbance or irritation it causes so that irritation is a negative emotion that arises and can affect the perceived value of the advertisement (Liu, et al., 2012).

Content relevance is the extent of a person's interest when he sees the advertisements that appear (Chang, 2013). Thus, the relevance of content in advertisements will be high if it is in accordance with the interests and preferences of consumers. The relevance of advertising content can affect how consumers respond to these advertisements, such as consumers will display a positive attitude towards advertisements if it is in accordance with their interests (Tseng & Teng, 2016).

2.2. Celebrity Endorsement Value

The theory about advertising value that is quite well known is Ducoffe (1995) which is a measure of the effectiveness of advertising and can also function as an index of customer satisfaction (Liu, et al., 2012). Research from Bauer and Greyser (1968) shows that consumers tend to agree with advertisements when they realize that the advertisements provide a lot of information well (Jung, et al., 2015). The conclusion that can be drawn is that advertising has effectiveness and customers are satisfied so that there is a positive value that appears. Research by Ducoffe (1996) on online advertising shows that advertising becomes more effective to Internet users if the information provided is more relevant. After that Ducoffe (1996) also found that attitudes towards advertising will be directly related to perceived pleasure (Jung, et al., 2015).

2.3. Purchase Intention

Grewal, Monroe, and Krishnan (1998) define purchase intention as a possibility that exists in the hands of customers who intend to buy a certain product, while Zeithamal (1988) finds that the customer's decision to buy a product is highly dependent on the value of the product and the recommendations shared by other consumers, for example on social media (Dehghani & Tumer, 2015). Analysis of purchase intention needs to be done to see how effective the advertising has been so that it can improve further marketing strategies (Kay, et al., 2020). Purchase intention can be used to test the implementation of a new marketing strategy to help managerial whether the concept is worth pursuing further and also decide which geographic market and consumer segment to target (Morwitz, et al., 2007).

2.4. Hypothesis

There are four hypothesis which are three direct impact and one indirect impact, which are below.

H1: Celebrity endorsement perception has a positive impact on celebrity endorsement value
H2: Celebrity endorsement perception has a positive impact on purchase intention
H3: Celebrity endorsement value has a positive impact on purchase intention
H4: Celebrity endorsement value mediates the casual relationship of celebrity endorsement perception and purchase intention.

3. METHODS

To obtain research data, a certain approach is needed. This study investigates how the influence of Celebrity Endorsement on Purchase Intention on social media; therefore, a suitable approach is to use quantitative methods in analyzing and interpreting the data. This study uses a questionnaire as a tool to obtain the required data from the population or sample. The final results in this study are numerical and concluded and described in narrative form. This study aims to see the influence of celebrity advertising on purchase decisions on social media.

The framework proposed in this study is using type two higher-order construct (reflective-formative). To analyze the data in the research is using Structural Equation Modeling (SEM), with three assessment which are assessment measurement model reflective, assessment measurement model formative, and assessment structural model (Hair, et al., 2019).

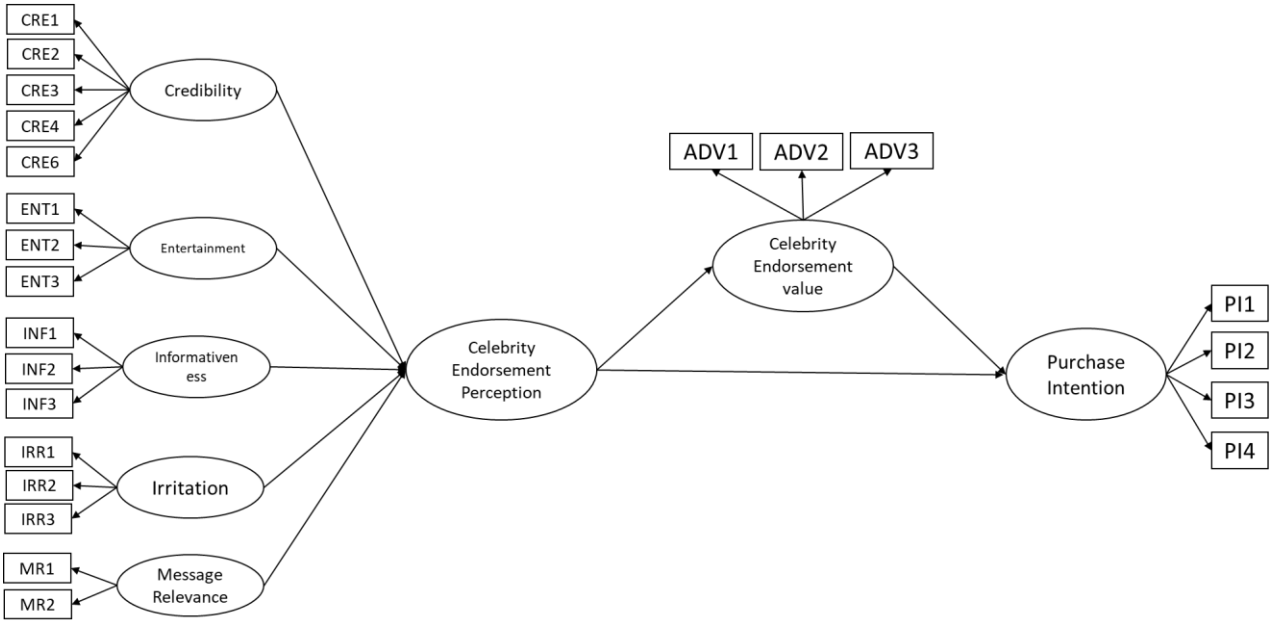


Figure 1. Framework of the study

4. RESULTS

This section of this study describes the survey results, questionnaire data processing and application using Structural Equation Modeling (SEM) Partial Least Square (PLS) and also the process analyzing the data from assessment of measurement model and assessment of structural model. The results from PLS-SEM in this study were interpreted to obtained the qualitative explanation to answer the hypothesis research.

4.1. Data Collection

This is a quantitative study based on data questionnaire. Data was collected using google form survey. Data were collected using a purposive sampling approach, to capture respondents for data collection, this study used social media Instagram as a mean to spread the survey. There is screening question to ensure the respondent's eligibility, such as: "Have you bought a fashion jewelry made from Alloy?" and "Have you seen an endorsement in Instagram which advertise fashion jewelry made from Alloy?". The items in the research instrument were based a five-point Likert scale. The data collection process is between June 13th – June 16th 2022 and collected 165 respondents.

Table 1. Respondents Demographic Profile

Profile	Characteristics	Frequency	Percentage
Age	< 18	14	76%
	18 – 25	125	16%
	26 – 33	26	8%
Sex	Female	156	95%
	Male	9	5%

4.2. Data Analysis and Results

PLS-SEM method is used to deal with higher-order reflective-formative constructs. As suggested by (Hair, et al., 2019), two-step approach to data analysis has beed adopted. The measurement model was assessed in the first step and the structural model was evaluated in the second step.

4.2.1. Assessment of the reflective construct

The measurement model is tested from the score of outer loadings, construct reliability, average variance extracted (AVE), and discriminant validity (Hair, et al., 2019). The score of outer loadings have to be > 0.708, construct reliability are seen from the score of Cronbach Alpha > 0.7, AVE > 0.5, and discriminant validity seen from cross loadings (Hair, et al., 2019). In the first running, five indicator of the outer loadings of the first-order reflective construct are under 0.708 so it must be deleted from the construct. The second running all indicator have scores > 0.708. The result for construct reliability and AVE are shown in the Table 2. The result shows that all indicators have scores Cronbach's Alpha > 0.7 and AVE > 0.5. For discriminant validity, the scores shown in the appendix of cross-loadings result.

Table 2. Cronbach's Alpha, Composite Reliability, AVE Score

	Cronbach's Alpha	Composite Reliability	Average Variance Extracted (AVE)
Celebrity Endorsement Perception	0.942	0.949	0.61
Celebrity Endorsement Value	0.892	0.933	0.822
Credibility	0.919	0.937	0.711
Entertainment	0.883	0.927	0.81
Informativeness	0.856	0.912	0.776
Purchase intention	0.844	0.896	0.686

4.2.2. Assessment of formative construct

As suggested by (Sharma, et al., 2021), the first step of analysis is to used to attain the latent variable score using repeated indicator approaced and in the second step is to calculate the

weight and significance by using the latend variable obtained from PLS algorithm. To analyze the formative construct VIF and significance of the indicator weight were used. The VIF value need to be bellow 5 which means that there is no multicullinearity. To analyze the significance of the weight we see from the score of t-statistics which need to be more than 1.96.

Table 3. Higher-Order Construct

Higher-order construct		VIF	t-statistics
Celebrity Endorsement Perception	Credibility	2.081	51.552
	Entertainment	2.881	74.766
	Informativeness	2.937	61987

4.2.3. Assessment of structural model

To evaluate the results of structural model as suggested by (Hair, et al., 2019), we evaluated the significance of the path coefficient, the R-square, the effect size, and Q-square. The path coefficient is significance when the t-statistics > 1.96. The R-square classified into three which are 0.75 = substantial, 0.50 = moderate, 0.25 = weak. The effect size classified into three which are 0.2 (small), 0.15 (medium), 0.35 (large). The Q-square score need to be more than zero. The results show that the scores of t-statistics in the path coefficient all direct and indirect hypothesis are significance. The last is SRMR score and NFI scores. The SRMR scores must be < 0.10 and in this study the result is 0.064 which is under 0.10. For the NFI scores, the result in this study is 0.882 which means that the model is 88% better than the null model

Table 4. Path Coefficient and Effect Size (f Square)

	Original Sample (O)	Standard Deviation (STDEV)	T Statistics (|O/STDEV|)	P Values	f Square
DIRECT					
Celebrity endorsement perception -> celebrity endorsement value	0.763	0.034	22.517	0	1.395
Celebrity endorsement perception -> purchase intention	0.546	0.07	7.772	0	0.318
celebrity endorsement value -> purchase intention	0.279	0.077	3.621	0	0.083
INDIRECT					
Celebrity endorsement perception -> celebrity endorsement value -> purchase intention	0.213	0.061	3.472	0.001	

Table 5. R Square and Q Square (Blindfolding)

Variabel	R Square	Q Square
Celebrity Endorsement value	0.582	0.473
Purchase Intention	0.608	0.408

4.2.4. Discussion

This study analyzes the influenced of celebrity endorsement perception on purchase intention. The hypotheses of this study include the direct and indirect effect. The findings in these study supports all the stated direct hypotheses and indirect hypotheses. The result suggest that celebrity endorsement perception has a significant positive impact on celebrity endorsement value and purchase intention. Celebrity endorsement perception is consumers' perceptions of celebrity endorsement or advertisements with celebrities. In the analysis of this research, there are five elements used, namely credibility, entertainment, informativeness, message relevance, and irritation. In conclusion, the greater the value of consumer perceptions of an advertisement, the greater the desire to buy goods/services in the advertisement. In previous research by (Sharma, et al., 2021), also shows that perception of consumer had a positive significant impact on the purchase intention directly and indirectly.

The next analysis in the study attempts to assess the indirect effect of celebrity endorsement value between celebrity endorsement perception and purchase intention. The results confirmed the existence of a mediating effect of celebrity endorsement value. Celebrity endorsement value is a value that given by consumer while seeing the advertisement. The greater scores of values that given the greater desire to buy goods/service. As resulted in Table 4, the t-statistics of indirect effects did not reveal strong mediating impact. The t-statistic of direct effect of celebrity endorsement perception towards purchase intention are higher.

This research shows that endorsement is a good way to promote product/service. When people see the endorsement with someone who they trust their credibility and it is fun to watch, the intention to buy the product/service is rising. To know the public target and promote using the right endorser might increase sales. For examples, endorsing a sport product to athlete. The followers of the athlete might be someone whom are into sports. So, choosing the right endorser also impact the increase sales because based on this study, endorsement significantly influence purchase intention.

5. CONCLUSIONS

Celebrity endorsement perception is validated as a higher order construct in this study. Based on this study, the celebrity endorsement perception has a direct effect on celebrity endorsement value and purchase intention; celebrity endorsement perception has a direct effect on purchase intention; celebrity endorsement value has a direct effect on purchase intention; and celebrity endorsement perception is transmitted indirectly to purchase intention through celebrity endorsement value. All direct and indirect hypotheses are supported by the study's findings. The findings in this study contribute the knowledge in the field of social media advertising by exploring how endorsement effect purchase intention.

REFERENCES

Akkaya, D. T., Akyol, A. & Simsek, G. G., 2017. The Effect of Consumer Perceptions on Their Attitude, Behaviour and Purchase Intention in Social Media Advertising. *Marmara Üniversitesi İktisadi ve İdari Bilimler Dergisi,* 39(II), pp. 361-388.

Chang, Y., 2013. Age Matters: Short message service advertising reading behaviors. *International*

Journal of Mobile Communications, 11(2), pp. 159 - 175.

Dehghani, M. & Tumer, M., 2015. A research on effectiveness of Facebook advertising on enhancing purchase intention of consumers. *Computers in Human Behavior,* Volume 49, pp. 597-600.

Goldsmith, R. E., Lafferty, B. A. & Newell, S. J., 2000. The Influence of Corporate Credibility on Consumer Attitudes and Purchase Intent. *Corporate Reputation Review,* 3(1), pp. 304-318.

Hair, J. F., Black, W. C. & Babin, B. J. A. R. E., 2019. *Multivariate Data Analysis.* Eight Edition ed. United Kingdom: Annabel Ainscow.

Hani, S., Marwan, A. & Andre, A., 2018. The effect of celebrity endorsement on consumer behavior: Case of the Lebanese jewelry industry. *Arab Economic and Business Journal,* Volume 13, pp. 190 - 196.

Instagram, n.d. [Online]
Available at: https://help.instagram.com
[Accessed 7 March 2022].

Jung, J., Shim, S. W., Jin, H. S. & Khang, H., 2015. Factors affecting attitudes and behavioural intention towards social networking advertising: a case of Facebook users in South Korea. *International Journal of Advertising,* 35(2), pp. 248-265.

Kay, S., Mulcahy, R. & Parkinson, J., 2020. When less is more: the impact of macro and micro social media influencers' disclosure. *Journal of Marketing Management,* 36(3-4), p. 248–278..

Liu, C.-L. E., Sinkovics, R. R., Pezderka, N. & Haghirian, P., 2012. Determinants of Consumer Perceptions toward Mobile Advertising — A Comparison between Japan and Austria. *Journal of Interactive Marketing,* Volume 26, pp. 21-32.

Morwitz, V. G., Steckel, J. H. & Gupta, A., 2007. When do purchase intentions predict sales?. *International Journal of Forecasting,* Volume 347–364, p. 23.

Redcomm, 2021. *Knowlegde - Influencer.* [Online]
Available at: https://redcomm.co.id/knowledges/5-tingkatan-influencer-yang-harus-anda-kenali-agar-tak-salah-pilih?readmore=true
[Accessed 8 April 2022].

Rudansky-Kloppers, S., 2016. Key factors influencing the online buying decision when purchasing products in specific product categories. *African Journal of Science, Technology, Innovation and Development,* pp. 2042-1346.

Sharma, A., Dwivedi, Y. K., Arya, V. & Siddiqui, M. Q., 2021. Does SMS advertising still have relevance to increase consumer purchase intention? A hybrid PLS-SEM-neural network modelling approach. *Computers in Human Behavior,* Volume 124, p. 106919.

Times, T. E., 2022. *Definition of Endorsements.* [Online]
Available at: https://economictimes.indiatimes.com/definition/endorsements
[Accessed 7 March 2022].

Tseng, F. C. & Teng, C. I., 2016. Carefulness Matters: Consumer Responses to Short Message Service Advertising. *International Journal of Electronic Commerce,* 20(4), pp. 525-550.

Wang, S. W. & Scheinbaum, A. C., 2018. Enhancing Brand Credibility Via Celebrity Endorsement: Trustworthiness Trumps Attractiveness and Expertise. *Journal of Advertising Research ,* 58(1), pp. 16-32.

Weismueller, J., Harrigan, P., Wang, S. & Soutar, G. N., 2020. Influencer endorsements: How advertising disclosure and source credibility affect consumer purchase intention on social media. *Australasian Marketing Journal.*

IT GOVERNANCE FOR SECURING MANAGEMENT INFORMATION SYSTEM IN INDUSTRIAL ESTATE USING ISO 27001:2013

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ABSTRACT

As the estate management of the industrial area in Gresik, PT. XYZ has obligation to provide internet service providers. Within "Perizinan Berusaha Berbasis Risiko", one of the requirements that must be fulfilled by PT. XYZ, is the need for measuring information security and protection of services provided. In order to guarantee and ensure the information security and protection of the provision for the internet service, thereby increasing the level of customer trust and potentially increasing the company's business performance, a standard framework is needed that can provide an overview to measure how the condition and readiness of PT. XYZ regarding those matter. In this case, the framework is based on the ISO 27001:2013 standard, namely Information Security Management System. This study uses a descriptive analysis method in the form of a check list and interviews with related parties in the IT Department of PT. XYZ to identify and analyze the condition and readiness of PT. XYZ in the plan to implement an Information Security Management System based on the ISO 27001:2013 standard, which can ensure the security and protection of internet service provider for industrial companies/tenants. The result will be concluded in percentage of conformity with the standard.

Keywords: Industrial estate management, internet service provider, information security management systems, ISO 27001:2013.

1. INTRODUCTION

Ability to access and to provide information quickly and accurately becomes very essential and critical for the company nowadays. The information quickly could spread all over the world, so an extra attention is needed to the factors of security and confidentiality from a data and information. Given the importance of the data, then information security must be created as optimal as possible. Moreover, lately there are many online crimes that often target important data and information to be used in criminal activities. For example, there are customer data and information from an organization that misused (example: around the end of 2021 and the beginning of this year news spread leakage of customer data of BPJS, BRI, Bukalapak and Tokopedia), then not only loss-making customers, but also the organization/company itself. To address the occurrence of information security breaches, it is a challenge for organizations or companies that need to find a method or a way to anticipate and deal with it (Bobbert &Mulder, 2015). That's why information security must really be pay attention so that there is no manipulation of data, destruction, hacking or destruction of information illegally.

In several previous studies, among others by (Mirtsch, et al.,2021); (Ki-Aries & Faily, 2017) and (Szczepaniuk, et al., 2020), explained that the Information Security Management System can be used to find out how is the condition of information system security in an organization that is adapted to the framework of the ISO 27001:2013 standard. The adjustments method can use gap analysis, descriptive analysis or evaluation in the form of an assessment or checklist as a tool.

Research that have been done before were in companies, government agencies, academies education and higher education at home and abroad. The result were in the form of percentage of compliance with iso 27001:2013 standards, values at a certain level or the measurement score of the information security management system as a reference. So as an estate management of the industrial area in Gresik, PT. XYZ intend to measure its information security level of compliance aligned with the ISO 27001:2013.

2. LITERATURE REVIEW

Disterer (2013) suggested that Information and information systems are important and become foundation for the company. Especially nowadays with more transfers and utilization of internal and inter-company data, the network becomes open and increase the potential risk to information and information systems. In order to reduce risk and avoid losses to the company, care needs to be taken to ensure adequate information security to address them. Information security is a concept related to the efforts made in order to protect information to defend its values against organizations and individuals (Silva, et al., 2012) and (Peltier, 2016).

While Zammani & Razali (2016), stated organizations that have problems with information security deficiencies, will usually be vulnerable to a large number of security breaches and incidents. In the current era of globalization, protection of information security is important to ensure sustainability of a company's business. Based on previous research by Omar (2021), which aims to present an information security management system model and knowing its current state, resulting in an information security structure and necessary resources, information assets, technical vulnerabilities and risks applied to all identifiable processes.

The complexity of business transactions requires enabling technology its users to manage information appropriately, relevantly and accurately. Currently with the continuous advancement of technology, new challenges and threats have emerged related to business information and information assets, such as the processing, storage and distribution of information to organizations. Information technology executives are looking for technology solutions to face the situation (Singh, et al., 2014).

If you want to achieve an information security that must be taken from the activity which implies compliance with laws, security policy, business functions, organizational structure and management commitment to introduce and invest in systems to manage information security – then necessary Information Security Management System - ISMS (Sikman, 2019). ISMS is a process and not a product, in which case it can be defined as a process that aims to identify and minimize information security risks to an acceptable level, the process must be manageable in accordance with established standards. ISMS is a continuous process that involves planning, implementing, monitoring and improving Information Systems activity (Singh, A. N., 2014).

To ensure the information is in a well-maintained state and the vision, mission and goals of the company can be achieved, the organization needs to have an effective management of information systems. At the initial stage of the implementation of information system management, top management must establish information system policies in accordance with

organizational goals. The information system policies are key requirements in information system management (Pathari, V., 2021).

The International Organization for Standardization (ISO) has introduced this standard with the concept of "Management System" into the field of information security, which is in line can be said to be the status of the device taken from the system that qualified to store/maintain information security processes. ISO 27001 is a special method structured on securing internationally recognized information. ISO 27001 is a document standard of the Information Security Management System, called ISMS, which provides a general overview about what a company should do in business to evaluate, implement and maintain information security systems in the company based on best practices in information security.

Information security is a process of protecting information to ensure several things as follows:

a. Confidentiality: ensuring that information can only be accessed by authorized parties
b. Integrity: ensuring that information remains accurate and complete, as the information is not modified without an explicit authorization
c. Availability: ensuring that information is accessible by authorized parties when needed

This information security can be achieved by carrying out a control consisting of policies, processes, procedures, organizational structures, and functions of information technology infrastructure.

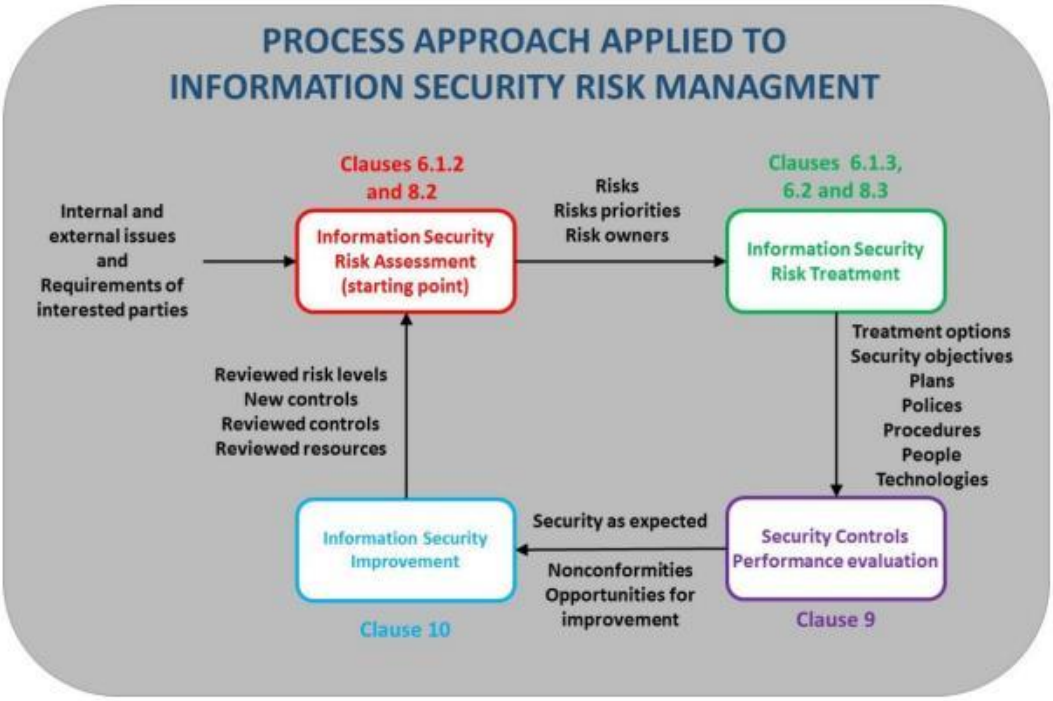


Figure 1. Process approach applied to information security risk management (Source : ISO/IEC 27001)

Important information security risks that affect the company originate of human behavior. Man is considered the biggest drawback factor of information security according to (Curry, 2018) and Da Silva (2011). For this reason, Information protection should not only consider technical issues, but also need to pay attention to social issues, for which there is no pure technology that

known at this time. Therefore, it is necessary to take steps towards information security which should not only discuss technology and physical issues, but also to address administrative problems, which change human behavior in a organization/company. The international standard ISO 27001 is the leading standard of the ISO 27000 series and contains the requirements of an ISMS. It has been presented as a model for the design, establishment, implementation, operation, monitoring, control, maintenance, and continuous improvement of ISMS information in any kind of organization.

3. METHODS

From the formulation of the existing problem and based on the reference framework of the ISO 27001:2013 standard, the next steps are identified and contrasted with the clause requirements of the ISO 27001:2013 standard. In this stage, it is carried out by observation and interview with IT experts in the company, using checklist criteria based on the clause requirements in the ISO 27001: 2013 standard as seen on Table 1. Each item should be classified in one of the states described in Table 1. This is to identify the suitability of the system, documents and other supports within the company. Annex A of the ISO 27001:2013 standard also used as control objectives and controls of this research.

Table 1. Check List Criteria

Description	Status Code
Process is defined / documented and practiced / implemented, comply with the requirements of the standard, It Complies 100%.	**Fully Implemented**
Process is practiced / implemented without adequate documentation; Process must be defined / documented to ensure repeatability of process and mitigate the risks. It meets around 50%.	**Partially Implemented**
Process is not defined and not practiced/implemented. It complies with 0%.	**Not Implemented**

4. RESULTS

Based on an interview with IT experts using checklist diagnosis of the clause requirements in the ISO 27001: 2013 standard to know the current status of compliance, below are the results as shown in Table 3 and using evaluation criteria established in Table 1. Table 3 partially shows the tool for measurement. According to the review carried out on each of the minimal and mandatory requirements of numerals four to ten of the ISO 27001:2013 standard, the summary of the level of compliance is presented in Table 2.

Table 2. Compliance level with the clause requirements ISO 27001:2013 standard

Requirements	Complies	Not Complies
Context Organization	25,00%	75,00%
Leadership	77,27%	22,73%
Planning	12,00%	88,00%
Support	52,00%	48,00%
Operation	6,00%	94,00%
Performance evaluation	0,00%	100,00%
Improvement	0,00%	100,00%
	24,61%	**75,39%**

Table 3. Measurement Result of Compliance Status with the clause requirements ISO 27001:2013 standard

ISO 27001 clause	Mandatory requirement for the ISMS	Status	Notes on Your Findings
	Context Organization		
4,1	**Understanding the organization and its context**		
4,1	The organization shall determine external and internal issues that are relevant to its purpose and that affect its ability to achieve the intended outcome(s) of its information security management system.	**Not Implemented**	There are no internal issues and external issues identifed for ISMS
	Leadership		
5,1	**Leadership and commitment**		
5,1	Management shall provide evidence of its commitment to the establishment, implementation, operation, monitoring, review, maintenance and improvement of the ISMS by:	**Partially Implemented**	Information security policies need to be defined in general terms to cover the entire scope to be implemented in ISMS
5.1 (a)	ensuring the information security policy and the information security objectives are established and are compatible with the strategic direction of the organization;	**Fully Implemented**	Information security policies need to be defined in general terms to cover the entire scope to be implemented in ISMS
5,3	**Organizational roles, responsibilities and authorities**		
5,3	Top management shall ensure that the responsibilities and authorities for roles relevant to information security are assigned and communicated.	**Not Implemented**	Information Security is still vacant, it needs to be followed up according to the needs of the company
	Planning		
6,1	**Actions to address risks and opportunities**		
6.1.1	**General**		
6.1.1	When planning for the information security management system, the organization shall consider the issues referred to in 4.1 and the requirements referred to in 4.2 and determine the risks and opportunities that need to be addressed to: a) ensure the information security management system can achieve its intended outcome(s); b) prevent, or reduce, undesired effects; and c) achieve continual improvement	**Not Implemented**	4.1 and 4.2 should be defined as the basis for planning in determining the risks and opportunities that need to be addressed in the ISMS
	Support		
7,1	**Resources**		
7,1	The organization shall determine and provide the resources needed for the establishment, implementation, maintenance and continual improvement of the information security management system.	**Partially Implemented**	Availability of Information Security personnel needs to be defined
	Operation		
8,1	**Operational planning and control**		
8,1	The organization shall plan, implement and control the processes needed to meet information security requirements, and to implement the actions determined in 6.1. The organization shall also implement plans to achieve information security objectives determined in 6.2.	**Not Implemented**	It has not been established of planning, implementation and control of processes necessary to comply with the information security requirements
	Performance Evaluation		
9,1	**Monitoring, measurement, analysis and evaluation**		
9,1	The organization shall evaluate the information security performance and the effectiveness of the information security management system. The organization shall determine:	**Not Implemented**	There is no monitoring, measurement, analysis and evaluation regarding information security management system
9,3	**Management review**		
9,3	Top management shall review the organization's information security management system at planned intervals to ensure its continuing suitability, adequacy and effectiveness. The management review shall include consideration of:	**Not Implemented**	Top management has not periodically review the suitability, adequacy and effectiveness of the information security management system
	Improvement		
10,2	**Continual improvement**		
10,2	The organization shall continually improve the suitability, adequacy and effectiveness of the information security management system.	**Not Implemented**	The organization has not yet continually improve the suitability, adequacy and effectiveness of the information security management system.

Refer to measurement result of compliance status with ISO 27001:2013 standard, clause number four to ten, the organization only define and consider compliance with the information security requirements in the IT Department. In other Department of the organization, aspects of information security have not been defined and considered within the procedures, process and other documented information.

Context of the organization which covered external and internal issues, needs and expectations of interested parties, determining scope of the information security management system and establishment, implementation, maintenance and continually improvement of information security management system complies 25% with the standard. Leadership including commitment, policy, organizational roles, responsibilities and authorities complies with the standard 77,27%. Planning consist of action to address risks and opportunities, information security objectives and planning to achieve them, complies 12% with the standard. Support which covered resources, competence, awareness, communication and documented information, complies with the standard 52%. Operation including operational planning and control, information security risk assessment and information security risk treatment, complies 6% with the standard. While performance evaluation and improvement are 0% complies with the standard. Performance evaluations including monitoring, measurement, analysis and evaluation, internal audit, and management review. Improvement consist of nonconformity and corrective action and continual improvement.

Based on Annex A of the ISO 27001:2013 as reference control objectives and controls listed, there are statement of applicability that have been confirmed by expert from IT Department.

Table 4. Control objectives and controls required by the standard and met by organization

	Control objectives and control	**Actual**	**Ideal**
A1	Information security policies	2	2
A2	Organization of information security	1	6
A3	Human resource security	6	6
A4	Asset management	6	10
A5	Access control	12	14
A6	Cryptography	0	2
A7	Physical and environmental security	9	15
A8	Operations security	9,5	14
A9	Communications security	4	7
A10	Systems acquisition, development and maintenance	4	13
A11	Suppliers relationships	0	5
A12	Information security incident management	0	7
A13	Information security aspects of business continuity management	1	4
A14	Compliance	4	8

Table 4 above presented the actual conditions versus ideal conditions required by the standard especially in Annex A ISO 27001:2013 as reference control objectives and controls. The information are obtained from the statement of applicability stated previously.

While figure 2 described the global report of compliance and maturity of the organization regarding control objectives and controls that ideal condition is still need to be achieved and implemented by the organization with comprehensive define, planning, implementing, monitoring,

measuring, analyzing, evaluating and auditing as well as reviewed by top management of the organization.

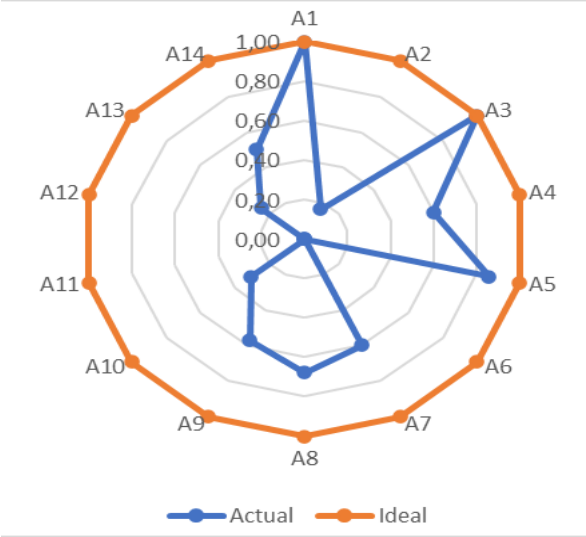


Figure 2. Control objectives standard (Ideal) vs control objectives that met by the organization (Actual)

6. CONCLUSIONS

In this research, a framework for measuring information security management system was proposed and applied in the organization of industrial estate management using ISO 27001:2013 standard. The results and data gained from the framework in the organization were successful. It is allowed the organization to know and analyze its current condition according to the requirements and control objectives of the standard. Additionally, technical vulnerabilities, information assets and risks applied to all process were identified.

Based on clause requirements ISO 27001:2013 standard, then refer to data and explanation above, the level of compliance of the organization presented 24,61% fulfillment and 75,39% non-fulfillment. This means that PT. XYZ as industrial estate management still need to get and achieve to fulfill manpower, infrastructure, financial, documents and others that required by the standard. Then control objectives standard that met by the organization is presented in the Table 4.

REFERENCES

Bobbert, Y. & Mulder, H., 2015. Governance practices and critical success factors suitable for busisness information security. Computational Intelligence and Communication Network, 7(2), pp. 1097-1104.

Curry, M. M. B. C. R. E. a. C. J., 2018. InfoSec Process Acrion Model (IPAM) : Systematically Addressing Individual Security Behavior. The Data Base fo Advances in Information Systems, 49(April), pp. 49-66.

Diesch, R., Pfaff, M. & Krcmar, H., 2020. A comprehensive model of information security factors for. Computers & Security, 92(2), pp. 1-21.

Disterer, G., 2013. ISO/IEC 27000, 270001 and 27002 for Information Security Management. Journal of Information Security, 4(April 2013), pp. 92-100.

ISO/IEC27001, 2013. Information Technology - Security Techniques - Information Security Management Systems - Requirements. 2 ed. Switzerland:ISO/IEC.

Ki-Aries, D. & Faily, S., 2017. Persona-centred information security awareness. Computers & Security, 70(9), pp. 663-674.

Mirtsch, M., Blind, K., Kocha, C. & Dudek, G., 2021. Information security management in ICT and non-ICT sector companies: A preventive innovation perspective. Computers & Security, 109(10), pp. 1 - 22.

Omar, Fonseca-Herrera, Rojas, A. E. & Florez, a. H., 2021. A Model of an Information Security Management System Based on NTC-ISO/IEC 27001 Standard. *IAENG International Journal of Computer Science,* 48(2), pp. 1-10.

Peltier, T. R., 2016. Information Security Policies, Procedures and Standards: guidelines for effective information security management. 1 ed. Florida: USA:CRC Press.33

Sikman, L. L. T. a. P. D., 2019. ISO 27001 – Information Systems Security, Development, Trends, Technical and Economic Challenges. International Journal of Engineering, XVII(November), pp. 45-48.

Silva, L., Costa, A. P., Poleto, T. & Moura, J., 2012. An analysis of and perspective on the information security maturity model: A case study of a public and a private sector company. Information Systems, 3(2), pp. 1684-1694.

Singh, A. N., Gupta, M. & Ojha, A., 2014. Identifying factors of "organizational information security management". Enterprise Information Management, 27(5), pp. 644-667.

Szczepaniuk, E. K., Szczepaniuk, H., Rokicki, T. & Klepacki, B., 2020. Information security assessment in public administration. Computers & Security, 90(7), pp. 1 - 11.

Zammani, M. & Razali, R., 2016. An Empirical Study of Information Security Management Success. Advanced Science Engineering Information Technology, 6(6), pp. 904-913.

The Influence of Work Environment, Management Support, Corporate Culture And Employee Engagement on Job Satisfaction And Employee Performance: A Sampling in SEM AMOS Modelling

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ABSTRACT

This studied explore the link between work environment, management support, corporate culture and employee engagement on job satisfaction and employee performance at LNG Company, sector considering direct, indirect with mediated interaction. Data were obtained from 268 employees at LNG Company. Data were obtained from 268 employees from selected employee catagories through proportional random sampling. However, 268 responses were deemed accurate and therefore used in the analysis. In the analytical process, SPSS and AMOS based on Structural Equation Modeling (SEM) were employed. From the findings, the studied data models met internal consistency reliability and convergent. Management support and employee engagement have significant effect on job satisfaction as mediation on employee performance variables. In addition, work environment, corporate culture and job satisfaction have significant effect on employee performance. It was statistically significant at p<0,06. However, work environment and corporate culture have not significant direct effect even though they are mediated by job satisfaction, also management support and employee engagement have not significant effect on employee performance. Based on the findings, it's recommended to entail valuing worker's contributions, communicating the company's progress, gain the function of supervise and empowerment. The workplace of all the factors could increase worker's engagement and lead to increased productivity.

Keywords: Work Environment, Job Satisfaction, Employee Performance, SEM-AMOS, LNG Company.

1. INTRODUCTION

In light of challenging substantial change circumstances, any establishment's sustainable growth relies on workers increased performance. Ideally, employees claimed as asset of company or business organization that assists the company in running the business. They have adequate knowledge and skills for achieving targets and maintain the continuity of business processes. Every company always expects the employees to meet the standard performances that have been set previously. The higher performance appraisal means that company has fit meet with performance expectation. Higher employee performance impacted on increasing company productivity, achieving company goals and wider company competitiveness in global competition (Robbins, 2006). Therefore, every company has its own challenges how to maintain and improves the performance of employees for achieving and implementing company's goals by providing positive stimulant too. Strategic steps that could be taken is evaluate the human resources at LNG

Company by taking the perspective each employee. The importance of the results of the study cannot devalued. First, this study's findings would allow companies to build human capital management approaches to improve their corporations overall value. Next, the results of this study will encourage decision-makers to create tailored strategies and initiatives that will positively inspire the development and survival of organization. Third, the research results could be controlling bodies such as LNG Company and other oil and gas company to advance their regulatory structure further. Finally, the research provides more modernized scientific data to current human resource management literature especially in LNG Company concerning job satisfaction and employee performance. This is of immense value to the academic field, as it serves as reference material for students and scholars who may wish to do further exploration on the current topic.

Several antecedents of employee performance have been examined and investigated by prior studies. For example, transformational leadership (Eliyana, 2019); motivation (Paais, 2020); human resource flexibility (Sabuhari, 2020), promotion (Tasman, 2021) and communication (Rusly, 2022). However, very little has been done on variables such as work environment (WE), management support (MS), corporate culture (CC) and employee engagement (EE) in LNG Company. This research was conducted to aid fill this gap. The studies as mentioned before, among others are deficient in scope as most human resource management related to JS and EP in various industry. By focusing on only LNG Company, this study contributively fills that gap. The research adds in the following ways to the current body of literature, first, numerous studies of WE, MS, CC, EE, JS and EP have been done. However, only a small number of studies considered either mediation or moderation in their analysis model. To the best of our knowledge, this is the first study to report on this study's variables in mediated interaction in the LNG Company context upon an extant review of the literature. Therefore, this research aims to fill the gap by creating an integrative model that considers many variables and mechanisms relevant to EP, mediated models. Second, most previous studies studied the relation between JS and EP with incomplete variable using partial least square focused on structural equation modeling (SEM). Most studies, end up using a small sample size for their analysis when using PLS-SEM. Hair Jr, Hult, Ringle and Sarstedt (2016) suggest that "some researchers have wrongly and misleadingly used these features to produce studies with exceedingly small sample sizes, even when the population is large and accessible without much effort. This study employed SEM-AMOS and used a larger sample size of two hundred sixty eights (268) for the study's analysis. Such a larger sample size provides more accurate mean values and gives a smaller margin of error. The contributions mentioned above are novel since they are deficient in JS and EP studies undertaken in the LNG Company context. The study is eventually unique since the investigators themselves carried it out; the study's hypothesis and intent are clearly defined; the techniques used are fully detailed; the findings are properly represented and the policy implications are properly explained.

2. LITERATURE REVIEW

Organizational Behavior

Organizational behavior (OB) is a field of study that investigates the impact individuals, groups and structure have on behavior within organizations for the purpose of applying knowledge toward improving an organization's effectiveness. To sum up definition, OB is the study of what people do in an organization and the way their behavior affects the organization's performance. Because OB is concerned specifically, absenteeism, employment turnover, productivity, human performance and management. OB include these core topics: motivation, leader behavior and power, interpersonal communication, group structure and processes, attitude development and

perception, change processes, conflict and negotiation, work design (Robbins, 2018). The main application of OB is improving interpersonal skills. By developing interpersonal skills managers can help organizations attract and retain valuable employees.

Work Environment

The work environment (WE) is a place where employee carry out work activities every day (Mardiana, 2005). WE are designed to fit perfect with employee satisfaction, also place or forum for employee to interact in change idea and motivate each other toward higher productivity (Brenner, 2004). Diamantidis and Chatzoglou (2018) suggested that WE and MS are the greatest influence factors (either directly or indirectly) on employee performance. WE can affect employees' emotions. If employees like their WE then they feel comfortable during their activities at work, impacted to their working time that can be used effectively and optimistically the employee's work performance also increase.

Management Support

Management Support (MS) is an important concept in providing explanation of the relationship between management's treatment, attitudes and behavior of employees toward their work and company. Management's treatment is accepted by employees and captured as organized stimuli and interpreted into perceptions of management support (Eisenberger, Huntington, Hutchison & Sowa, 2002). MS outline is how the organization or company valuation of employees and contribution also care about employee and well-being.

Corporate Culture

Corporate culture (CC) is defined as values, beliefs and behaviors that are consistent among all of the member of organization or company. The Denison model is based on four cultural traits of effective organizations that are involvement, consistency, adaptability and mission. Involvement is described as effective organizations empower their people, build organizations around teams and develop human capability at all levels (Becker, 1964; Lawler, 1996; Likert, 1961). Consistency is described as organizations also tend to be effective because they have "strong" cultures that are highly consistent, well-coordinated and well-integrated (Davenport, 1993; Saffold, 1988). Adaptability, ironically, organization that are well-integrated are often the most difficult ones to change (Kanter, 1983). Last, mission, successful organizations have a clear sense of purpose and direction that defines organizational goals and strategic objectives, also expresses a vision of how the organization will look like in the future (Hamel & Prahaland, 1994; Mintzberg, 1987, 1994; Ohmae, 1982).

Employee Engagement

Employee engagement (EE) is an individual's involvement with satisfaction and with enthusiasm for the work he or she does (Robbins, 2018). To evaluate engagement, we might ask employees whether they have access to resources and opportunities to learn new skills, whether they feel their work is important and meaningful, and whether interactions with coworkers and supervisors are rewarding. EE is very important for organization, because of the greater level of EE that have by organization is more profitable for the organization (Rothmann, 2017).

Job Satisfaction

Job satisfaction (JS) is a positive feeling about one's job resulting from an evaluation of its characteristics (Robbins, 2018). JS is the level of one's feelings after comparing the performance or perceived results compared to their expectations. However, the level of satisfaction is a function of the difference between perceived performance and expectations. The higher assessment of activities that are felt in accordance with the wishes of the individual is the higher satisfaction. Rivai (2005) suggest for several reason why companies must pay attention to JS which can be categorized according to the focus on employee or company, first, humans have the right to be

treated fairly and respectfully, this view from a humanitarian perspective, JS is an extension of the reflection of good treatment. Second, benefit perspective that JS can create behavior affects the company function.

Employee Performance

Employee performance (EP) is work performance or output both quality and quantity achieved by employee per certain period time in carry out their duties accordance with the responsibility given to them (Mangkunegara, 2014). EP appraisal is an assessment carried out systematically to find out the results of employee work and organizational performance. In addition, to determine appropriate job training, provide a better response in the future and as a basic for determining policies in terms of promotion and determination of rewards.

Hypotheses Development and Conceptual Framework:

Work Environment and Employee Performance

A comfortable WE cause the level of concentration of employees at work to increase and this condition causes the level of employee productivity increase. Significant and positive relationship between WE and EP. This reinforces point a view that the WE affect EP.

H1 = work environment directly influences employee performance

Management Support and Employee Performance

EP is one of the factors that affect the level of success of a management. Higher MS is provided, the employee will maximize their performance. Due to significant MS, it will have an impact on EP. Therefore, MS plays important role in EP.

H3 = management support directly influences employee performance

Corporate Culture and Employee Performance

CC covers broader and deeper aspect becomes the basic for creating ideal organizational climate. Therefore, the company rules are regulated as overall organizational culture impacted on how employees deal with their work and certainly will affect EP.

H5 = corporate culture directly influences employee performance

Employee Engagement and Employee Performance

Employees who have engagement are better prepared to learn new things by realizing their ideas, therefore they achieve a high level of success in the WE. The level of loyalty greatly affects the degree of EP owned by individual to the company.

H7 = employee engagement directly influences employee performance

The Link Between Job Satisfaction and Employee Performance

Employees have needs that must be met, when these expectations can be met, employee will feel relieved and calm in every job they do. Studied have been done by Platis, et al (2015) and Inuwa (2016) suggest positive relationship between JS and EP. The majority of employees who are satisfied at work will have a better average performance when compared to employees who are dissatisfied with their work.

H9 = job satisfaction directly influences employee performance

The Mediation Role of Job Satisfaction

Previous studies have linked WE and JS, if the WE are very pleasant, it will lead to sense of JS and increased work results in employees, which of course will take benefit to the company. Other studied MS to JS, Pathak (2012) suggest when employees feel that management care about their welfare and opinions, they will feel JS. Last, EE to JS which important thing to be grown in every employee, engage employees will have high engagement which can influence employees in completing work and tend to have satisfactory work quality.

H2 = work environment indirectly influences employee performance, mediated by job satisfaction

H4 = management support indirectly influences employee performance, mediated by job satisfaction
H6 = corporate culture indirectly influences employee performance, mediated by job satisfaction
H8 = employee engagement indirectly influences employee performance, mediated by job satisfaction

The Conceptual Framework

Based on the literature reviewed, the conceptual framework for this study is presented below.

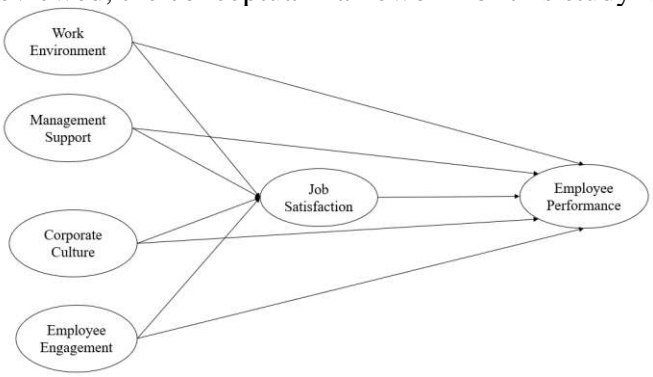


Figure 1. The Conceptual Framework

3. METHODS

Target Population

The population is defined as a category of the research object, has one or more common characteristics, and is the subject of interest to the investigator. Employees from management level and non-management level from LNG company were used as the study's population.

Research Sampling and Sample Size

The sampling applies to an approach to choosing a part of the sample population that will represent the whole study population. This research followed a proportionate stratified random sampling technique where every employee was given an equal opportunity to answer the questions asked. The sample size used for analysis was 268, all of whom were employee from LNG company.

Data Instrument and Collection

To achieve the objectives of the study, the researcher gathered information from the study population. The research used the questionnaire as a medium to request information from the population. The questionnaire included questions related to the participants' demographic characteristic. There were questions in the second part of the questionnaire that help examine the variable to be evaluated. Participants were called upon to rate the items based on the 5-points Likert with the scaling pole ranging from strongly disagree (1) to strongly agree (5). 268 online questionnaires were sent to respondents through digital platforms. They were deemed fit and accurate, then used for discussion.

Measurement of Variables

WE were measured with seven items adapted from (Fawcett, et al, 2018) and MS was measured with nine items from (Vietzhal Rivai, 2010 and Palomo, et al, 2010). Also, CC was measured with six items from (Denison, 1990). Then, EE was measured with eight items from (Fawcett, et al, 2008 and Saeed, et al, 2014). Also, JS was measured with seven items from (Colquitt, et al, 2013 and Hasibuan 2014). Last, EP was measured with seven items from (Inuwa, 2016). All items were measured on a scale of 1 to 5. Table 1 reveals the items used for each variable.

Table 1. Measurement of Variables

Construct	Indicator	Measurement Items
Work Environment	WE1	Manager believes that I can do my job well
	WE2	I earn the trust from work environment for the work I do
	WE3	My work environment has mutual respect among employees
	WE4	My work environment treats employees fairly and equally
	WE5	I can show concern for co-workers
	WE6	I can show attention for co-workers
	WE7	I have chance to make friends in my work environment
Management Support	MS1	Manager always coordinate with subordinates in carrying out decision making
	MS2	Manager always coordinate with subordinates in carrying out their respective jobs
	MS3	Manager have good communication with subordinates
	MS4	Manager seek suggestion for ideas from subordinates for decision making
	MS5	Manager is able to motivate subordinates to keep working
	MS6	Manager is able to provide good role model to their subordinates
	MS7	Manager always monitor subordinate's work and warns if something goes wrong
	MS8	Manager compliments my performance
	MS9	Manager gave negative response (constructive response) to my performance
Corporate Culture	CC1	There is a clear and consistent set value in managing business within company
	CC2	There is a code of ethics that regulates employee behavior
	CC3	There is a clear agreement to do something
	CC4	Manager always convey important information related to company updates
	CC5	Manager always take the right step of decision making
	CC6	Manager thought about my training/certification needs
Employee Engagement	EE1	I feel confident about my current job
	EE2	I have knowledge of my current job
	EE3	I can complete important tasks in my job well
	EE4	I feel enthusiastic about my work
	EE5	I'm proud to tell others that I'm part of the company
	EE6	I'm loyal to the company
	EE7	I have told other that this company is ideal to work for.
	EE8	My current manager recognizes that I'm a value employee
Job Satisfaction	JS1	My work is very interesting
	JS2	My work lives up to my expectations
	JS3	I am willing to replace my co-worker who is absent
	JS4	I can spend time to help ithers at work
	JS5	I feel that my salary and other incentives are appropriate
	JS6	I am satisfied with my current position
	JS7	I feel like fit in with my current co-workers
Employee Performance	EP1	I know what the company's criteria are in assessing employee performance
	EP2	I am responsible for my work
	EP3	I understand the task so I can do it well
	EP4	I am able to complete urgent/unexpected work on time
	EP5	I maintain the frequency of my attendance in the work environment well
	EP6	I can carry out the assigned task effectively
	EP7	I can carry out the assigned task efficiently

4. RESULTS

The research involved confirmatory studies in confirming the validity of the model. SPSS version 22.0 was used to process descriptive statistics to measure the demographic profile of the sample. AMOS version 26 software was used to evaluate the research model.

Empirical Results

Table 2 reveals that for age distribution, more males responded to questionnaire than females. Overall, males representing 91,04% (244) and females representing 8,96% (24). This indicate that more males responded to the items than females. The findings, therefore, reveals that more males than females dominate the LNG sector.

Table 2. Demographic Tabulation

Description	Count		%Within	
	Male	Female	Male	Female
Gender	244	24	91,04 %	8,96 %
Job Level				
VP Level	2	0	0,75 %	-
Senior Manager Level	7	0	2,61 %	-
Manager Level	12	1	4,48 %	0,37 %
Non-Manager Level	76	11	28,36 %	4,10 %
Lower Management	68	8	25,37 %	2,99 %
Non-Management	79	4	29,48 %	1,49 %
Education				
Senior High School	5	0	1,87 %	-
Diploma	130	12	48,51 %	4,48%
Bachelor	92	12	34,33 %	4,48 %
Master	17	0	6,34 %	-

Table 3 display the reflective model for SEM-AMOS for internal consistency reliability, convergent and discriminant validity. The indicator loadings, average variance extracted (AVE), composite reliability (CR) and Cronbach alpha (CA) values of the latent constructs were extracted after performing the confirmatory factor analysis on all the constructs. In SEM-AMOS model, the indicator loading was above 0,70 and the findings ranged from 0,743-0,912. The Cronbach alpha ranged from 0,705-0,770; met suggested threshold of above 0,7. All the constructs met the AVE's minimum required value of 0,5. AVE's values for WE, MS, CC, EE, JS, EP are 0,7669; 0,7755; 0,7880; 0,6542; 0,7216 and 0,7253 respectively and they having met above minimum threshold requirement proposed for the internal consistency and reliability check, we can conclude that the model is accurate enough for the analysis.

Table 3. Construct Reliability and Validity

Construct	Indicators	Indicator Loading (≥0,70)	Cronbach Alpha (≥0,70)	Composite Reliability (≥0,70)	AVE (≥0,50)
Work Environment	WE1	0,912	0,749	0,9584	0,7669
	WE2	0,856			
	WE3	0,883			
	WE4	0,895			
	WE5	0,882			
	WE6	0,857			
	WE7	0,845			
Management Support	MS5	0,806	0,754	0,9422	0,7755
	MS6	0,893			
	MS7	0,900			
	MS8	0,894			
	MS9	0,906			
Corporate Culture	CC1	0,865	0,770	0,9489	0,7880
	CC2	0,913			
	CC3	0,912			
	CC5	0,888			

	CC6	0,855			
Employee Engagement	EE3	0,773	0,765	0,9043	0,6542
	EE5	0,742			
	EE6	0,854			
	EE7	0,803			
	EE8	0,860			
Job Satisfaction	JS1	0,822	0,720	0,9120	0,7216
	JS2	0,861			
	JS3	0,874			
	JS4	0,844			
Employee Performance	EP2	0,881	0,705	0,9294	0,7253
	EP4	0,897			
	EP5	0,868			
	EP6	0,810			
	EP7	0,802			

Assessment of the Structural Model

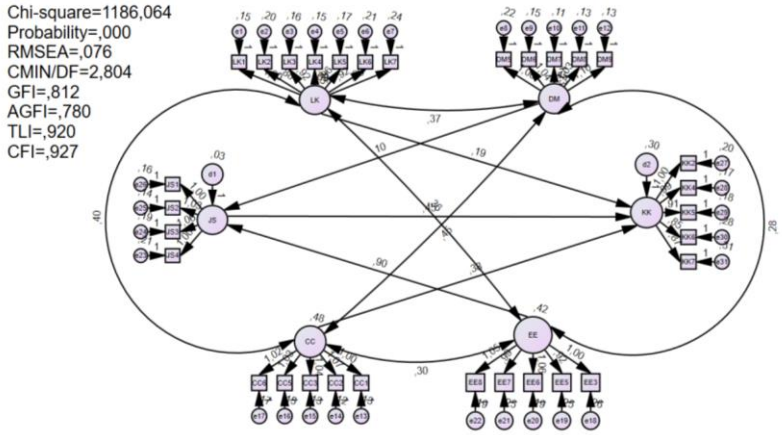


Figure 1. The Structural Model (SEM-AMOS)

We assessed the direct relationship in the study's mode. Table 4 reveals, HI [WE→EP], H5 [CC→EP] and H9 [JS→EP] are supported which have p-value 0,000 respectively (p<0,06). This findings implied, the better WE will affect EP. Actually, LNG company respects the various backgrounds of its employee, regardless of ethicity and religion. In addition through commitment to upholding the principles of good corporate governance (GCG) and code of conduct towards continous improvement of the company and carried out concsistently and continously. This finding discloses that WE are a critical element that can impact employee' performance in an organziations. In other hand, this finding suggests that managers must consider thee most effective factors that bring employee JS which has a positive impact on the EP in an organizations. It is therefore crucial for managers to maintain a good work atmosphere to encourage employees. Organizations and managers should then focus on developing the worker's workplace environment in numerous ways. This should entail valuing worker's contributions, communicating the company progress and achievement to workers, thus instilling ownership in workers, providing a stable atmosphere. Management must have a place of work that guarantees the above. This will enable employees to give in their all and be committed to their organizations which serve as a driving force for organizational success and growth.

Table 4. Hypothesis testing (direct relationship)

Hypotheses	p-Value	Decision
H1: WE → EP	0,000	Supported
H3: MS → EP	0,556	Unsupported
H5: CC → EP	0,000	Supported
H7: EE → EP	0,165	Unsuppported
H9: JS → EP	0,000	Supported

We assessed the indirect effect; thus mediation analysis. First, table 5 reveals that H6 [MS→JS→EP] and H8 [EE→JS→EP] are supported which have p-value 0,011 and 0,000 respectively. This findings implied, LNG business is slowly trasformated, in order to remain the needs of clean environmentally friendly energy at the same time. In realizing the sustainability of this role, LNG company need support from management, employees and partner also collaborates with various stakeholders. In other hand, LNG company is the first company that achieve ISRS^{TM} 9 and also continously carries out improvement program which currently have 14 environmetal related patents and 6 patents in the application process. The author further indicated that engaged workers appear to encourage meaningful interaction and efficiency in their organizations. This results means that the presence MS and EE is an establishment leads to improved EP. Individuals with a high degree of company loyalty and happiness can reflect the organization's good behaviour, offer the best of their abilities, sacrifice, be faithful to the organizations. This implies that an individual with high degree of JS aims to demonstrate high level of work performance. It is therefore crucial to regularly review employee' commitment and satisfaction to resolving any problems that may occur make sure that workers maintain a favorable attitute to work which is crucial for total organizational success.

Table 5. Hypothesis testing (indirect relationship)

Hypotheses	p-Value	Decision
H2: WE → JS → EP	0,097	Unsupported
H4: MS → JS → EP	0,011	Supported
H6: CC → JS →EP	0,860	Unsupported
H8: EE → JS →EP	0,000	Supported

6. CONCLUSIONS

To a great extent, the exact estimation of people's beliefs, expectations and values relies on how investigators choose respondents from a given population. This variability may have a significant effect on the empirical and managerial implication of the research and outcomes. The findings for direct relationship are HI [WE→EP], H5 [CC→EP] and H9 [JS→EP] are supported which have p-value 0,000 respectively (p<0,06). Last, for indirect relationship are H6 [MS→JS→EP] and H8 [EE→JS→EP] are supported which have p-value 0,011 and 0,000 respectively. There are several managerial implications of this study, first our research findings advocate that manager should be familiar with the factor that influence JS and EP. This is mostly applicable in LNG sectors where employees are constantly facing unenthusiastic, less empowerment and leak supervision which is likely decrease work performance. Importantly, it is prudent for managers to implement policies that will enhance JS and thus lead to EP. These policies should consider congruency between employee's EE, WE and CC. Moreover, managers should involve employees in updating transformation company business review to establish the factors that will increase JS and EP in their respective organizations.

Limitation and Recommendations

This research did not involve employee outside LNG Company. Future research may also be performed to address the limitation described by expanding the research to other settings and company to achieve an extensive generalization of the analysis using AMOS. Future studies should also accommodate other variables in order the research more robust. However, this study will add to the literature on determinant of JS and EP in LNG Company. Again, the result will add the scanty literature available and serve as a guide to other researchers about the use of sampling in SEM-AMOS modelling analysis.

REFERENCES

Brenner, P. (2004). *Workers Physical Surrounding. Impact Bottom Line Accounting*: Smart Pros.com.

Colquitt, J.A., Lepine, J.A., & Michael J. Wesson. (2013). *Organizational Behaviour (3rd ed.).* New York: McGraw-Hill.

Diamantidis, A.D & Chatzoglou, P. (2018). "Factors Affecting Employee Performance: An Empirical Approach". *International Journal of Productivity and Performance Management.*

Denison, Daniel R., Stephanie Haaland and Paulo Goelzer. (1991). Corporate Culture and Organizational Effectivenes: Is There A Similar Pattern Around The World?. *The Academy of Management Review.*

Eisenberger, R., Stinglhamber, F., et. Al. (2002). Perceived Supervisor Support: Contributions to Perceived Organizational Support and Employee Retention. *Journal of Applied Psychology, 87, 565-573.*

Eliyana, Anis., Syamsul Ma'arif., Muzakki. (2019). Job Satisfaction and Organizational Commitment Effect in the Transformational Leadership Towards Employee Performance. *Europena Research on Management and Business Economics,* Volume 25, pp. 144-150.

Fawecett, S.E., Brau, J.C., Rhoads, G.K., Whitlark, D and Fawcett, A.M. (2008). "Spiritually and Organizational Culture: Culvating the ABC's of an Inspiring Workplace", *International Journal of Public Administration,* Volume 31 No.4, pp. 420-438.

Hasibuan, Malayu SP. (2014). *Manajemen Sumber Daya Manusia*, Cetakan Keempatbelas, Jakarta, Penerbit: Bumi Aksara.

Inuwa, M. (2016). Job Satisfaction and Employee Performance: An Empirical Approach. *The Millenium University Journal;* Volume 1*, No. 1; 2016.*

Mangkunegara, A.A.A.P. (2011). *Manajemen Sumber Daya Manusia Perusahaan*. Bandung: Remaja Rosdakarya.

Paais, Maartje., Jozef R. Pattiruhu. (2020). *Journal of Asian Finance, Economics and Business,* Volume 7 no.8, pp. 577-588.

Palomo, M., Beinart, H., & Cooper, M. J. (2010). Development and Validation of the Supervisory Relationship Questionnaire (SRQ) in UK Trainee Clinical Psychologists. *British Journal of Clinical Psychology (2010),* Volume 49*, 131-149.*

Pathak, D. (2012). Role of perceived Organizational Support on Stress- Satisfaction Relationship: An Empirical Study. *Asian Journal of Management Research,* Volume 3, No. 1, pp. 153-177.

Plantis, C., Reklitis, P dan Zimeras, S. (2014). Relation Between Job Satisfaction and Job Performance in Healthcare Services. *International Conference on Strategic Innovative Marketing,* September 2014.

Rivai, V. (2005). *Manajemen Sumber Daya Manusia Untuk Perusahaan Dari Teori ke Praktik.* Jakarta: Raja Grafindo Persada.

Robbins, S.P. (2006). *Organizational Behaviour 12th Edition.* Pearson Education.

Rusly, Hendri., Yessica Sardina Purba. (2022). Analysis of the Influence of Work Environment and Commucation on Employee Performance of PT. Citas Otis Elevator Medan. *Jurnal Mantik,* Volume 5, pp. 2245-2250.

Sabuhari, Rahmat., Achmad Sudiro., Dodi W. Irawanto., Mintarti Rahayu. (2020). *Management Science Letters,* Volume.10, pp. 1777-1786.

Tasman., Zulkifli Musannip Effendi Siregar., Meisa Fitri Nasution. (2021). The Influence of Work Environment, Promotion and Job Satisfaction on Employee Performance. *Budapest International Research and Critics Institute Journal,* Volume 4 no 3**,** pp. 4026-4031.

GREEN BUILDING FEATURE ADDITION MODEL TO ACHIEVE CERTAIN SERTIFICATION LEVEL FOR AN APARTMENT

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ABSTRACT

The implementation of green building requires a large investment which can result in high selling prices and low apartment occupancy rates. However, from the buyer's point of view, it still needs to be studied whether they really need the green building features. This study aims to model the addition of green building features in apartments to get green building certification associated with market interests. This research was conducted in Surabaya, with respondents from prospective apartment buyers, in order to obtain the factors that influence their decision to buy an apartment. Additional types of green building features are obtained from the greenship standards for existing buildings from the Green building Council Indonesia (GBCI). Six aspects of Greenship, namely: Appropriate site development (ASD), Energy Efficiency and Conservation (EEC), Water Conservation (WAC), Material Resource and Cycle (MRC), Indoor Health and Comfort (IHC), Building Environment Management (BEM) is used as the basis for adding building features.The results show that the selling price of the apartment is not the only buyer's decision in buying an apartment unit. Several factors that influence the decision of apartment buyers are distributed into 6 aspects of Greenship.

Keywords: Sustainable Development, GBCI, Certification Level, Addition of Green Building Features.

1. INTRODUCTION

Limited land problem in big cities in Indonesia makes apartments as the most rational option to live in for most people, because of their strategic location and supported by various supporting facilities, but there are things that are often forgotten by property developers or end users of an apartment. Environmental pollution by an apartment is quite large either from the construction process and during its operational period. According to Surapto & Wulandari, (2009) the waste from the construction process alone is large enough for the scale of an apartment building, not to mention the presence of air and water pollution due to construction and operational processes. Environmental pollution in the operational stage can be in the form of disposal and consumption. Disposal waste can be in the form of water and air pollution. Air pollution can be in the form of releasing carbon dioxide (CO2) and chlorofluorocarbons (CFCs) (Gusnanda, 2019). Tall buildings

such as conventional apartments and other skyscrapers are the largest contributor to carbon dioxide (CO2) emissions globally with more than 30% (Ayu, 2019). Meanwhile, water pollution can be in the form of domestic waste water and industrial waste water (Rizza, 2013). On the other hand, consumption can be interpreted as an inefficient use of energy. With all the bad impacts that trigger global climate change, this has led to the emergence of a concept known as green building which has recently begun to be crowded among high-rise buildings.

A green building is a building that has been certified and designed based on the assessment criteria for a green building. The assessment is called greenship and provided by Green Building Council Indonesia (GBCI). The assesment is divided into 6 criteria consisting of Appropriate Site Development (ASD), Energy Efficiency and Conservation (EEC), Water Conservation (WAC), Material Resources and Cycles (Material Resources and Cycle – MRC), Indoor Air Health and Comfort (IHC), and Building and Environment Management (BEM) (Kurniawan & Simanjuntak, 2019). From the scores that have been collected from the GBCI assessment criteria, the 6 categories may gather 117 point and then divided into 4 certification classes, namely Bronze, Silver, Gold, and Platinum with different minimum values. Where the higher the level of green building implementation adopted, the higher the level of certification.

With the minimum value limit for each level of certification and the many choices of factors that can be chosen, the scenarios for adding green building features are very large. This makes many green buildings make the investment cost factor as a determinant of adding green building features with the aim of suppressing the increase in selling prices. However, this is often not accompanied by a market analysis of the customer's perspective on green building features. Meanwhile, cost is not the only determinant of customer decisions in buying apartments (Onggo, 2017).

Therefore, this study aims to propose a model for adding green building features based on market perspective factors to achieve a level of certification. It is hoped that from this research, a suitable model for an apartment can be obtained to achieve a certain level of certification in the Surabaya market.

2. LITERATURE REVIEW

Sustainability has become a topic of discussion lately. This concept has also begun to touch the construction and property sectors, especially for buildings (Kurniawan & Simanjuntak, 2019). Sustainable development is a development concept that not only prioritizes current needs, but also future needs (Brundtland, 1987). The concept of sustainability or the sustainability of a property in this case an apartment building is formed by three main pillars, namely the environment, society, and economy (World Submit Outcome, 2005). Rather than that, the concept of green building is present as the key to achieving sustainable development. With the many green building rating systems that have been developed with reference to environmental, society, and economic aspects, a building can be the right tool to achieve sustainable development (Awadh, 2017).

Indonesia has the Green Building Council Indonesia (GBCI) which was established in 2009 by professionals in the building design and construction sector to implement the green building concept and has become an established member of the World Green Building Council (WGBC) based in Toronto, Canada. GBCI has 4 main activities, namely: market transformation, training, green building certification based on a typical Indonesian assessment tool called Greenship, as well as collaboration programs with stakeholders.

As one of the independent (non-government) institutions engaged in green building, GBCI provides an assessment parameter for building aspects so that it can be said as a green building which is stated in a certification given by PT Green Building Certification (SBH). Assessment parameters are divided into 6 categories consisting of Appropriate Site Development (ASD), Energy

Efficiency and Conservation (EEC), Water Conservation (WAC), Material Resources and Cycle Cycle – MRC), Air Quality and Indoor Air Comfort (Indoor Air Health and Confort – IHC), and Building Environment Management (BEM) (Kurniawan, 2019).

Each category of Greenship assessment is divided into several sub categories which are intended to be able to assess a building in detail from each category. Each sub-category has several assessment aspects that have different value weights. The value will be given if a building has met the criteria from the assessment aspect. For example, the Appropriate Site Development (ASD) assessment category has ASD-P1, ASD-P2, and ASD 1-ASD 7 sub categories. ASD-P1 and ASD-P2 are sub categories that must be met by a buildings, while ASD 1-ASD 7 is a sub-category of choice. ASD 1 is still divided into several aspects of assessment and their value

Market acceptance is a measurement parameter to see the level of success of a product in a market. In a product, there will always be personal judgments made by the producer which are not necessarily in accordance with market conditions so that there is a gap created (Meyers, 1955).

From that, it is necessary to have an analysis of market behavior as input in management's considerations to make decisions. In the context of apartments, customer considerations for investing in an apartment are not limited to the selling price, but there are also product concept factors, location, promotions, and facilities (Onggo, 2017).

In relation to the consideration of the apartment management in determining the addition of green building features, the analysis of market behavior can be interpreted in the form of the greenship factor. This is based on non-price factors in the buyer's consideration to invest in an apartment according to Onggo, 2017 which is relevant or in line with the concept carried out in the greenship assessment factor. For example, the location and facility factors in previous studies are in line with the Appropriate Site Development factor on the greenship factor which contains factors related to the site location, while the building concept factor is relevant to several factors such as Water Conservation, Material Resources and Cycle, and Indoor Air Health and Confort. which discusses the concept of a building to become a green building

Various studies on green buildings have been carried out previously as was done (Putro & Raflis, 2019) which analyzes the Life Cycle Cost of a green building. There is also research on the appropriate method of calculating Life Cycle Cost (Pernetti, Garzia, Oberegger, 2021). The research on green buildings was carried out by reviewing the financial aspects of green buildings and aimed to show how green buildings can reduce costs over the course of their operation, but have not taken into account market interests. Therefore, this research is aimed to aims to model the addition of green building features in apartments to get green building certification associated with market interests

3. METHODS

In this study, it is divided into 2 main stages, namely the Purchasing Decision Factor Analysis stage and the Green Building Feature Addition Modeling stage which is intended to answer the research problem. To answer the main problem in this study, several stages are needed. The first stage is the literature review stage which is intended to obtain the variables that will be used in the Purchasing Decision Factor Analysis stage.

In the Purchasing Decision Factor Analysis stage the variables that have been obtained from literature review are 6 greenship category from GBCI which then is described into 63 questionnaire questions with likert scale (1= Least Important, 2= Less Important, 3= Moderately Important, 4= Important, 5= Most Important) as the measurement parameter. The questionnaire then will be distributed to 100 respondents who is a potential buyer for an apartment in Surabaya.

The data is then analyzed at the Importance Factor Analysis stage with the aim of getting the order of the most important factors in the greenship assessment factor according to the buyer's point

of view. This stage is done by summing the responses from respondents on each factor which is then sorted from the highest number to the least number

Along with these stages, secondary data was also collected in the form of feature data in apartments in general in Surabaya which was intended to obtain the basic model of the apartment as the non-cost added feature.

After the Importance Factor Analysis stage and the secondary data collection stage were completed, the Green Building Feature Addition Modeling stage was then carried out by doing green building feature addition modeling, the model is based on the importance ranking factor and non-cost added features. Modeling will be carried out by prioritizing non-cost added features to get free GBCI points before adding features with additional investment costs based on the importance ranking factor to aimed at meeting the minimum greenship standards for each certification level (Unclassified, Bronze, Silver, Gold, and Platinum).

4. RESULTS

Purchasing Decision Factor stages are carried out by conducting a survey of the Surabaya market with a total of 100 respondents. The list of survey questions is a GBCI category that was described into 63 questionnaire questions. This questionnaire was then tested by conducting interviews with 40 respondents to test the validity and reliability of the questionnaire. From the 63 questions, it was found that all variables were valid and exceeded the rtable value for 40 respondents and a significant level of 5%, which was 0.304 and reliable with the cronbach alpha parameter of 1.013 > 0.7 so that it can be said to be reliable.

After finding valid and reliable questionnaires, questionnaires were distributed to 100 respondents where the measurement parameters were used Likert Scale with a scale of 1-5. From these parameters, an evaluation is then carried out by adding up the points obtained by each factor from 100 respondents.

After obtaining the total number for each factor, then data processing is carried out to find out which factor is the most important to the least important by sorting the number of survey values from the largest to the smallest. As can be seen in **Table 1** that there are several factors that have the same value so that they then have the same rank. To overcome problems that may arise, for factors with the same rank, if factor selection is required, decision determination will be made based on the additional investment costs of these factors.

Table 1. Importance Factor Ranking

No	Category	Point	Rank	No	Category	Point	Rank	No	Category	Point	Rank
35	WAC 5.3	473	1	30	WAC 3.1	457	16	23	EEC 5.1	446	31
14	ASD 7.1	472	2	46	MRC 4.1	457	16	27	EEC 7.1	445	32
25	EEC 5.3	469	3	15	ASD 7.2	455	18	9	ASD 3.3. B	444	33
36	WAC 6.1	466	4	32	WAC 5.1 A	455	18	55	IHC 6.1	443	34
22	EEC 4.2	464	5	26	EEC 6.1	454	20	60	BEM 3.1	443	34
40	MRC 2.1	464	5	37	WAC 7.1	451	21				
53	IHC 4.3	464	5	49	IHC 2.1	451	21				
7	ASD 3.1	461	8	1	ASD 1.1	450	23				

No	Category	Point	Rank	No	Category	Point	Rank	No	Category	Point	Rank
11	ASD 5.1 A	461	8	43	MRC 3.3	450	23				
54	IHC 5.1	461	8	45	MRC 3.5	450	23				
29	WAC 2.1	460	11	47	MRC 5.1	450	23				
52	IHC 4.1	460	11	57	IHC 8.1	450	23				
56	IHC 7.1	460	11	19	EEC 3.1	449	28				
18	EEC 2.1	459	14	10	ASD 4.1 B	447	29				
20	EEC 3.2	458	15	63	BEM 5.1	447	29				

The modeling process is carried out by first sorting the factors that require additional investment costs and those that do not. The justification of factors that do not require additional investment costs is carried out by considering the basic features that exist in apartments in general and all SOP-based factors in apartment building management as non-cost added feature and were found 26 factors as a non-cost added feature with a total GBCI points earned are 35 points as shown in **Table 2**.

Table 2. Non-cost added feature

No	Category	Criteria	Point
1	ASD 1.1	There are at least 5 types of public facilities within the reach of the main road as far as 500 m from the site.	1
2	ASD 2.1	There is a reduction in the use of private motorized vehicles by implementing one of the options: car pooling, feeder buses, reducing reserved parking with other incentives from building management to tenants, or parking tariff discrimination.	1
3	ASD 3.1	The existence of a landscape area in the form of vegetation (softscape) that is free from garden buildings (hardscape) which is located above the land surface with an area of at least 30% of the total land area. The area taken into account includes the garden above the basement, roof garden, terrace garden and wall garden. Plant formation in accordance with the Minister of Public Works Regulation No. 5/PRT/M/2008 regarding Green Open Space (RTH) Article 2.3.1 concerning Vegetation Criteria for Yards.	1
4	ASD 3.3 A	The use of 60% of local plants from local nurseries with a maximum distance of 1000 km.	1
5	ASD 3.3. B	Use of productive plants, at least 10% of the landscaping area.	1
6	ASD 5.1 A	Reduction of the volume of rainwater runoff from the land area to the city drainage network by 50% of the total average daily rain volume which is calculated based on the calculation of rainwater discharge in wet months.	1
7	ASD 6.1	Have and implement Standard Operating Procedures (SPO) to control plant pests and weeds using non-toxic materials.	1

No	Category	Criteria	Point
8	EEC 3.1	Use a minimum of 80% high frequency (electronic) ballast and/or LEDs in common workspaces.	2
9	EEC 5.1	Operation and maintenance guide for the entire AC system (chiller, Air Handling Unit, cooling tower)	1
10	EEC 5.2	If point 1 has been fulfilled, then it is added with the periodic operation and maintenance guide for all other equipment systems (transportation systems in buildings, distribution systems for clean and dirty water (pumps) and backup power plants.	1
11	EEC 5.3	There is a monthly report for a minimum of the last 6 months for the operation and maintenance of the building system in an orderly manner in accordance with the format stated in the operation and maintenance manual.	1
12	WAC 2.1	There is a standard operating procedure and its implementation regarding the maintenance and inspection of the plumbing system on a regular basis to prevent leakage and water wastage by showing the water balance in the last 6 months for initial certification*.	2
13	MRC 3.1	The existence of Standard Operating Procedures, Training and Reports for collecting and sorting waste based on organic and inorganic types in the last 6 months for initial certification*.	1
14	MRC 3.2	If you have done organic and inorganic sorting, carry out organic waste processing independently or in collaboration with official organic waste processing bodies.	1
15	MRC 3.3	If you have done organic and inorganic sorting, treat inorganic waste independently or in collaboration with an official body for processing inorganic waste that has the 3R principle (Reduce, Reuse, Recycle).	1
16	MRC 3.4	There are efforts to reduce packaging waste made of styrofoam and non-food grade plastic.	1
17	MRC 4.1	The existence of Standard Operating Procedures, Training and Management Reports on B3 waste management including: lamps, batteries, printer ink and used packaging for cleaning materials in the last 6 months for initial certification*.	2
18	MRC 5.1	The existence of Standard Operating Procedures and reports on the distribution of used goods that can still be reused in the form of furniture, electronics and spare parts through donations or the used goods market in the last 6 months for initial certification*.	1
19	IHC 2.1	Smoking is prohibited in all areas of the building and does not provide a special building/area inside the building for smoking. When providing a designated smoking area outside the building, it must be at least 5 m away from the entrance, fresh air entry points and window openings with follow-up procedures for monitoring, documentation and response systems to smoking bans.	2

No	Category	Criteria	Point
20	IHC 4.1	If the results of the measurement of indoor air quality meet the pollutant gas standards in Table 1. Pollutant Gases for Office Workplaces.	3
21	IHC 5.1	Room thermal conditions are generally at a temperature of 24°C – 27°C and Humidity relative 60% +5%.	1
22	IHC 6.1	The measurement results show the level of illumination (illumination) in each workspace in accordance with SNI 03-6197-2000 concerning Energy Conservation in Lighting Systems*.	1
23	IHC 7.1	The measurement results indicate that the sound level in the workspace is in accordance with SNI 03-6386-2000 concerning Specifications for Sound Levels and Reverberation Time in Buildings and Housing (Recommended Design Criteria)*.	1
24	IHC 8.1	Conducting a building user comfort survey including air temperature, room lighting level, sound comfort, building cleanliness and the presence of pest control. Minimum respondents are 30% of the total permanent building users.	3
25	BEM 3.1	The existence of an integrated structure within the operational structure and maintenance of the building in charge of maintaining the application of the principles of sustainability/green building.	1
26	BEM 4.1	For commercial buildings: have a Lease Agreement containing clauses that the Tenant will meet the criteria in the GREENSHIP for Existing Building at least 1 benchmark in each category of ASD, EEC, WAC, IHC, MRC and BEM.	2
		Total	35

With the minimum point requirement to get the Bronze, Silver, Gold, Platinum certification levels, 41, 53, 66, 83 points are needed, respectively. Therefore, additional factors with additional investment costs are needed. With the number of factors with the addition of an investment cost of 37 factors, it is necessary to select factors that are sorten from Importance Factor Ranking that have been obtained previously until the model reach the highest certification level which is Platinum. The model that has been obtained then be categorized based on 6 greenship factors to show which factor is needed for each certification level as in **Table 3.**

Table 3. Green building feature addition model for each certification level

Category	GBCI Point	Investment Cost Addition	Importance Factor Ranking	Bronze	Silver	Gold	Platinum
Appropriate Site Development							
ASD 1.1	1	No	-	V	V	V	V
ASD 2.1	1	No	-	V	V	V	V
ASD 3.1	1	No	-	V	V	V	V
ASD 3.3 A	1	No	-	V	V	V	V

Category	GBCI Point	Investment Cost Addition	Importance Factor Ranking	Bronze	Silver	Gold	Platinum
ASD 3.3. B	1	No	-	V	V	V	V
ASD 5.1 A	1	No	-	V	V	V	V
ASD 6.1	1	No	-	V	V	V	V
ASD 7.1	1	Yes	2	V	V	V	V
ASD 7.2	1	Yes	18				V
ASD 4.1 B	1	Yes	29				V
Energy Efficiency and Conservation							
EEC 3.1	2	No	-	V	V	V	V
EEC 5.1	1	No	-	V	V	V	V
EEC 5.2	1	No	-	V	V	V	V
EEC 5.3	1	No	-	V	V	V	V
EEC 4.2	3	Yes	5	V	V	V	V
EEC 2.1	1	Yes	14		V	V	V
EEC 3.2	10	Yes	15		V	V	V
EEC 6.1	5	Yes	20				V
EEC 7.1	3	Yes	32				V
Water Conservation							
WAC 2.1	2	No	-	V	V	V	V
WAC 5.3	2	Yes	1	V	V	V	V
WAC 6.1	1	Yes	4	V	V	V	V
WAC 3.1	8	Yes	16			V	V
WAC 5.1 A	1	Yes	18				V
WAC 7.1	2	Yes	21				V
Material Resource and Cycle							
MRC 3.1	1	No	-	V	V	V	V
MRC 3.2	1	No	-	V	V	V	V
MRC 3.3	1	No	-	V	V	V	V
MRC 3.4	1	No	-	V	V	V	V
MRC 4.1	2	No	-	V	V	V	V
MRC 5.1	1	No	-	V	V	V	V
MRC 2.1	3	Yes	5		V	V	V

Category	GBCI Point	Investment Cost Addition	Importance Factor Ranking	Bronze	Silver	Gold	Platinum
MRC 3.5	1	Yes	23				V
Indoor Health and Comfort							
IHC 2.1	2	No	-	V	V	V	V
IHC 4.1	3	No	-	V	V	V	V
IHC 5.1	1	No	-	V	V	V	V
IHC 6.1	1	No	-	V	V	V	V
IHC 7.1	1	No	-	V	V	V	V
IHC 8.1	3	No	-	V	V	V	V
IHC 4.3	5	Yes	5		V	V	V
Building Environmental Management							
BEM 3.1	1	No	-	V	V	V	V
BEM 4.1	2	No	-	V	V	V	V
BEM 5.1	2	Yes	29				V

6. CONCLUSIONS

Based on the Purchasing Decision Factor Analysis that has been carried out, it is found that the selling price of the apartment is not the only buyer's decision in buying an apartment unit. Several factors that influence the decision of apartment buyers are distributed into 6 aspects of Greenship. The 10 most important factors that influence the decision to buy an apartment include 3 Appropriate Site Development factors, 2 Energy Efficiency and Conservation factors, 2 Water Conservation factors, 1 Material Resources and Cycle factor, and 2 Indoor Air Health and Confort factors. The implementation of market point of view in green building feature addition selection can be applied to other market and apartment by conducting the same methods used in this research and adjust the necessary data to the relevant conditions.

REFERENCES

Abelson, P.W. & Chung. (2005). Property Prices and the Value of Amenities. *Journal of Environmental Economics and Management*, 6, 11-28.

Ali, W. (2021). Demand Theory. *Journal of Business & Financial Affairs*, 10:4, 2329-6771.

Amstrong, G., dan Kotler, P. (2008). Prinsip-prinsip Pemasaran, Edisi ke- 12. Jakarta: Erlangga.

Awadh, O. (2017). Sustainability and green building rating system: LEED, BREEAM, GSAS and Estidama critical analysis. *Journal of Building Engineering*, 25-29.

Del, I. H., Roger, J., Kenneth, A.C., & Amit, M. (2007). Consumer Behaviour, *Tata McGraw Hill, New Delhi*.

Faqih, M.A.A. (2018). Analisis Biaya dan Permintaan dalam Penetapan Harga Pokok Penjualan Unit Apartemen Jember Town Square. *Skripsi Universitas Jember*.

Hair JR., J. F., B lack, W. C., Babin, B. J., & Anderson, R. E. (2010*). Multivariate Data Analysis (Seventh ed.)*. Pearson Prentice Hall.

Harahap, P.P., Purnomo, E.P.. & Agustyara. (2020). SUSTAINABLE DEVELOPMENT: THE IMPACT OF APARTMENT DEVELOPMENT IN SLEMAN AREA ON COMMUNITY LIVES. *Journalbalitbangdalampung*, 2354-5704.

Hua Kiefer, M.A. (2007). Essays on applied spatial econometrics and housing economics. Ph.D. *Thesis, Ohio State University*, USA.

Huang, X., Lin, Y., Zhou, F., Lim, M.K., & hen, S. (2021). Agent-based modelling for market acceptance for electric vehicles: Evidence from China. *Sustainable Production and Consumption 28*. 206-217

Kotler, Philip et al. (2000). Manajemen Pemasaran Perspektif Asia Buku 1..Jakarta: Erlangga

Kurniawan, B., & Simanjuntak, M.R. (2019). PERBANDINGAN PERSYARATAN GREEN BUILDING DI INDONESIA DAN SINGAPURA. *TECHNOPEX-2019 Institut Teknologi Indonesia*, 2654-489X.

Moyer, R. (1968). International Market Analysis. *Journal of Marketing Research*, 5(4),353-360.

Napier, T. (2016). *Construction Waste Management*. Whole Building Design Guide. U. S. Army Corps of Engineers, Engineer Research and Development Center. Construction Engineering Research Laboratory

Nasar, K.K., & Manoj, P.K. (2015). PURCHASE DECISION FOR APARTMENTS: A CLOSER LOOK INTO THE MAJOR INFLUENCING FACTORS. *International Journal of Research in Applied,Natural and Social Sciences*, 3(5), 105-112.

Onggo et al. (2019). FAKTOR YANG MENENTUKAN KEPUTUSAN MEMBELI APARTEMEN. *Program MM Sekolah Bisnis dan Ekonomi Universitas Prasetya Mulya*.

Pernetti, R., Garzia, F. & Oberegger, U. F. (2021). Sensitivity analysis as support for reliable life cycle cost evaluation applied to eleven nearly zero-energy buildings in Europe. *Sustainable Cities and Society*, 74(2021), 102139.

Putro, R.W.S., &Raflis. (2019). Analisis Life Cycle Cost pada Green Building Peringkat Platinum di Indonesia. *Prosiding Seminar Intelektual Muda*, 1, 368-373.

Tjiptono, Fandy dan Gregorius C. (2012). Pemasaran Strategik, Mengupas Pemasaran Strategik, Branding Strategy, Customer Satisfaction, Strategi Kompetitif hingga e- Marketing. *Yogyakarta: CV Andi Offse*t.

University of Houtson. (2015). Lesson 8-Business Application:Breakeven Analysis,Equilibrium Quantity/Price.

Walpole, R. E. (1995). Pengantar Statistika. Edisi ke-3. Jakarta: *Gramedia Pusaka Utama*.

World Summit Outcome. (2005). United Nations, Resolution adopted by the General Assembly. 60/1, Agenda items 46 and 120. 2005.

Surapto, H., & Wulandari, S. (2009). STUDI MODEL PENGELOLAAN LIMBAH KONSTRUKSI DALAM PELAKSANAAN PEMBANGUNAN PROYEK KONSTRUKSI. Proceeding PESAT, 3,18858-2559.

Rizza, R. (2012). HUBUNGAN ANTARA KONDISI FISIK SUMUR GALI DENGAN KADAR NITRIT AIR SUMUR GALI DI SEKITAR SUNGAI TEMPAT PEMBUANGAN LIMBAH BATIK. *Skripsi Universitas Negeri Semarang*.

Zuo, J., & Zhao, Z.Y. (2014). Green Building Research-Current Status and Future Agenda:A Review. *Renewale and Sustainable Enenrgy Reviews*, 30,271-281.

EVALUATION OF USER EXPERIENCE ON HAND GESTURES TOUCHLESS COMPUTERS

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ABSTRACT

The development of Human and Computer Interaction Technology has made rapid progress over the past decade, A few years ago, the words "input device" that appeared in our minds there were only two objects, namely: the keyboard and the mouse.Today, with the evolution of computers many input devices were created to change the way of interacting with computers.Artificial Intelligence Systems through Zero User Interface Technology allow humans to communicate with computers using natural means of communication such as voice, movement, sight, or even thoughts.to realize a more efficient and expressive interaction with the representation of a language that is universally acceptable. In line with this, the Covid-19 Pandemic has forced people to form new habits by implementing several health protocols, one of which is the treatment of objects that are accustomed to being touched that have the potential for covid-19 transmission, if the surface that has been contaminated with droplets is touched and afterwards directly touches the eyes, nose, and mouth.Therefore in an effort to reduce the potential was carried out a study to evaluate the application of the Touchless Computer System Using Hand Gestures in terms of its usefulness for users as an alternative method of human and computer interaction that aims to solve the problem of how people can continue to carry out activities using the computer, without touching the mouse .In this case, the Usability Testing method according to ISO 9241-11 Standard is used to measure the usefulness of the system through 3 aspects, namely effectiveness, efficiency and user satisfaction. RAD (Rapid Application Development), Convex Hull and Convexity Defect are also used as a system implementation method that focuses on recognizing images by user hand gestures in real-time, as well as detecting differences in hand gestures in various users to be able to move the cursor like how the mouse works.The result of this study is an evaluation of the application of the Touchless Computer System Using Hand Gestures used in covid-19 self-assessment activities on the JATIM SELF CHECKUP COVID-19 website application. This research is expected to provide solutions for a future where humans and computers can be more closely bound, through a friendlier human computer interaction (HCI), so that it can generate many benefits, have a great impact on human life.

Keywords: AI, Image Recognition, Hand Gesture Recognition, Covid 19, Health Protocol, HCI, Zero UI, Usability.

1. INTRODUCTION

Human hand gesture recognition by Artificial Intelligence systems has been a valuable development over the past decade and has been adopted in any field, such as high-precision surgical robots, health monitoring equipment, and gaming systems. AI gesture recognition systems that were originally visual only have been improved by integrating inputs from wearable sensors.The most efficient and expressive way of human communication is through hand gestures, which is a universally accepted language. It is expressive enough that mute and deaf people can understand it. (Bandi, et al., 2021) States that the use of physical gestures is an easy way to use in communicating in everyday life, which is a group of movements that can actually form an entire language. Hand gesture recognition provides a natural, intuitive, and suitable way for human behavior communication between humans and computers, allowing users to be more comfortable and have a realistic feeling when operating (Yun, et al., 2012).On the other hand, the coronavirus pandemic has also caused major changes in the world that impact the daily lives of mankind. Changes from remote work to normal, to the popularity of touchless technology, there are many aspects of life that may remain forever changed (ttt.studio, 2020).In addition, the Covid-19 pandemic has made touchless technology-based equipment very attractive. This is due to the demand that businesses must still be able to increase productivity and at the same time must be able to reduce employee concerns about being infected with the virus. Touchless technology allows us to touch objects with the minimum possible. Quoted from (Today, 2008), "Touchless technology is a good idea, because hard surfaces are significant transfer points for bacteria and viruses," says Charles Gerba, PhD, a microbiologist at the University of Arizona, Tucson."Much of what people put on surfaces can be picked up by the next person who comes along, and in an age where people are sharing more space and surfaces than ever before, touchless technology can help prevent cross-contamination."Many infection prevention professionals believe that touchless technology has an impact on preventing cross-contamination in healthcare environments. In addition, the Covid-19 pandemic has made touchless technology-based equipment very much in demand.This is due to demands that business actors must continue to be able to increase productivity and simultaneously must be able to reduce employee fears of being infected with the virus. In this research, a real-time hand gesture system will be proposed. The experimental setup of the system uses the high-definition recording features of a fixed-position low-cost web camera mounted on the top of a computer monitor or a fixed camera on a laptop, which captures snapshots using the Red Green Blue [RGB] color space from a fixed distance. This process is divided into four stages, namely image preprocessing, region extraction, feature extraction, and feature matching. Therefore, the author will conduct research on evaluating the user experience on a touchless computer using hand gesture recognition to accommodate the needs of human interaction with computers through the recognition of finger movements using a camera without touching it (Touchless) as a substitute for a mouse through the application of the Covid-19 Self-Assessment using the JATIM SELF CHECKUP COVID-19 website application. The Aim is to improving the touchless experience for users and reducing the potential for Covid-19 transmission through inanimate objects (computers) that are touched during this pandemic.

2. LITERATURE REVIEW

2.1 Gesture

Gesture is a non-verbal behavior in the movement of hands, and fingers [9]. The combination of hand shape, orientation and hand movement to convey a message from a person is an explanation of what gesture is. Gesture is an important source of information, because it can reduce language ambiguity or misunderstanding in communication.

2.2 Jatim Tanggap COVID-19

JATIM TANGGAP COVID-19 is a web-based application which includes the JATIM SELF CHECKUP COVID-19 application launched by the East Java Provincial Government to make it easier for the people of East Java to make early detection of recognizing the symptoms of indications of being attacked by Covid-19 and being aware of its spread. The application that can be accessed on the page; https://checkupcovid19.jatimprov.go.id/ contains how to recognize yourself whether each individual is in the category of contracting the Covid-19 virus or not. The application is also equipped with Self Assessment.Self Assessment is a simple tool that can help determine whether each individual is healthy or there are symptoms that require further assessment, examination and testing for COVID-19. The Self-Assessment tool is adapted from the COVID-19 Self-Assessment from British Columbia, Canada. In this tool people can complete this assessment for themselves and others (East Java Provincial Communication and Informatics Office, 2020).

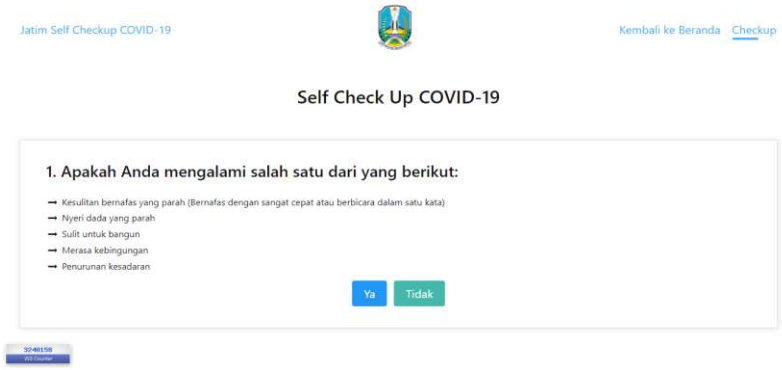


Figure 1 Website JATIM Self Checkup Covid-19 (Dinas Komunikasi dan Informatika Provinsi Jawa Timur, 2020)

2.3 Human Computer Interaction (HCI)

Human and Computer Interaction The interaction model between humans and systems involves five components, namely users or humans, interactions, computer systems, activities and work environments. The main key of HCI is usability. Usability is the degree to which a product can be used by users, to achieve goals effectively, efficiently and satisfactorily in using it (ISO, 1998).

2.4 Computer Vision

Computer Vision is computer imaging where the application does not involve humans in the visual repetition process. In other words, images are examined and processed by the computer.

2.5 Convex Hull

In the Convex Hull method there is a convex polygon, which is a polygon that has no concave parts. If any two points are selected from a polygon (including its sides and the area covered by its sides) and the two points are connected by a straight line. If all straight lines that can be formed from two points in the polygon do not cross the boundary of the polygon then the polygon can be called a convex polygon.

2.6 Convexity Defect

The Convexity Defect method provides very useful information for understanding contour shapes. Many characteristics of complex contours can be described by the convexity defect. Figure 2 illustrates the convexity defect of a star-shaped plane, the green line represents its convex hull.

2.7 RAD (Rapid Application Development)

The RAD (Rapid Application Development) software development method is a software development process that emphasizes short development cycles. The stages in the RAD method are divided into 4 stages, namely Requirements Planning, System Design, Development process & feedback collection and Implementation or product completion.

2.8 Usability Testing

Usability Testing is one way to find out whether users can easily use the application, how efficiently and effectively an application can help users achieve their goals and whether users are satisfied with the application used.

3. METHODS

This research includes several stages, in general the stages carried out are depicted in the following flow chart. In detail, the stages of the research to be carried out are described in the following diagram.

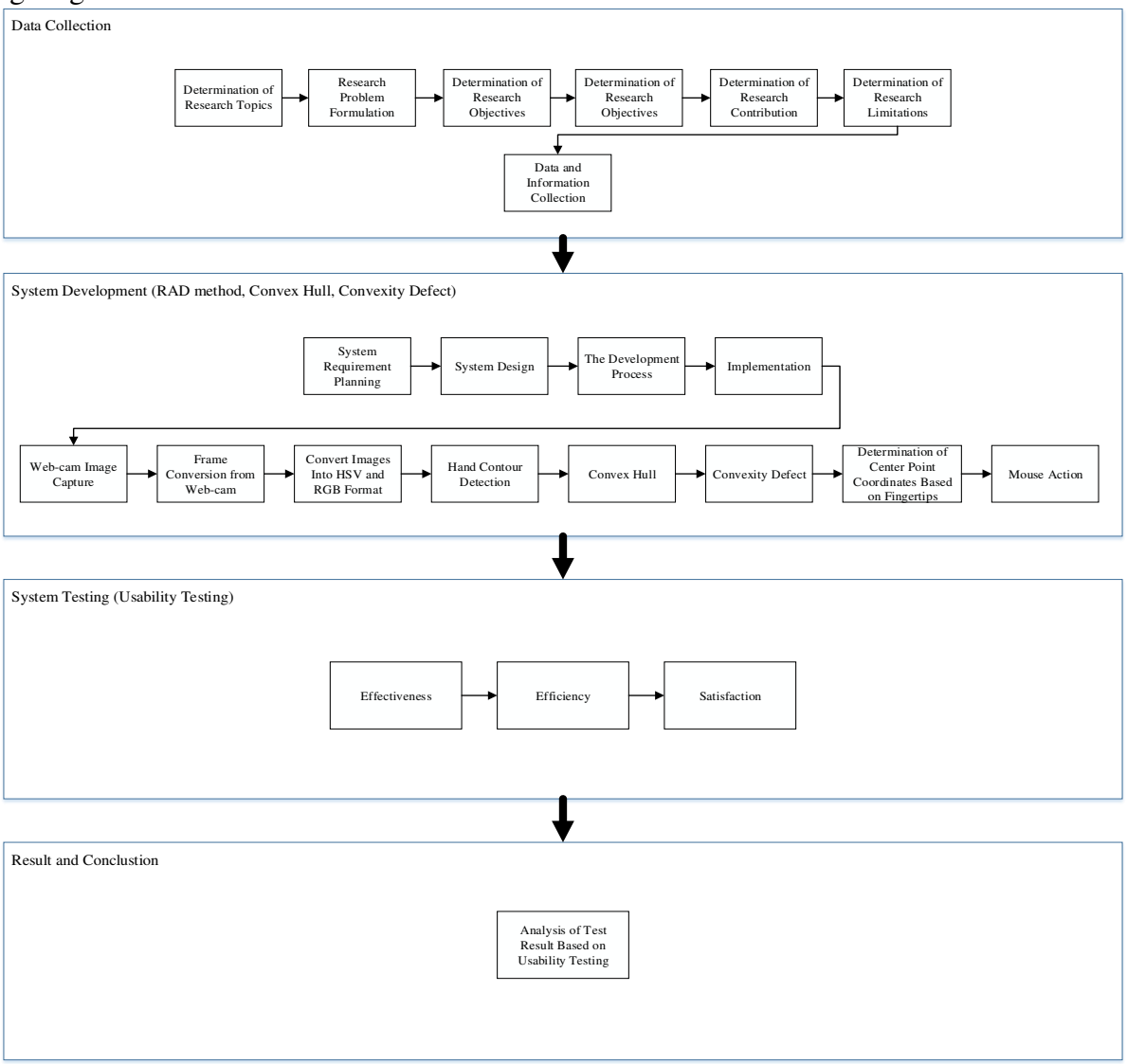


Figure 3 Detailed research flow of designing a touchless computer system using hand gesture recognition.

3.1 Data Collection Stage

At this stage, the research topic is determined, then the problem formulation is carried out, followed by determining the objectives, after that determining the benefits of this research, then determining the contribution of the research, followed by determining the research limitations. In the next stage, namely data and information collection, a literature study is carried out through a journal review process related to hand gesture recognition which will be used as a reference in determining methods, supporting tools in system development, and an overview of system testing later.

3.2 System Development Stage

The System Development Stage in this study uses the RAD (Rapid Application Development) method which begins with System Requirements Planning which includes planning the needs of tools, programming languages, methods, libraries, and supporting devices such as what will be used in system development. Next is the System Design stage including display design, system flow design and programming code structure design, followed by the Development Process, namely coding, followed by the final stage, namely implementation. In this case the system works through several stages with the support of the Convex Hull method (Polygon line formation formed from the five fingertips) and Convexity Defect (Line formation between the inner end of the finger to the outer end). The stages are as follows:

1. Real-time Image Capture from Web-Cam.
2. Frame conversion from Web-Cam.
3. Image Conversion in HSV and RGB formats.
4. Hand Contour Detection.
5. Convex Hull.
6. Convexity Defect.
7. Determination of Center Point Coordinates Based on Fingertips
8. Mouse Action.

3.3 System Testing Stage

The System Testing Stage, in this case Usability Testing, is carried out to measure whether the existing system has fulfilled usability for users.The ISO 9241-11 standard defines usability as the extent to which a product can be used by specific users to achieve specific goals with effectiveness, efficiency and satisfaction in a specific context of use (International Organization for Standardization, 2016).

3.4 Results and Conclusion Stage

At this stage, the results of the system testing process will be discussed, starting from the implementation results stage to the test results, so that a conclusion will be drawn regarding the success of the design of the touchless computer system using hand gestures recognition in meeting the research objectives.

4. RESULTS

The results of research and discussion are divided into 3 sub-chapters, including: Overview of the Research Object, Presentation and Analysis of Data, and Discussion

4.1 Overview of Research Objects

4.1.1 Touchless Computer Using Hand Gestures

Is a development of a touchless computer system using camera assistance to detect user hand gestures obtained from a web camera in realtime into a language that matches the output recognized by the system, converted into commands for moving the mouse cursor.

4.1.2 Jatim COVID-19 Response

Is a web-based application in which there is a JATIM SELF CHECKUP COVID-19 application. In this case, it was launched by the East Java Provincial Government to make it easier for the people of East Java to carry out early detection of recognizing symptoms about indications of being attacked by Covid-19 and being aware of its spread. There are 7 questions that need to be answered (yes / no) by the user to get self checkup results with healthy conditions. The 7 steps include:

1. Select the Check Condition Option / Return to Home.
2. Fill in the Self Identity Answer Apakah Anda Mengalami Salah Satu Dari Yang Berikut ?(Kesulitan bernafas, nyeri dada, sulit bangun, merasa kebingungan, penurunan kesadaran).
3. Apakah Anda Mengalami Salah Satu Dari Yang Berikut ?(Nafas pendek saat istirahat, ketidakmampuan untuk berbaring karena sulit bernafas, kondisi kesehatan kronis karena sulit bernafas).
4. Apakah Anda Mengalami Salah Satu Dari Yang Berikut ?(Demam, batuk, bersin, sakit tenggorokan, sulit bernafas).
5. Apakah Anda Muncul Gejala Setelah 14 Hari Setelah Traveling Ke Luar Negeri atau Kota yang terjangkit ?
6. Apakah Anda memberikan perawatan atau melakukan kontak dekat dengan seseorang dengan COVID-19 (kemungkinan atau dikonfirmasi) saat mereka sakit (batuk, demam, bersin, atau sakit tenggorokan)?
7. Apakah Anda memiliki kontak dekat dengan seseorang yang bepergian ke luar Negeri dalam 14 hari terakhir yang menjadi sakit (batuk, demam, bersin, atau sakit tenggorokan)?

4.2 Data Presentation and Analysis

4.2.1 Hand identification on camera

This section describes how the process of identifying differences in human hand patterns using image recognition with camera tools is carried out.

4.2.1.1.System requirement planning

a. Minimum Hardware & Software Requirements:

Personal Computer/Laptop
Processor: Intel(R) Core(TM) i7-4750HQ CPU @2.00Ghz (8 CPUs), ~2.0GHz.
Operating System : Windows 10 Pro 64-bit
Memory: 8 GB RAM
HDD : 100 GB Free Hard Disk Space
Display 1: 15.6 inch, 1366 x 768 (HD) or Higher Configuration: RGB Stripe
Display 2 : 32 inch, 1366 x 768 (HD) or Higher Configuration: RGB Stripe
Web Camera: USB2.0 UVC HD Webcam

4.2.1.2 System Design

a. Hardware Configuration Design

The use of a PC / laptop that has a web camera installed in its operation is set at a distance between the user and the camera and screen as far as 50 cm to a maximum of 100 cm to adjust the camera range.

4.2.1.3 Development Process

Several functions were implemented including: Identification of landmarks on the hand (Convex Hull and Convexity Defects Detection), search for index and middle fingers, search for which finger is moving up, find the index finger that is moving up alone among the other four fingers.

4.2.1.4 Implementation

The implementation process includes the following steps: Image Capture from WebCam, Frame Conversion from webcam, Contour Detection /Find hand landmarks (Detection of Convex Hull and Convexity Defects).

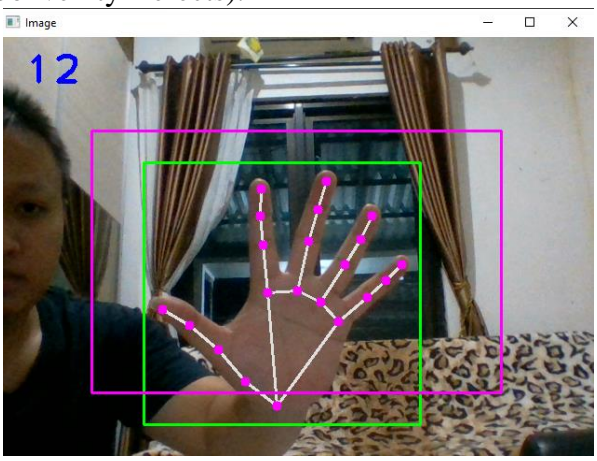


Figure 4 System Implementation

Figure 4 shows the screenshot when the system has successfully detected the hand with the support of WebCamera. The number 12 (in blue) is the frame conversion value of the WebCamera. The "find hand landmark" function receives an RGB image and detects the hand in the frame and finds key points as white lines connecting each point (colored purple) as an indicator of hand gesture detection / landmark detection using (Convex Hull and Convexity Defects).In its implementation, testing was carried out in a closed room using 2 screens of different sizes, namely 15.6 inches and 32 inches, with the same distance between 50 cm - 100 cm the user moves his hand in front of the camera on a 15.6 inch screen then 32 inches alternately.The results obtained by the system can still properly detect hands even with different screen sizes. However, it was found that the screen size also affects the range of user movement in moving the hand for mouse control, the larger the screen, the longer the range needed for the user to be identified by the system.

4.2.2 Identification of important points in hand gestures for mouse movement

This section describes how the needs analysis of the touchless computer using hand recognition system is carried out in identifying human hand patterns to be able to move the mouse on the computer.

4.2.2.1 Determination of the center point of coordinates based on the Fingertips

In determining the center point of the mouse cursor coordinates, the system detects which finger movement is being lifted among the 5 fingers on one hand through the fingersup function, in this case the tip of the raised index finger is used as the center point of the coordinates that will be used as the mouse cursor point as in Figure 23 below, then the system converts the coordinates on the camera with the coordinates on the screen.

4.2.2.2.Mouse Action

There are several steps in the system to convert hand movements captured from the camera into a Mouse Action. In this research there are 2 types of Mouse Actions that are applied, namely Movement & Click. The movement action is formed from several stages, including:

1.The process of detecting the center point of the coordinates based on the predetermined finger movement.

2. Convert the midpoint coordinates into mouse coordinates on the PC screen.

3. The process of smoothing the conversion value.
4. Mouse movement action.

Meanwhile, click actions are formed of:

1. The detection process of the index and middle fingers lifting together.
2. Detecting the distance between the two fingers (index and middle).
3. The process of calculating the distance between the two fingers (if the distance is short, it will trigger the Mouse click action).
4. Mouse click action.

4.2.3 Evaluation of user experience through usability testing

The evaluation process in the application of the touchless computer using handgestures recognition system is carried out with a scenario: users carry out COVID-19 self-assessment activities on the JATIM SELF CHECKUP COVID-19 website application with the support of the touchless computer using handgestures recognition system, the initial process is to open the website page via a shorcut link on the desktop, then the user answers 7 questions that must be completed sequentially with multiple choices (yes / no) until the final stage, namely the display of assessment results. Evaluation of the usefulness of the system in these activities considers 3 aspects namely Effectiveness, Efficiency and Satisfaction.

4.3 Discussion and Review

4.3.1 Effectiveness

Effectiveness is how much the system can help users in completing their tasks. The performance is measured by the time it takes the user to complete a predetermined task, in this case there are 7 questions that need to be answered (yes / no) by clicking on one of the buttons (yes / no) with the support of Touchless Computer Using Hand Gestures by the user to get self checkup results with healthy conditions, as well as by measuring the number of errors made by users in completing the task.To obtain quantitative data, a calculation tool is used, namely the Completion Rate to measure the completion rate (Mifsud, 2015) and which is then used as a Key Performance Indicator. As for the results of usability testing to measure the level of effectiveness with the object of research, the Completion Rate Respondent data that has been documented through video is obtained and then recapitulated. The recapitulation is done by calculating how many tasks can be completed from the scenario that the respondent has completed as in table 4.1 below.

$$Effectiveness = \frac{Number\ of\ tasks\ completed\ successfully}{Total\ number\ of\ tasks\ undertaken}\ x\ 100\%$$

The Compeletion Rate Effectiveness calculation process is as follows:

- Total tasks = 8
- Respondent R01 successfully completed all 7 tasks
- Respondent R02 successfully completed all 7 tasks
- Respondent R03 successfully completed all 7 tasks
- Respondent R04 successfully completed all 7 tasks
- Respondent R05 successfully completed all 7 tasks
- Respondent R06 successfully completed all 7 tasks
- Respondent R07 successfully completed all 7 tasks
- Respondent R08 successfully completed all 7 tasks
- Respondent R09 was only able to complete 2 of the 7 tasks
- Respondent R10 successfully completed all 7 tasks

Compeletion Rate:

R01 = 7 / 7 * 100% = 100%
R02 = 7 / 7 * 100% = 100%
R03 = 7 / 7 * 100% = 100%
R04 = 7 / 7 * 100% = 100%
R05 = 7 / 7 * 100% = 100%
R06 = 7 / 7 * 100% = 100%
R07 = 7 / 7 * 100% = 100%
R08 = 7 / 7 * 100% = 100%
R09 = 2 / 7 * 100% = 29%
R10 = 7 / 7 * 100% = 100%

Effectiveness =

(100% + 100% + 100% + 100% + 100% + 100% + 100% + 28% + 100%) / 10 = 93 %

No	Respondent Code	Number of Task Performed	Total Tasks	Compeletion Rate
1	R01	7	7	100%
2	R02	7	7	100%
3	R03	7	7	100%
4	R04	7	7	100%
5	R05	7	7	100%
6	R06	7	7	100%
7	R07	7	7	100%
8	R08	7	7	100%
9	R09	2	7	29%
10	R10	7	7	100%
Average =				93%

Table 1. Compeletion Rate Effectiveness Result

The data in table 1 shows that the average Completion rate resulting from the application of the touchless computer using handgestures recognition system in COVID-19 self-assessment activities on the JATIM SELF CHECKUP COVID-19 website application is 93%. Based on the standard effectiveness criteria reference is 78%, above this figure it can be interpreted that it has exceeded the standard effectiveness criteria or has a good predicate (Good).

4.3.2 Efficiency

Time Based Efficiency Table 2 below is the result of the processing time of each task by the respondent, worth 1 if the respondent is declared successful, otherwise it is worth 0 if the respondent is declared a failure in working on tasks in testing COVID-19 self-assessment activities using a touchless computer system using handgestures recognition on the JATIM SELF CHECKUP COVID-19 website application.

Task Time = End Time – Start Time

$$Time\ Based\ Efficiency = \frac{\sum_{j=1}^{R}\sum_{i=1}^{N}\frac{n_{ij}}{t_{ij}}}{NR} \qquad Overall\ Relative\ Efficiency = \frac{\sum_{j=1}^{R}\sum_{i=1}^{N} n_{ij}t_{ij}}{\sum_{j=1}^{R}\sum_{i=1}^{N} t_{ij}} \times 100\%$$

Where:

N = The total number of tasks (goals)
R = The number of users
n_{ij} = The result of task i by user j; if the user successfully completes the task, then N_{ij} = 1, if not, then N_{ij} = 0
t_{ij} = The time spent by user j to complete task i. If the task is not successfully completed, then time is measured till the moment the user quits the task

No	Respondent Code	Compeletion Time / second (tij)	Task Result (nij) *1 = success, 0 = failed*
1	R01	59	1
2	R02	32	1
3	R03	71	1
4	R04	42	1
5	R05	35	1
6	R06	45	1
7	R07	40	1
8	R08	35	1
9	R09	120	0
10	R10	37	1
Time Based Efficiency **=**		0,31	(goals/sec)
Overral Relative Efficiency **=**		77%	

Table 2. Results of Time-Based Efficiency and Overral Relative Efficiency

The process of calculating Time Based Efficiency and Overral Relative Efficiency is as follows:

N (Number of Tasks) = 7
R (Number of Respondents) = 10

- Respondent R01 successfully completed all 7 tasks (valued 1) with a time duration of 59 seconds. (nij =1, tij =59).
- Respondent R02 successfully completed all 7 tasks (valued 1) with a time duration of 32 seconds. (nij =1, tij =32).
- Respondent R03 successfully completed all 7 tasks (valued 1) with a time duration of 71 seconds. (nij =1, tij =71).
- Respondent R04 successfully completed all 7 tasks (valued 1) with a time duration of 42 seconds. (nij =1, tij =42).
- Respondent R05 successfully completed all 7 tasks (valued 1) with a time duration of 35 seconds. (nij =1, tij =35).
- Respondent R06 successfully completed all 7 tasks (valued 1) with a time duration of 45 seconds. (nij =1, tij =45).
- Respondent R07 successfully completed all 7 tasks (valued 1) with a time duration of 40 seconds. (nij =1, tij =40).
- Respondent R08 successfully completed all 7 tasks (valued 1) with a time duration of 35 seconds. (nij =1, tij =35).
- Respondent R09 failed to complete the task (valued 0) with a time duration of 120 seconds. (nij =0, tij =120).
- Respondent R10 successfully completed all 7 tasks (valued 1) with a time duration of 37 seconds. (nij =1, tij =37).

Time Based Efficiency =
((1/59) + (1/32) + (1/71) + (1/42) + (1/35) + (1/45) + (1/40) + (1/35) + (0/120) + (1/37)) / (7 * 10) = 0.31 goals/second.
Overral Relative Efficiency = ((1*59) + (1*32) + (1*71) + (1*42) + (1*35) + (1*45) + (1*40) + (1*35) + (0*120) + (1*37)) / (59 + 32 + 71 + 42 + 35 + 45 + 40 + 35 + 120 + 37) * 100% = 77 %.
In this test, 1 respondent "Respondent R09" stopped when the test had been running for 2 minutes and did not continue the process. According to (Shukairy, 2022) Nij worth 0 is if the task is not successfully completed by the user, then the time measured is until the user quits the task. According to (Mifsud, n.d.) Nij is 0 if the user gives up without completing the task. Whereas according to (Sergeev, 2010) In the case of failed scenario completion, it is measured up to the time of termination of the scenario by the respondent as a result of giving up the goal or leaving the system, so that in this case "Respondent R09" is considered unable to complete the task that has been given, (Nij = 0).The results of the calculation of Time Based Effieciency obtained a value of 0.31, which means that the average speed level obtained by users in completing task is 0.31 goals/second. Furthermore, the results of the calculation of the value of each task done by the respondent are then calculated by the Overall Relative Efficiency formula, the total score of all tasks is then divided by the total tasks. From the total score of all respondents, it is then averaged so that the results of the efficiency calculation for usability testing on this research , in this case a value of 77% is obtained so that it can be said that the use of a touchless computer system using handgestures recognition in COVID-19 self-assessment activities on the JATIM SELF CHECKUP COVID-19 website application is efficient.

4.3.3 Satisfaction

The results of measuring user satisfaction variables in Usability Testing on this research as shown in Table 4.3 with the SUS (System Usability Scale) method, in this case resulting in an average value of 77%. Here are 10 questions from the System Usability Scale (SUS) that have been translated into Indonesian:

1.I think I will use this system again
2.I find this system complicated to use
3.I find the system easy to use
4.I need help from other people or technicians in using this system
5.I feel the features of this system work properly
6.I feel that there are many things that are inconsistent (mismatched in this system)
7.I feel others will understand how to use this system quickly
8.I feel the system is confusing
9.I feel there are no barriers in using this system
10.I need to familiarize myself first before using this system 10.

Answer	**Score**
Strongly Disagree (STS)	1
Disagree (TS)	2
Undecided (RG)	3
Agree (S)	4
Strongly Agree (SS)	5

Rules for Calculating SUS:

1.Every odd numbered question, the score of each question obtained from the user score will be reduced by 1.

2.Every even numbered question, the final score is obtained from the value of 5 minus the score of the question obtained from the user.

3.SUS score is obtained from the sum of the scores of each question which is then multiplied by 2.5.

Score calculation rules to apply to 1 respondent. For further calculations, the SUS score of each respondent is sought for the average score by summing all scores and dividing by the number of respondents. The following formula calculates the SUS score:

$$\bar{x} = \frac{\sum x}{n}$$

$\bar{x}$ = skor rata-rata

$\sum x$ = jumlah skor SUS

n = jumlah responden

SUS Score	Grade	Adjective Rating
> 80.3	A	Excellent
68 – 80.3	B	Good
68	C	Okay
51 – 68	D	Poor
< 51	F	Awful

Table 3 SUS (System Usability Scale) Score Grade

Satisfaction Score Standard (SUS) = 68

No	Repondent	Original Score									
		Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10
1	R1	4	3	4	1	5	1	5	1	4	2
2	R2	4	3	4	1	5	1	5	1	4	1
3	R3	4	2	4	1	5	1	4	2	4	5
4	R4	5	2	4	1	5	2	4	2	4	5
5	R5	4	3	4	2	4	2	5	2	4	5
6	R6	5	1	5	1	5	1	5	1	5	5
7	R7	5	2	4	2	4	2	4	2	4	5
8	R8	5	2	5	1	5	1	5	1	4	5
9	R9	4	3	3	4	4	1	4	3	4	5
10	R10	5	1	4	1	4	1	4	1	4	5

Table 4 SUS (System Usability Scale) using a questionnaire.

Calculated Score										Total	Score
Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10		(Total x 2.5)
3	2	3	4	4	4	4	4	3	3	34	85
3	2	3	4	4	4	4	4	3	4	35	88
3	3	3	4	4	4	3	3	3	0	30	75
4	3	3	4	4	3	3	3	3	0	30	75
3	2	3	3	3	3	4	3	3	0	27	68
4	4	4	4	4	4	4	4	4	0	36	90
4	3	3	3	3	3	3	3	3	0	28	70
4	3	4	4	4	4	4	4	3	0	34	85
3	2	2	1	3	4	3	2	3	0	23	58
4	4	3	4	3	4	3	4	3	0	32	80
Average Score (Final Result)											77

Table 5 Shows that the average value of SUS (System Usability Scale) is 77%.

The minimum standard score is 68% or 50% of the total satisfaction score that can be obtained. In this test it can be concluded that the category is acceptable (Good).

6. CONCLUSIONS & SUGESSTION

6.1 Conclusions

Based on the results of the User Experience Evaluation research on Touchless Computer Using Hand Gestures, it can be concluded as follows.

1. The process of identifying the user's hand on the camera by the system can be done well through several stages including: capturing images from the WebCam, converting frames from the webcam, and detecting finger contours / "Find hand landmarks" (Detection of Convex Hull and Convexity Defects). From these several stages, programming functions are made that are applied to the system so that the system can capture the movement of the fingers, then the system draws a line following the movement of the user's fingers as an indicator. From testing with 2 different screens, namely 15.6 inches and 32 inches, it can be concluded that the larger the screen size, the greater the distance that needs to be reached by the user to be identified by the system.
2. Different user (human) hand patterns can be identified well through the stages: determination of the midpoint coordinate based on the predetermined fingertip (in this case the index finger), conversion of the midpoint coordinate into mouse coordinates on the PC screen, the process of smoothing the conversion value, then the action of moving the mouse cursor on the computer (displacement). The mouse action "click" is formed through several stages, among others: Detection of the index and middle fingers that lift together, detection of the distance between the two fingers (index and middle), the process of calculating the distance between the two fingers (if the distance is short it will be the trigger for the Mouse click action). From some of these stages, programming functions are made that are applied to the system, so that users can control the computer using mouse actions (click and move) without direct contact (Touchless).
3. Evaluation of User Experience on Touchless Computer Using Hand Gestures through a usability testing approach to COVID-19 self-assessment activities on the JATIM SELF CHECKUP COVID-19 website application to get the value of system usability by considering 3 aspects namely Effectiveness, Efficiency and Satisfaction as ISO 9241-11 Standard in this study can be concluded as follows:

No	Usability Aspect	Usability Test Results
1	Effectiveness	93% (Good)
2	Efficiency	77 % (Good)
3	Satisfaction	77 % (Good)

Table 6.1 Usability Test Results.

a. Effectiveness

The results of measuring the effectiveness aspect of the application of the touchless computer using handgestures recognition system in COVID-19 self-assessment activities on the JATIM SELF CHECKUP COVID-19 website application resulted in an average compeletion rate of 93%. Referring to the standard effectiveness criteria (78%), it can be interpreted that the effectiveness aspect of the system has exceeded the standard effectiveness criteria or has a good predicate.

b. Efficiency

In measuring the efficiency aspect, the Time Based Effieciency value is 0.31. This means that the average speed level obtained by users in completing COVID-19 self-assessment activities using a touchless computer system using handgestures recognition on the JATIM SELF CHECKUP COVID-19 website application is 0.31 goals/second. Meanwhile, the calculation of Overall Relative Efficiency obtained a value of 77%, so it can be said that the use of a touchless computer system using handgestures recognition in COVID-19 self-assessment activities on the JATIM SELF CHECKUP COVID-19 website application is quite efficient.

c. User Satisfaction

In measuring the User Satisfaction aspect through the System Usability Scale approach through filling out questionnaires by users, the average SUS (System Usability Scale) value is 77%. The standard value that must be achieved by a product is at least 68% or 50% of the total satisfaction value that can be obtained. In other words, it can be interpreted that the value obtained in testing user satisfaction variables on the use of a touchless computer system using handgestures recognition in COVID-19 self-assessment activities on the JATIM SELF CHECKUP COVID-19 website application is included in the acceptable (Good) category.

6.2 Suggestion

1. Suggestions for Policy Recommendations

   The results of the User Experience Evaluation research on Touchless Computer Using Hand Gestures show that the application of Touchless technology can effectively provide its own experience for users, therefore the authors suggest that the utilization of Touchless Computer technology Using Hand Gestures can be applied to support E-Commerce activities in public places such as Electronic Payment Points or commonly called E-Kios that exist today to support the sale of electricity tokens, transportation tickets, or other sales, in addition to the use of Touchless Computer Technology Using Hand Gestures can be applied as an auxiliary tool for Electronic Vending Machines so that it can allow users to make purchases without direct contact so that it is easier and provides its own experience for users. In addition, Touchless Computer Technology Using Hand Gestures will be very suitable if applied to the use of computers with large screens for information needs that are far from the reach of users.

2. Suggestions for Further Research Studies

   User Experience Evaluation Research on Touchless Computer Using Hand Gestures is limited to the use of hands with index fingers and middle fingers as indicators of recognition by the system to control the mouse, therefore it is hoped that future researchers can develop other systems by utilizing other fingers as indicators, especially other senses besides hands, and especially can replace other controllers besides the mouse, for example: keyboards so as to improve user experience and interaction on computers.

REFERENCES

Aksa2011, 2016. *Camera Webcam Computer - Free Photo on Pixabay.*

Ashok, A., 2021. *The Future Of Customer Experience: Zero User Interfaces.*

Astana, I. N. Y., HA, R. & Wibowo, M. A., 2015. Influence Of Bidding Strategy On Project Performance in Construction. Advances in Natural and Applied Sciences, Volume 9, pp. 65-71.

Bandi, R. et al., 2021. *Gesture Recognition using Convex Hull and Hull Defects Method to Control Electronic Appliances in Home*. INTERNATIONAL JOURNAL OF ENGINEERING RESEARCH & TECHNOLOGY (IJERT), 09(05), p. 256.

International Organization for Standardization, 2016. ISO/IEC 25022:2016 *Systems and software engineering — Systems and software quality requirements and evaluation (SQuaRE) — Measurement of quality in use. ISO/IEC 25022:2016 ed. Geneva: International Organization for Standardization.*

Kieras, D., 2003. Using the Keystroke-Level Model to Estimate Execution Times. 3, p. 11.

Kyocera Global, 2020. Air Gesture: A next-generation technology that uses gestures to control smartphones, automotive navigation systems, and more.

Shukairy, A., 2022. *Usability Metrics: A Guide To Measuring The User Experience.*

stambol, 2021. *Touchless Technology in the Wake of COVID-19.*

Xu, Y., Park, D.-W. & Pok, G., 2017. *Hand Gesture Recognition Based on Convex Defect Detection. International Journal of Applied Engineering Researc*h, Volume 12, p. 7075.

Yun, L., Lifeng, Z. & Shujun, Z., 2012. *A Hand Gesture Recognition Method Based on Multi-Feature Fusion and Template Matching*. Procedia Engineering, Volume 29, pp. 1678-1684.

BUSINESS FEASIBILTY ANALYSIS OF RENEWABLE WIND TURBIN GENERATOR PROJECTS IN BANYUWANGI

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ABSTRACT

One of the very large renewable energy potentials in Indonesia is the Wind Turbine Generator (PLTB). PLTB Banyuwangi is one of the development programs that has been stated in the Business Plan for the Provision of Electricity. The results of the initial measurement of wind speed obtained the average annual value in the Wongsorejo sub-district, Banyuwangi Regency reaching more than 5 m/s, this indicates that the area is very promising for PLTB development. The method used in this research is the analysis of electrical energy generated every year and Capital Budgeting to determine the financial feasibility parameters including cash flow analysis, IRR, NPV and Payback Period. From the results of the study, it was found that the Banyuwangi 80 MW PLTB Development project was financially feasible with an IRR value of 9.24% higher than the WACC value of 5.91%, and a positive Net Present Value of 668,066,295,000 rupiahs, and the payback period value for 9 years. The results of the sensitivity analysis show that the Banyuwangi PLTB project is not feasible if the value of the capacity factor of the generator is below 35% or the value of the electricity tariff is below 945 IDR/Kwh

Keywords: Wind Turbine Generator, Capital Budgeting, IRR, NPV

1. INTRODUCTION

Electricity is a very important source of energy in society, almost all sectors of life depend on the availability of electrical energy, even electricity is the main indicator for the level of a country's economy. The higher the electrification ratio of a country, it is certain that the level of the economy and the welfare of the country will increase

The Electricity Supply Business Plan document (2020) shows that electricity sales in Indonesia from 2015-2020 resulted in a fairly consistent growth at 3.5%, except in 2020, almost all areas of Indonesia experienced the COVID-19 pandemic, which resulted in there are restrictions in the territory of Indonesia, especially the industrial sector, so that it has a direct effect on the decline in electricity sales

Table 1 Electric Power Sales

Description	Year						
	2014	2015	2016	2017	2018	2019	2020
Electric Power Sales (Mwh)	196.418	200.600	213.455	221.066	232.433	243.058	241.140
Growth (%)		2,13%	6,41%	3,57%	5,14%	4,57%	-0,79%

Renewable energy is the main alternative in overcoming dependence on the use of fossil energy. The country of Indonesia greatly benefits from the potential of renewable energy resources, this is due to Indonesia's geographical position which is surrounded by oceans, volcanoes, islands, sunlight which throughout the year illuminates almost all areas of Indonesia. The wind potential in Indonesia is also very large. Despite the enormous potential for renewable energy, practically most of the renewable energy potential in Indonesia has not been fully utilized, as shown in the figure below, the average use of renewable energy is around 2% compared to its potential.

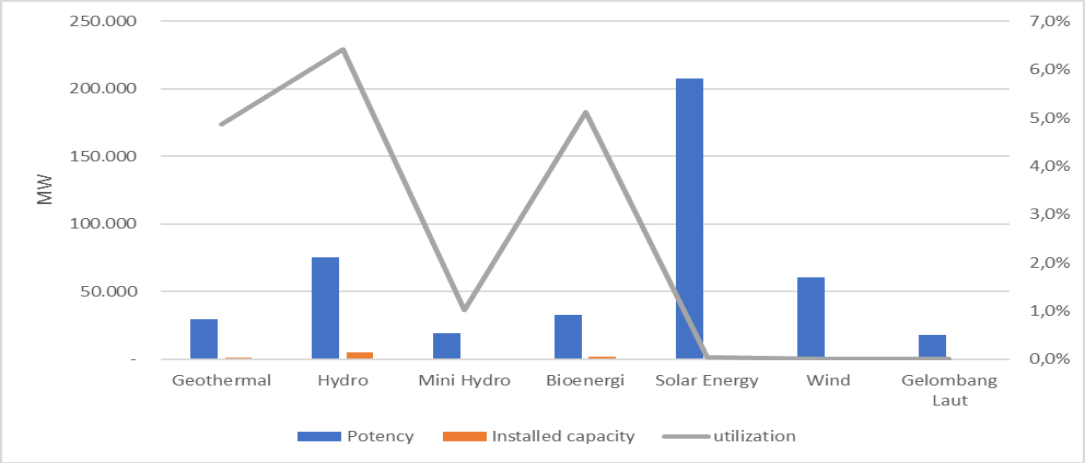


Figure 1 Potential use of renewable energy

PT XYZ as one of the largest power generation companies in Indonesia, seeks to support the government's achievement by planning to build a PLTB with a capacity of 80 MW in Wongsoredjo sub-district, Banyuwangi Regency, East Java. This will support the acceleration of power generation capacity based on New and Renewable Energy in East Java Province, which is currently only realized about 1%.

The Wind Turbine Generator development plan in Banyuwangi is based on several things, including the wind speed parameter in the Wongsoredjo sub-district of Banyuwangi, which on average exceeds 5 m/s, this is in accordance with the research of Salih, Taha, and Alawsaj (2012) which states that wind speed has a large effect to the electrical energy produced, where the Cut In wind speed is 4-5 m/s, and electrical energy will increase as the wind speed increases, if the wind speed value is below 4-5 m/s then the Wind Turbine Generator will not function to generate electricity.

The main challenge of developing a PLTB project is the level of economy. PLTB investment is a large-scale project investment. According to Siswanto (2000) large projects have characteristics including absorbing and binding large amounts of funds and the benefits obtained will only be generated in a long time span.

The purpose of this study is to analyze the financial feasibility of the wind power plant development project in Banyuwangi, using several parameters such as IRR, Payback Period, Net Present Value, as well as conducting sensitivity analysis on important parameters that affect project feasibility.

2. LITERATURE REVIEW

2.1 Wind Turbine Generator

A Wind turbine Generator is basically a machine that is able to convert wind energy into mechanical (kinetic) energy and eventually turn it into electrical energy. At this time there are several types of wind turbines used, based on the position of the axis of rotation of the rotor, divided into two, namely horizontal axis wind turbines and vertical axis wind turbines. Based on Stavrakakis (2012) the process of generating electricity by PLTB starts from the wind with a certain speed blowing on the rotor blade, which causes the rotor to rotate, the rotor then moves the generator shaft, from this generator the kinetic energy is then converted to produce electricity which will be flowed through the Grid System and in the end to electricity consumers

2.2 Project Investment Cost

Ijjou Tizgui (2018) said that Investment Costs are any costs incurred starting from the project idea appearing until the time the project operates. In the Win Turbine Generator project located in the middle of the sea (onshore) the investment cost will be higher than on land off-sore, this is due to the location, technology, and handling of more complicated equipment.

2.3 Capital Budgeting

According to Brigham (2009), Capital Budgeting is a planning process in selecting and conducting investments whose cash flow exceeds one year or in the long term, while according to Syamsudin (2009) Capital budgeting is all activities or processes starting from collection, evaluation, selection. and determination of investment alternatives that will provide returns or income for the company within a period of more than one year.

Capital Budgeting is usually a company decision in order to maintain the existence and sustainability of the Company in the future period. The investment usually focuses on adding real production assets, for example in the world of power generation, for example: Construction of Hydro Power Plants, Solar Power Plants and others

2.4 Net Present Value

One of the financial feasibility criteria that is often used is Net Present Value (NPV), according to Siswanto (2020) NPV is the difference between the present value of all annual Net Cash Flows that will be received by investors during the useful life of the project and project investment cost.

From the Net Present Value, we can find out whether an investment project is feasible or not, if the NVP value > 0 (positive) then the project is feasible to continue, if NPV = 0, then the project is said to break even (no profit and no loss) and if NPV < 0 (negative) then the project is not feasible to continue

2.5 Payback Period

According to Brigham (2009), the payback period is the time required for net income to match the investment costs incurred. In another definition, it is stated that the payback period is the time required for the project to collect internal funds (net cash flow) to return the amount of funds that have been inventoried in the project. The development of the payback period method is the discounted payback period in which all cash flows received are changed or withdrawn to the current period (present value).

As an alternative to testing the financial feasibility of a project, the payback period has several weaknesses, so that the payback period is the second alternative after other financial feasibility parameter processes are carried out.

2.6 Interest Rate of Return (IRR)

Interest Rate of Return is one of the popular and standard methods of financial feasibility test carried out in determining the prospects of a project. In accordance with the formula, IRR is an interest rate that equates the present value of the expected cash outflow with the Present Value of the expected cash inflow.

2.7 Sensitivity Analysis

According to De Oliviera (2012) Sensitivity analysis is a procedure that analyzes the impact of changes in financial or economic studies due to changes in the value of variables related or correlated with investment projects. Some of the benefits derived from sensitivity analysis are assisting investors or project owners in assessing the feasibility if conditions change either gradually or extreme and helping formulate strategies that are carried out to reduce the risk of loss.

3. METHODS

3.1 Research Stages

Stages in research of feasibility analysis of the wind power plant project in Banyuwangi is shown in the following figure

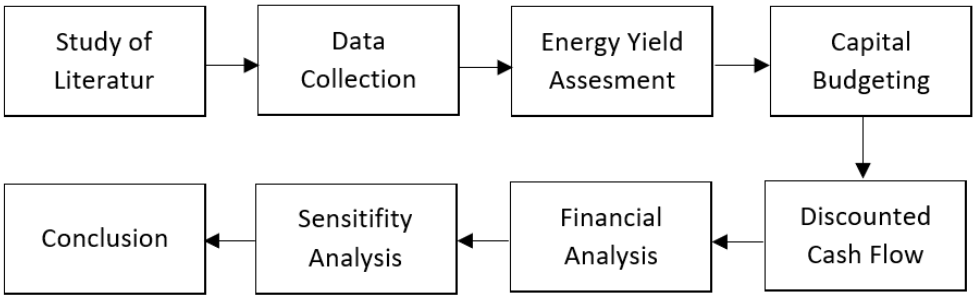


Figure 2 Research Stages

The first step that must be done is literature study and data collections. Some data that must exist, such as the coordinates of the project location, environmental conditions of the project area, government regulations related to electricity tariffs, initial investment cost data and others

3.2 Energy Yield Assessment

Energy Yield Assessment serves to find out how much potential production is produced each year during the period of use of the Wind Turbine Generator. Energy Yield Assessment is heavily influenced by several parameters including: Type or brand of Wind Turbine Generator used, Environmental conditions (wind speed, humidity) around the project area.

Energy yield Assessment will have a major effect on the calculation of the amount of income (revenue) obtained, the greater the electricity production produced, the greater the income

3.3 Financial feasibility analysis

In the financial feasibility analysis, the first step is to calculate the WACC (Weight Cost of Capital) which is a calculation method by combining the Cost of Debt with the Cost of Equity, where the value will be multiplied by the proportion of each source of funding.
The next step is to calculate the initial investment cost (CAPEX) and operating costs (OPEX). followed by compiling cashflow during the useful life of the project and as the last step is to calculate financial feasibility parameters such as Net Present Value, Interest Rate of Return using the following formula:

$$NPV = \frac{CF1}{(1+r)^1} + \frac{CF2}{(1+r)^2} + \ldots\ldots + \frac{CFn}{(1+r)^n} - Io \quad \text{(Equation 1)}$$

Note :
CF = annual net cash flow value, from 1st year to n year
Io = Initial investment costs
r = discount rate

$$IRR = r_1 + \frac{NPV_1}{(NPV_1 - NPV_2)}(r_2 - r_1) \quad \text{(Equation 2)}$$

r_1 = Discount Rate that will produce a value NPV(+)
r_2 = Discount Rate that will produce a value NPV(-)
NPV_1 = Net Present Value positif
NPV_2 = Net Present Value negatif

4. RESULTS

4.1 Energy Yield

From the calculation of the energy yield assessment using the Windpro application, the net value of electricity production for a year is 301,414,080 kWh
.

Table 2 Energy Yield Wind Turbine Generator

Wind Turbine Generator (78,2 MW-23 WTG)		
Total WTG	23	Buah
Capacity	3400	kW
Total Capacity	78200	kW
Max Production a year	685.032.000	kWh
Capacity Factor	44%	%
Net Production a Year	301.414.080	kWh

4.2 Funding Structure and WACC

The Banyuwangi wind power plant project uses a project cost source that comes from the company's equity of 25% and debt of 75%. From the calculation results, the Cost of Equity value is 9.83% and the Cost of Debt is 4.61%. So that the WACC value is 5.91%

Table 3 Value of WACC

No	Variable	Value
1	Kd	4,61%
2	Ke	9,83%
3	Equity Proportion	25%
4	Debt Proportion	75%
5	WACC	5,91%

4.3 Capex and Opex

From the calculation results, initial investment value and operational costs are as follows :

Table 4 Initial Investment Value (CAPEX)

No	Variabel of Initial Investment (CAPEX)	in M US$
		WTG (78,2 MW-23 WTG)
1	EPC Cost	126,38
2	Interconnection and Transmission Line	13,78
3	Land Cost	9,35
4	Insurance during Construction	0,63
5	Contingency Cost	6,32
Total (M US$)		156,46
Power rated power total (kW)		78200
Total CAPEX/kW (US$/kW)		2000,77

Table 5 Operational Cost

No	OPEX Breakdown	Cost 1st year
1	WTG Operation Maintenace	1,92
2	Balanced of Plant Operation Maintenance	0,64
3	Administration and Management Cost	0,4
4	Salaries and Benefit	0,72
5	Insurance Pembangkit	0,19
6	Contingency Cost	0,19
Total (M US$ / Tahun)		4,06
Cost OM US$/kW		0,05075

4.4 Electricity Sales Revenue

From the calculation results, it is found that the estimated value of electricity sales revenue over a useful life of 25 years is as follows:

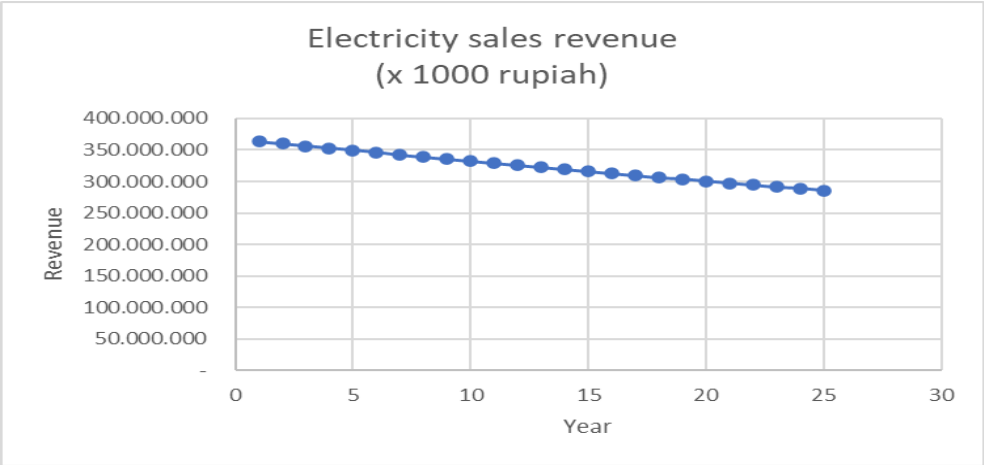


Figure 3 Electricity Sales Revenue

4.5 Financial Analysis

The following figure is a net project cashflow for a useful life of 25 years, from the calculation results obtained an NPV value of 668,066,295,000 rupiahs and an IRR value of 9.24% greater than the WACC value of 5.91%. From the two parameters above, it can be concluded that the wind power plant development project in Banyuwangi is financially feasible

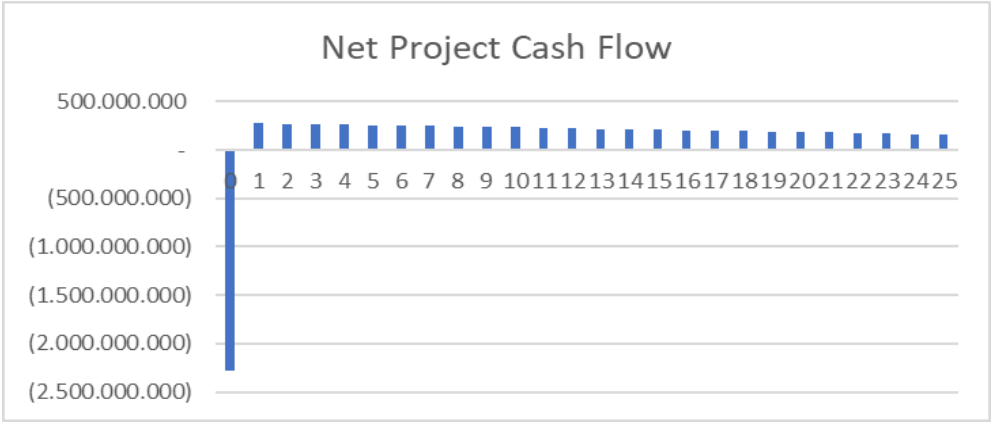


Figure 4 Net Project Cash Flow

From the cashflow analysis, the payback period value is also obtained as follows:

Table 6 Payback Period

Description	Year
Payback Period	8 Years 11 Month
Discounted Payback Period	13 Years 9 Month

4.6 Sensitivity Analysis

In measuring the sensitivity limit that can be accepted in investment feasibility, a feasibility analysis is needed by changing the parameters that have a large enough effect or the parameters can be communicated to change, in this study the variable that will change is the electricity tariff.

From the calculation results, the results of the sensitivity analysis of electricity rates to the NPV and IRR values are as follows:

Table 7 Sensitivity Analysis

Tarif Listrik	980,54	1032,15	1086,47	1143,66	1203,85	1267,21
IRR	5,37%	6,11%	6,87%	7,64%	8,43%	9,24%
NPV	- 120.246.423	21.670.361	171.056.449	328.304.963	493.829.715	668.066.295

The sensitivity analysis with the electricity tariff variable shows that for electricity rates above Rp. 1032, the NPV value is Positive and the IRR value is above WACC, so it is still financially feasible, when the electricity tariff value is below Rp. 1032, the NPV value is negative and the IRR value is below the WACC value. which means that financial analysis is categorized as not feasible

6. CONCLUSIONS

Based on the test results of the various financial parameters used, the following conclusions are obtained:

1. The Wind Power Plant Project, with a composition of funding of 25% Equity and 75% Debt, is financially feasible with an IRR parameter of 9.24% exceeding the WACC value = 5.91%, and a positive Net Present Value value of 668,066,295,000 rupiah
2. The financial feasibility of a wind power plant project becomes unfeasible if it exceeds the limit value of electricity tariffs below Rp. 1032

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REFERENCES

Brigham, E.F, dan Houston, J.F (2009), *Fundamentals of Financial Management*, 12th edition, South-Western Cengage Learning, Mason USA

De Oliviera, W.S and Fernandes, A.J (2012), "Economic feasibility analysis of a wind farm in Caldas da Rainha, Portugal", *International Journal Of Energy And Environment,* Vol 3

PT PLN (2021), *Rencana Usaha Penyediaan Tenaga Listrik (RUPTL)*, PT PLN, Jakarta

Salih, S.M, Taha, M.Q, dan Alawsaj, K.W (2012), "Performance analysis of wind turbine systems under different parameters effect", *International Journal Of Energy And Environment*, Volume 3, Issue 6

Stavrakakis, G (2012), *Elictrical Part Of Wind Turbine*, Vol 2, pp. 269–328, Elsevier Ltd

Sutojo, Siswanto (2000), *Studi Kelayakan Proyek Konsep Teknik dan Kasus*, Cetakan 1, Damar Mulia Pustaka, Jakarta

Tizgui, Ijjou dan El Geuzar, Fatima (2018), "Estimation and Analysis of Wind Electricity Production Cost in Morocco", *International Journal of Energy Economics and Policy*. Vol 8, Issue 3, EconJournals

IMPROVING INBOUND LOGISTICS COST USING LEAN APPROACH – PRACTICAL CASE OF AUTOMOTIVE MANUFACTURING in THAILAND

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ABSTRACT

Reducing logistic costs is an important part of reducing the overall cost of production and achieving a competitive price. Lean logistics offers a solution to this challenge by identifying waste within the logistic process; as well as providing countermeasures through changes in processes and equipment, as well as time reduction. This research features an automotive company facing the challenge of reducing the cost of inbound logistics, especially in their logistic processes for local parts.

An analysis of cost reduction through Value Stream Mapping (VSM) or Material Information Flow Chart (MIFC), Process Activity Mapping, and Toyota Production System's own four rules of logistics found that logistic processes in local parts are Necessary Non-Value Added (NNVA) and that lean logistics have been achieved. The analysis also identifies moving factors of logistic costs for local parts: truck utilization, truck loading efficiency, and distance covered in each route, all influencing the number of trips necessary. These results are used to make recommendations for improvement.

The resulting recommendations are predicted to result in a cost reduction of approximately 25.4% of the target, which could be achieved through lessening the number of trips made and increasing loading efficiency.

Keywords: logistic costs, inbound logistics for local parts, lean logistics, material information flow chart, process activity mapping

1. INTRODUCTION

Logistics is notably an important function in the operations and supply chain management, however it is costly. As developing nations in Asia, logistics cost in Thailand continue to rise along with the inflation of the country. According to Thailand's Logistics Report (Office of the

National Economic and Social Development Council, 2020), the increase in logistic costs reached up to 6.7% in the year 2019. This increase inevitably results in an increase of product prices.

Lean is one of most popular paradigms to make its mark in the field of manufacturing, promoting a culture of continuous improvement with its tools and practices applied in a variety of sectors and organizations (Mayr et al., 2018). Womack et al. (1991) defines lean as a chain of activities and solutions to eliminate waste through reducing activities that do not add value and adding activities of value. This concept is derived from the Toyota Production System (TPS), which is known as lean manufacturing. To be able to achieve lean manufacturing, lean logistics must be achieved (Myerson, 2012).

The company upon which this paper is based is a global automotive company that manages the logistics processes from its suppliers to their production plant. This company faces an increase in logistic costs due to several factors: a rise in wages, fuel, traffic jams causing halts in the logistic processes, as well as unstable demand. These factors also add to the complexity of the logistics management. The company aims to lower its logistic costs each year with a target of 4%, calculated from the costs of each unit of vehicle it produces.

The logistics processes at the company consists of the outbound and inbound logistics. Inbound logistics is further split into the management of the flow of imported and local parts from suppliers to the production plant. Outbound logistics manage the delivery of vehicle units to consumers. The cost of inbound logistics becomes a part of the product price, and the cost of outbound logistics is later added into that price. This study looks at the inbound logistics for local parts, which make up 80% of the parts used to manufacture vehicles at the production plant.

2. LITERATURE REVIEW

Logistics Management and Supply Chain Management

Logistics is a crucial part of the supply chain, where the supply chain management coordinates and integrates as a whole the flow of materials, information, and finances along the supply chain, from raw material processes all the way to consumers. Logistics itself is a function that is responsible for the transportation and storage of materials (Christopher, 2011). Logistics is a position of resources that is tightly related to time and the strategic management of the total supply chain management. As such, logistics must be efficient: deliveries must be made quickly and on time, on a low cost and with little waste. It should have quick responses, high productivity, a low number of stocks, no damage, and highly dedicated logistic staff. The logistic process will add value if it is able to deliver products on time with no damage.

In order to fulfill the above demands, logistics must be flexible. There are two important aspects that must be considered, which are 1) planning and 2) a flexible execution of said plan in the field. Lately, logistics have become of utmost importance for every organization and a crucial part of all economic activities (Christopher, 2011). Without logistics, there would be no movement of materials, thus no operations being done and no products being sent, and in the end, no consumers being served. Often, logistics are also considered expensive. In the current situation, logistics has become a reference of how competitive a country is in terms of its supply chain. As well, it has become the key in the competition between supply chain management

Logistics by Toyota: No Logistics

The Toyota Production System (*Cho*) serves as a basis for Toyota's logistics. The philosophy behind Toyota's logistics is **No Logistics,** which, in practice, is understood as logistics being necessary despite not adding value to the product. As such, the entire logistics activity at

Toyota's supply chain management (SCM), from production to sales, aims to lower costs and improve its services. Thus, it is important for the following to be done:

a. Minimalizing logistics between production plants;
b. Designing transportation that is punctual and efficient in the amounts necessary

There are four basic principles in Toyota logistics, which is referred to as four basic rules of logistic planning and implementation. They are:

1. Cyclic processes*:* to have standardized processes and even distribution of load
2. Short Lead Time: the ability to adjust logistics according to changes in the demands of production
3. High Cubic Efficiency: to always carry an optimum load, increasing the efficiency of loading and transportation
4. Flexibility: the ability to change the implementation of plans following changes from external factors, such as occurences of disaster

Lean Logistics

A systematic approach to identifying and eliminating activities that do not add value, which are referred to as *Muda* (waste), through constant improvement within the processes. The implementation of lean into a series of processes is guaranteed to lead to a decrease in cost.

Value Stream Mapping/Material Information Flow Chart (MIFC)

Value stream mapping is a method of identifying waste within lean logistics or lean manufacturing (Hines and Rich, 1997). According to Monden (1983), within processes there are three categories that could be identified for improvement: non value added, necessary non value added, and value added. Hines and Rich (1997) propose a few tools that could be used to manage value stream mapping. One of which, called Process Activity Mapping, is to be used in logistics. To be able to look at the entire process, identification of processes is further continued through the 5W+2H method.

Logistic Costs

Water (2003) defines logistic costs as the entirety of the cost spent to move materials for products from beginning to end. The cost is further broken down into the equation below:

> **Total logistic cost** = transportation cost + warehouse costs + cost of stock storage + packing cost + cost of utilization or information processes + miscellaneous costs (administration and other costs).

3. METHODS

The research detailed in this paper is done in cooperation with an outsourced logistic partner, which handles the logistic planning and operations of inbound logistics in an automotive company. Inbound logistics for local parts is chosen for analysis as it makes up 80% of the total logistic cost. A reduction in logistic costs for local parts would bring the company closer to the reduction target, as well as become an achievement that is more visible.

The approach chosen is lean logistics. A Material Information Flow Chart (MIFC) is used to map the business processes for inbound logistics for local parts. Following that, an analysis using Process Activity Mapping is conducted to identify the *muda* (waste) within the processes,

through a process of observation and discussion. The working group, consisting of the logistics partner, supplier, the receiver at the plant, as well as the logistics planning department, are all involved in a discussion that aims to determine delivery routes from the supplier to the production plant.

An analysis of lean is completed by assessing the ongoing processes against the four rules of logistics of the Toyota Production system: 1) cyclic processes, 2) shorten lead time, 3) high cubic efficiency, and 4) flexibility. Further analysis is completed by determining time difference through comparing actual conditions with the implemented standards. This further determines occasions of waste to identify potential areas for cost reduction.

The MIFC is then also used to analyze costs and determine the driving factors for costs. These factors are determined through analyzing formulations and an examination of a sample of deliveries, to get a picture of actual conditions. The sample chosen is big volume delivery. Through these analyses, inefficiency is further identified, which opens up another opportunity for cost reduction. Results from the analyses are then compiled to form suggestions for improvement and potential cost reductions calculated, which results in the final suggested reduction in logistic costs.

4. THE CASE ANALYSIS

This case study is based on a real problem from the automotive industry, which features an inbound logistics process for local parts whose delivery from supplier to production plant is based on the Milk Run system. The result of the observations and checks of the process identifies seven distinct processes; the time and activities of each are then compared to the Standard Operation Procedure (SOP) with actual situation.

4.1 An overview of the company's inbound logistics for local parts

The delivery process from the supplier to the production plan is in figure 1 below

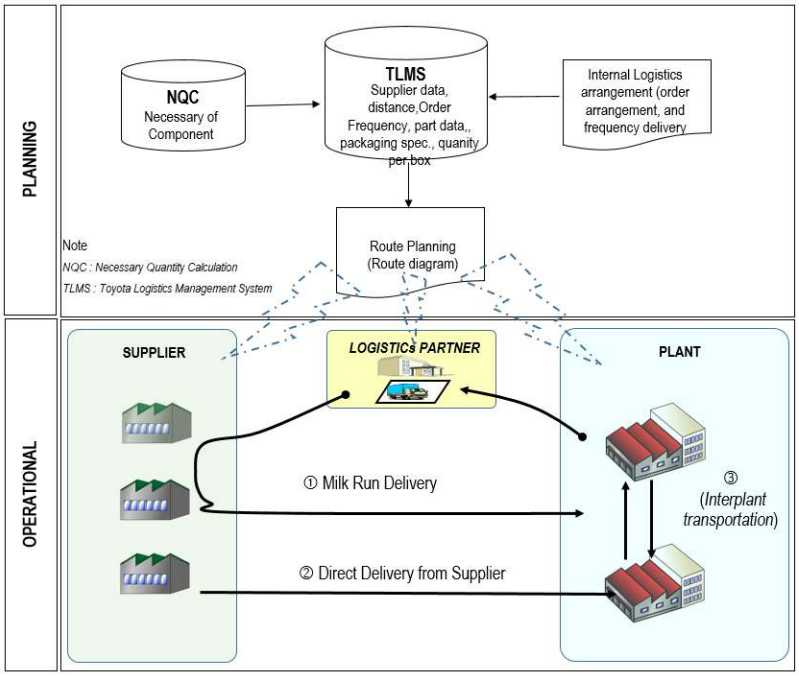


Figure 1: Route Planning Process and Operation Logistics from Supplier to Production Plant

The delivery process from suppliers to the production plant is made up of two large groups of processes, which are the planning department and the operational department. From three distinct delivery processes, the milk run delivery is the largest process in terms of cost as well as route.

Suppliers are divided into five area zones, due to deliver to three production plants. The data obtained from observing the aforementioned seven processes is used to construct a MIFC.

4.2 Value Analysis

Process Activity Mapping is completed using the MIFC. The results show that all the logistics processes within the inbound logistics for local parts are Necessary Non-Value Added (NNVA). There are no processes found to be Non-Value Added. Occurring problems and differences in plan versus actual could still be absorbed into the predetermined allowance.

Table 1: Value Analysis for Local Component

	Process	Time	Activities					Clasification		
			O	T	S	W	A	VA	NVA	NNVA
1.	Planning Process - Production volume convert to volume metric and discussion with plant --> route simulation for selection of supplier and zone of supplier - Communication with Log Partner and Plant Admin	15 days	X							X
2.	Logistics Partners Preparation Process	10 minute	X				X			X
3	Transportation from yard to 1st supplier and 2nd supplier	average by GPS		X						X
4.	Supplier Process '- Check in with mobile application and administration - Checking for readiness volume	5 min + (m³order x 0.5 min)	X				X X X			X
5	Transportation from supplier to plant receiving	ave GPS		X						X
6.	Waiting Truck	min =10 minute, mak = 30 minute				X				X
7.	Process at Plant - Unloading part at Receiving Area - Loading empty boks - Administration process	5 min + (m³order x 0.5 min)	X X X				 X			X

Note : O = Operation : T = Transportation S = Storage : W = Waiting : A = Administrasi

4.2 Lean analysis using four rules of logistics

The four rules of logistics according to the Toyota Production System are used as a form of assessment for lean. The aforementioned working group assesses activities using the following parameters: cyclic processes, short lead time, cubic efficiency and flexibility. The result of the assestment are compiled in Table 2.

Table 2 : Lean Analysis with Four Rules of Logistics for Local Component

Proses		CYCLIC OPERATION		SHORT LEAD TIME	CUBIC EFFICIENCY	FLEXIBILITY
		*H *)*	*S *)*			
1.	Planning Process					
	- Production volume convert to volume metric and	O	O	O	O	O
	discussion with plant --> route simulation for	O	O	O	O	O
	selection of supplier and zone of supplier	O	O	O	O	O
	- Communication with Log Partner and Plant Admin					
2.	Logistics Partners Preparation Process	O	O	O	O	O
3	Transportation from yard to 1st supplier and 2nd supplier	O	O	O	O	O
4.	Supplier Process					
	'- Check in with mobile application and administration	O	O	O	O	O
	- Checking for readiness volume	O	O	O	O	O
5	Transportation from supplier to plant receiving	O	O	O	O	O
6.	Waiting Truck	X	O	X	X	X
7.	Process at Plant	O	O	O	O	O
	- Unloading part at Receiving Area	O	O	O	O	O
	- Loading empty boks	O	O	O	O	O
	- Administration process	O	O	O	O	O

Note : X = None/cannot do
O = Available (Done)

*) H = Heijunka S *) Standarization

The analysis found that processes have reached lean logistics. It is able to adjust with changes in demand, and as such it is ready to play its part in achieving lean manufacturing.

4.3 Lead time Analysis

Differences are found between planning and actual in specific day and night shifts in the representative route SA01. This difference was already covered by the allowance in time due to external factors, and did not disturb the production line. Countermeassure for this case will be discussed further with information system due to the need to make a different timing plan for day and night shifts. With this analysis lead time process follows the planning.

4.4 Cost Analysis

Cost analysis identified the driving factors of logistics costs as follows: truck utilization, loading efficiency and the distance of each route. The logistics cost reduction method is seeing which in the overall process contributed to highest volume per day using Pareto. Shown in Table 3 that factory BP has highest volume of 17893 m^3/day. Continuing check found that receiving small parts at dock P1 has highest trip per day and also has 119 suppliers involved. It can be said that dock P1 was big contributor of logistics cost.

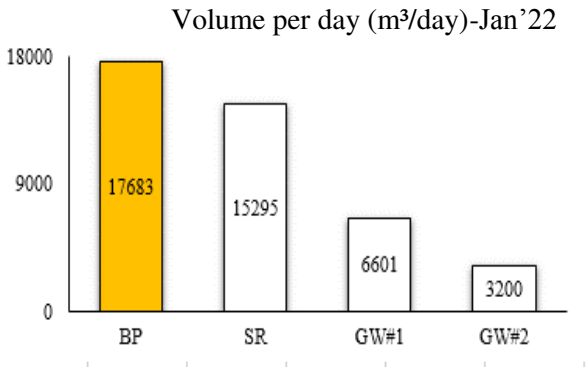


Figure 2 : Volume metric per day in each plant

Table 3 : Volume metric per day by Receving Dock at BP plant

Kode Dock	Dock Name	jumlah pemasok	volume per hari	Trip per hari
P1	(A) Small Part (P-Lane)	119	5475	199
P2	(A) Small Part (Non P-Lane)	1	0.4	3
P3	(A) Big part (P-Lane)	36	4271	147
P4	(A) Big part (Non P-Lane), frame	6	738	22
P5	Wheel Disc, Tire	11	1547	62
P6	(A) Axle (P-Lane)	12	809	48
P7	(A) Engine (P-Lane)	6	1191	36
P9	(W) non P-lane & Sequence	1	952	48
PW	(W) part (P-Lane)	19	2690	154
PR	Resin Part	1	8	2
		212	***17,683***	***721***

To further narrow down the above information, zone C was found to have the most number of suppliers delivering to dock P1. Summarized in Figure 3 is the loading efficiency of these trips, as well as the logistic costs contributed per kilometer of distance for each m³ of load.

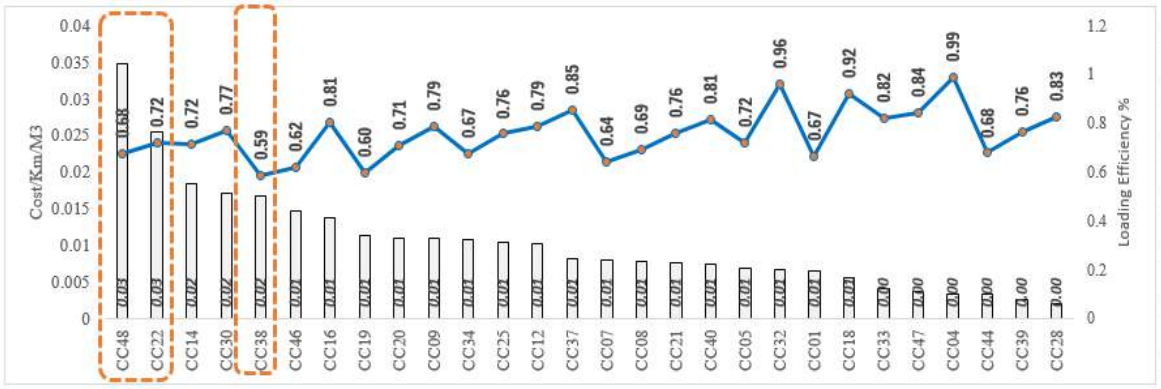


Figure 3 : Graph of Route Pareto vs L*oading Efficiency* vs Cost/km/m³

From the above data, it is narrowed down that the three biggest contributors of cost/km/m³ are routes CC48, CC22 and CC38 (Table 4). The load in these three routes are examined to determine the loading efficiency. The loads are pictured in Figure 4 to see the actual loading.

Table 4 : Route selected as representative

rute	cost/km/m3	loading efisiensi
CC48	0.035	68%
CC22	0.025	72%
CC38	0.017	59%

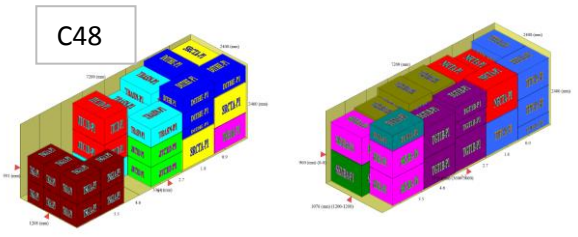


Figure 4 : Actual Loading efficiency for 2 routes

These checks for efficiency help identify the potentials for cost reduction. 5 Why questions are used to determine the root cause of the high costs, which are:

1. Too many variants of box sizes and types, cannot be stacked on each other, causing reduced efficiency.
2. There is less truck capacity than available load with additional supplier
3. Limitation of one logistics partner handle one zone supplier in one zone

From the root causes detailed above, these activities of cost reduction could be proposed as a countermeasure:

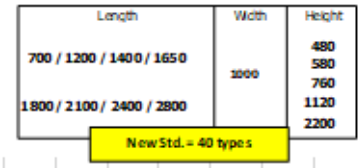
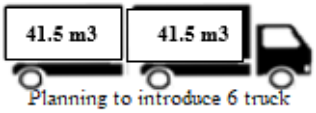
1. Review of box variants, with more considerations for stackability
2. Changing the truck type for a bigger one in some high-activity zones to increase loading capacities
3. Free zone concept for maximizing of loading with free of logistics partners.

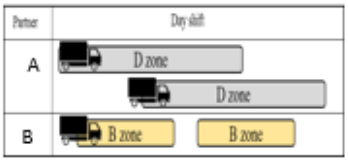
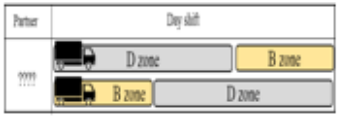
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4.5 Suggestions for Cost Reduction

Each of the proposed activities for cost reduction are analyzed in table 5, below:

Table 5 : Proposed Activities for Cost Reduction at Local Component

No.	Activity	Existing Condition	Estimation of Cost Reduction
[1]	Review and Change type of Box	**Previous** - Box and pallet type = 68 types - Image of problem  un achieved efficiency overhang and remaining empty space **Idea :** Reducing the type of boxes increasing stackability  	- Estimated Cost reduction : ➔ Stackbility increase ➔ Reducing truck frequency ➔ Cost reduction : = 0.8 MB x 8 month realization = 6,4 Mill Bath = 185,773 US$/year - items need to consider : ➔ Introduce in new model for reducing the investment
[2]	Full Trailer Utilization	- Previous  - Proposal  Planning to introduce 6 truck	- Estimation of Cost Reduction : ➔ Reducing number of trip : = 6 x 0.03 x 12 month = 2.16 Mill Bath - 62,698.47 US$ per year -

No	Activity	Change Point	Estimation of Cost Reduction
[3]	Free zone Logistics Flexible Logistics partner	- Previous : 1 logstics partner = 1 xone supplier  - Proposal : Free cone supplier and log prtner  	- Flexible logistics partners --> reducing trip ➔ = 0.3 Mill Bath (target per trip) = 0.3 x 6 bulan = 1.8 Mill Bath = 52,248 US$/year - Consideration item : - Preparation on Logistics partner

From the above table, estimated total logistics cost can be calculated as follows:

= 185,773 + 62, 698 + 52,248 (in US$)

= 300,719 US$

With an estimated total of 512,000 unit vehicles produced per year, the cost reduction reaches 0.58 US$ per unit. As such, the total cost of inbound logistics for local parts is reduced from 55.75 US$ per unit to 55, 17 US$ per unit.

5. CONCLUSION

This study shows the practical uses of MIFC and Process Activity Mapping in finding areas of potential cost reduction based on lean logistics. All of the logistic processes for local parts in the studied company is found to be Necessary Non-Value Added, and have achieved lean logistics with its flexible lead time. Further analysis of lead time shows that some differences in planning and actual situations do occur, but has been solved by the pre-planned time allowance. There is room for improvement in lead time through cooperating with information systems for support. Additionally, an analysis of cost is completed to explore the potentials of cost reduction within the logistics process. From there a plan is developed to reduce cost through increasing loading efficiency, by reviewing the variant of boxes loaded into trucks, aiming for higher stackability, and changing truck types to allow for higher loading capacities. This study could be further expanded by developing an ideal MIFC to reduce touching, with the support of information system.

REFFERENCES

Acero R., Torralba. Padalahrez-Moya, R., Antonio Pozo, J., 2019. Value Stream Analysis in Military Logistics: The improvements in Order Processing Procedure

Christopher, Martin, 1992. Logistic and Supply Chain Management: Strategies for Reducing Costs and Improving Services. Financial Times Pitman Publishing

Bennet, David. Klug, Florian, 2011. Logistics supplier Integration in the Automotive Industry

Hines, P. and Rich, N., 1997. "The Seven value Stream mapping tools", International Journal of Operations & Production Management, Vol. 17, pp. 146-64

Jones, Daniel T., Hines, P and Rick N., Lean Logistics, Cardiff Business School, Cardiff UK

Jorge Gonzales-Resendiz, Cecilia K.A., Arturo Realyvasque V., Humberto HR., Carrillo T.G., 2018. Integrating Simulation-Based Optimization for Lean Logistics: A Case Stuty

Mayr., A, dkk (2018) Lean 4.0, A Conceptual Conjunction of Lean Management and Industry 4.0, Institute for Factory Automation and Production Systems, Friedrich-Alexander Univeristy Erlangen-Nuremberg, Fuerther Str, 246b, 90429 Nuremberg, German

Monden, Y. (1983), Toyota Production System: An Integral Approach to Just-in-Time, Institute of Industrial Engineers, Norcross.

Myerson, Paul. 2012. Lean Supply Chain and Logistics Management. The McGraw-Hill Companies, Inc.

Pujawan, I Nyoman, Mahendrawathi ER., 2010. Supply Chain Management, Edisi Kedua, Penerbit Guna Widya, Surabaya, Indonesia.

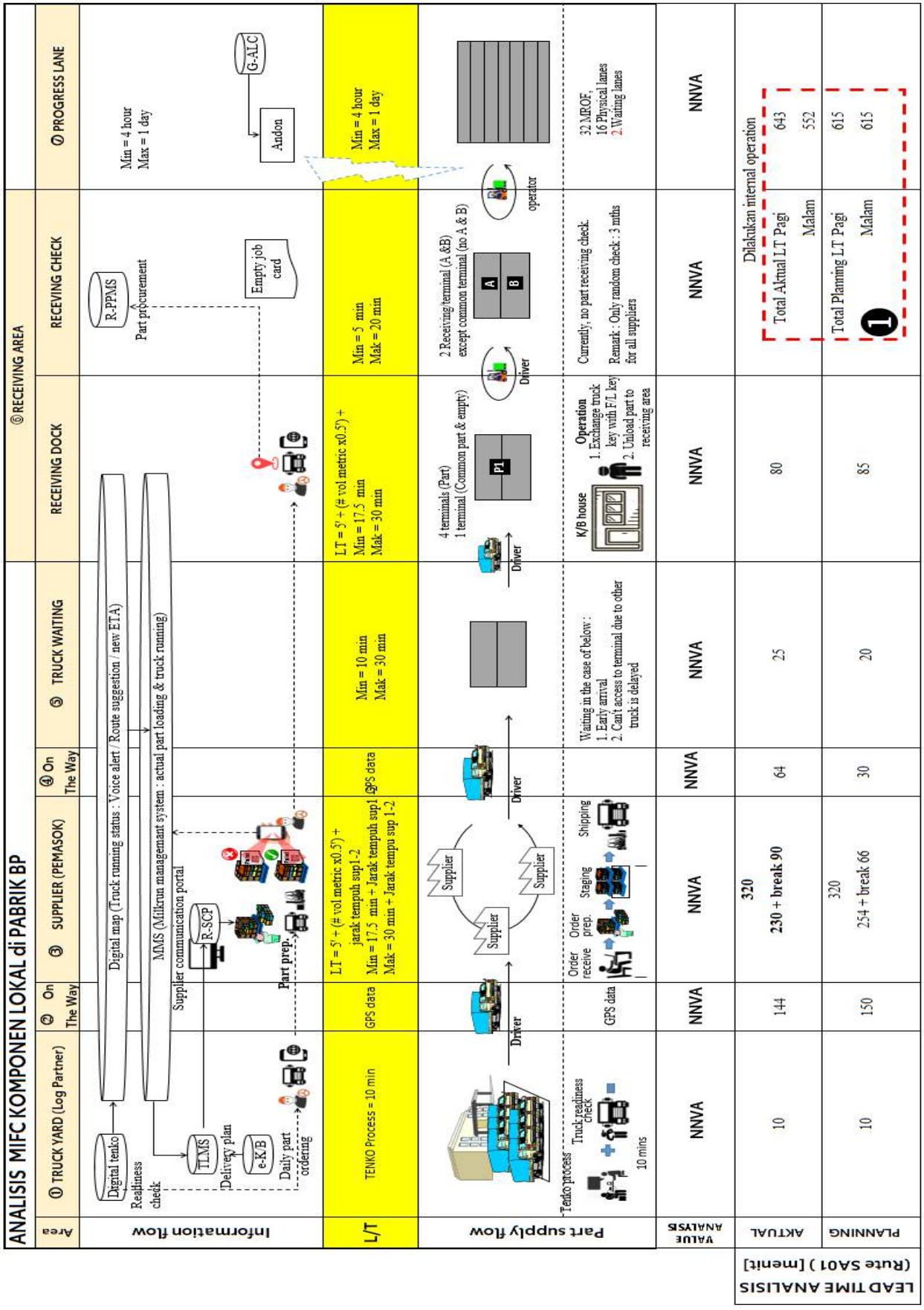
Toyota Motor Coorporation (TMC) Logistics Administration, 2015. Logistic Manual

Toyota Motor Manufakturing Indonesia (TMMIN) Operating Consulting Management Division (OMDD), 2018, Material Information Flow Chart Manual.

Thailand's Logistics Report 2019, Office of The National Economic and Social Development Council, September 2020.

Womack, J.P.; Jones, D.T.; Roos, D. The Machine that Changed the World: The Story of Lean Production; Harper Perennial: New York, NY, USA, 1991.

ATTACHMENT


ANALISIS MIFC KOMPONEN LOKAL di PABRIK BP
⑥ RECEIVING AREA
① TRUCK YARD (Log Partner)
② On The Way
③ SUPPLIER (PEMASOK)
④ On The Way
⑤ TRUCK WAITING
RECEIVING DOCK
RECEIVING CHECK
⑦ PROGRESS LANE
Area
Information flow
L/T
Part supply flow
VALUE ANALYSIS
AKTUAL
PLANNING
LEAD TIME ANALISIS (Rute SA01) [menit]
Digital tenko
Readiness check
Delivery plan
Daily part ordering
TLMS
e-KB
Digital map (Truck running status : Voice alert / Route suggestion / new ETA)
MMS (Miltkrou management system : actual part loading & truck running)
Supplier communication portal
R-SCP
Part prep.
R-PPMS
Part procurement
Empty job card
Andon
G-ALC
Min = 4 hour
Max = 1 day
TENKO Process = 10 min
GPS data
LT = 5' + (# vol metric x0.5') + jarak tempuh sup1-2
Min = 17.5 min + Jarak tempuh sup1
Mak = 30 mnn + Jarak tempu sup 1-2
LT = 5' + (# vol metric x0.5') +
Min = 17.5 min
Mak = 30 min
Min = 10 min
Mak = 30 min
Min = 5 min
Mak = 20 min
Tenko process
Truck readiness check
10 mins
Driver
Supplier
Order receive
Order prep.
Staging
Shipping
Waiting in the case of below :
1. Early arrival
2. Can't access to terminal due to other truck is delayed
4 terminals (Part)
1 terminal (Common part & empty)
P1
K/B house
Operation
1. Exchange truck key with F/L key
2. Unload part to receiving area
2 Receiving terminal (A &B)
except common terminal (no A & B)
A
B
operator
Currently, no part receiving check.
Remark : Only random check : 3 mths for all suppliers
32 MROF,
16 Physical lanes
2.Waiting lanes
NNVA
10
144
320
230 + break 90
64
25
80
Dilakukan internal operation
Total Aktual LT Pagi
643
Malam
552
10
150
320
254 + break 66
30
20
85
Total Planning LT Pagi
615
Malam
615
1

VALUE PROPOSITION DESIGN FOR OFFSHORE FLOATING RESIDENTIAL TOURISM BUILDING USING DESIGN THINKING

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ABSTRACT

Offshore floating residential buildings are a prospective tourism development concept in the next few years, expected to attract domestic visitors and contribute to increasing the value of the Gross Domestic Product (GDP) of the Republic of Indonesia. Potential for offshore residential buildings in Indonesia is still in the refinement stage and has not become the main tourism destination of choice. One of the case studies used in this research is the ITS Ocean Farm Pilot Project which is the result of design, infrastructure, economic, and technical research from the Institution of Research and Community Service at the Center for Marine Studies, Sepuluh Nopember Institute of Technology. The Design Thinking method could explore the interaction of experiences, user comfort, and anxiety from potential visitors to offshore marine tourism residences. The qualitative method is used in this research, and information is gathered using a survey strategy, resulting Group tourists consisted of 91.5 percent of southern Malang's visitors with a tendency for one day trips in mind (64 percent), which contradicts with the Ocean Farm module's design that was aimed to made for solo traveler. Data collection is conducted by in-depth interviews with four categories of visitor segments categorized through the selection of companions while on vacation at the southern Malang beach. Almost 29 core problems felt by various tourists that visiting South Malang Beach found in Define stage, and re-selected trough 3 layers of Value Proposition Canvas, Also, meeting user needs through the Value Proposition Canvas to help understand patterns in determining the product value of ITS Ocean Farm. resulting 2 groups of ideations; 1. The development of Ocean Farm that can be provided, and 2. Offshore Floating Building development recommendations. The findings from this study are expected to help the management of similar businesses to determine strategies to attract tourists and pay attention to customer needs by validating ideas and prototypes trough Design Thinking Methods.

Keywords: Design Thinking, Value Proposition Canvas, Affinity Diagrams, Marine Tourism, Offshore Residential Buildings, Tourism Development.

1. INTRODUCTION

Maritime tourism is a prospective economic sector in Indonesia. It is stated that Indonesia's marine tourism potential includes: 3,257 million km² of sea area, 99,093 km of coastline, 20.87 million hectares of marine conservation areas, coastal and small islands and 17,461 islands (Kementrian Kelautan dan Perikanan Republik Indonesia, 2020). Findings suggest that offshore marine fish aquaculture will grow globally, with growing populations and increasing demand for fish that will continue to drive aquaculture production. It is predicted that some technologies will evolve over time into two or three models in the next decade (California Environmental

Associates, 2018). Researchers have studied well the economic impact of marine and coastal tourism at both macro and micro levels, agreed that marine coastal tourism is one of the main tourism products worldwide (Buitargo, et al., 2019). Coastal areas are rapidly becoming an important tool for marine conservation (Abecasis, Schmidt, & Longneck, 2013) and a critical component for ecosystem-based approaches to sustainable tourism management (Chae, Wattage, & Pascoe, 2012). Tourism is a sector that cannot stand alone but requires support from various stakeholders (Hanafiah, Jasmi, Razali, & Sulaiman, 2019). In this case, tourists become an inseparable part because they are a catalyst for infrastructure development. Proper infrastructure design can support coastal development, tourism and recreational activities that can increase the synergy between marine tourism infrastructure. Evidently, the income generated from coastal tourism contributes to the local economy, creates coastal tourism jobs, and can support more than six million jobs in the fishing industry (Kementerian Kelautan dan Perikanan Republik Indonesia dan Proyek Sustainable Ecosystems , 2018).

OCEAN Farm-ITS will be located in one of the coastal natural attractions which is the government's pledge program, based on the 2016 Malang Regency Spatial Plan which is planned to be placed 500 meters from the beach, with a minimum sea depth of about 13 meters, octagonal shaped, with outside diameter 39.6 meters and inside diameter is 33.6 meters. This Offshore Building is a concept development using offshore floating net cage structure that has the function of fish cultivation and special tourism for study, education, and recreation purposes. The tourism concepts offered such as; Floating Net Cages Tour, Fish Cultivation Education, Ecotourism Hotels, Restaurants, Snorkeling & Diving. OCEAN Farm-ITS is semi-submersible or half-submerged and half-floating. The submerged part is a cage that has a depth of 10 meters and made of iron structure that has strong durability and able to withstand high waves of up to 8 meters (Yani Purnawanti, 2018).

Previous studies and research are limited to studies that examine the design of technical and economic infrastructure, which have not used the Design Thinking approach and user convenience that can explore the user experience from the customer side. This approach can produce an in-depth picture of each user's concerns and expectations that require urgent solutions as a determinant of the main catalyst for tourism as well as satisfactory retention of the various types of facilities offered. Based on the psychographic segmentation data of South Malang Beach tourists, it is known that most respondents who choose to stay with their families are 47%, there are also respondents who choose to be with their partners by 32% and rarely are respondents who choose to travel alone (Priambudi & Karningsih, 2018). In addition, substitution prices, income, tastes, promotional costs, population density, political situation, security, access and transportation distances are very important in this industry (Lise & Tol, 2000), where consumer decisions on tourism choices are strongly influenced by economic factors such as; demographics, geography, government regulations, communication media and technology (Middleton, Fyall, Morgan, & Ranchhod, 2009). Therefore, a floating residential building requires product definition, target market and strategic recommendations according to its potential segment. This study aims to obtain the right product definition for potential segments in the Ocean case study. Farm ITS that needs to be done to provide recommendations for the right strategy for planning and developing offshore residential buildings to achieve the desired target.

2. LITERATURE REVIEW

The Design Thinking method is a comprehensive method of creative problem solving that involves the user in the thinking process and makes the user's perspective the main consideration of the problem-solving process (Brown, 2008). This method is popular enough for creating value

for potential users and overall market opportunity, not based on appearance and function alone, but integrating human needs, technical possibilities, and requirements for business success. Design-thinking processes might be enhanced by thinking how relationships between people and places contribute to meaning, it is important to being aware of patterned use that embrace place, rather than cast it as just another factor of a design problem (Overmyer & Carlson, 2019).

Several similar studies have used case studies and deep interview methods to capture the perceptions of visitors and stakeholders. Measuring experience in tourism and hospitality consumption settings with all four components (emotional, cognitive, sensorial, and conative) is critical due to the intangible and highly hedonistic nature of products (Godovykh & Tasci, 2020). Furthermore, various sources of antecedents and outcomes of experiences such as pre-visit, onsite, and post-visit stages are also vital in capturing tourism and hospitality experiences that are intertwined with many other factors. The Customer Journey Map is an appropriate method for understanding product or service use cases at various points in time (Liedtka, 2014). Personas are created to represent users during the design process effectively and can collect market segment data and identify user stereotypes (Tonkinwise, 2017). Understanding the temporal profile of tourism experience allows analyzing individual effects to design better tourism experiences. The responsibilities lie on the shoulder of visitors, the local community, and policymakers in adopting sustainable development practices that could impact of marine and coastal tourism, especially the economic, social, and environmental aspects (Hanafiah, Jasmi, Razali, & Sulaiman, 2019).

An important part of the overall value creation process is Value Proposition Canvas (VPC) that supports the development of customer experiences aimed at matching needs and work in achieving appropriate solutions to problems or products that match market needs (Osterwalder, Pigneur, Bernada, & Smith, 2014). Value orientation is a direct predictor of ecotourism satisfaction, very important to understand the relationship among value orientation, satisfaction and future development demands, which can provide guidance for the future . The develop ment of marine ecotourism should balance the interests of various groups and maximize the overall interests of stakeholders (Chen, et al., 2021). Ghina and Afifah (2021) in their article entitled Value Proposition Design for Custom Clothing Startup Using Design Thinking Approach, explain about customers' significant issues who use custom clothing services, the tailors' significant issues, and solutions to these problems. The aim of their research is to explore the interaction between custom clothing businesses and their users. Data collection is conducted by in-depth interviews with tailors and sewing service users.

Case studies and deep interview methods to capture the perceptions of visitors and stakeholders by measuring experience with emotional, cognitive, sensorial, and conative components also various sources outcomes of experiences such as pre-visit, onsite, and post-visit stages are vital because it’s intertwined with many other factors. By focusing on user-centered design process, it is important to thinking how relationships between people and places contribute to meaning, also being aware of patterned use that embrace place. Combination of VPC in Design thinking hopefully could explain about customers' significant issues and explore the interaction between vistors and Offshore Floating Building to give the best solution.

3. METHODS

Started with identification of problems, looking at the differences between facts and theory, and Literature Review to get a theoretical basis for ideas. Surveys were conducted to determine the demographics of tourists to southern Malang, the activities they engaged in, and their likes and dislikes while travelling. Users are included in the problem-solving process using the Design Thinking method, which makes the user's perspective the primary factor to consider

(Brown, 2008). The potential respondents chosen from the questionnaire will continue towards the observation stage through a depth interview that will be conducted using the following criteria: Male & Female, Ever Visited South Malang Beach, Travel to South Malang Beach alone, Travel to South Malang Beach with friends, Travel to South Malang Beach with family, Travel to South Malang Beach with partner.

This process carried out to determine which Personas can successfully represent users during the design phase and gather and identify user stereotypes (Tonkinwise, 2017). Every detail of tourist needs, and interactions will be processed through User Journey Mapping. An empathy map will be generated in line with the needs of each persona segment to determine consumer behaviors toward innovative products, and it will be associated at the Define stage using the Value Proposition Canvas. In the ideation phase, the data will also be categorized using an affinity diagram by choosing the topic or aim that represents the issue. The information was subsequently gathered and organized for sorting to produce a qualitative summary of the closely linked needs and implications between needs, which could influence how urgently potential tourists might come up with new ideas for offshore residential building innovations through the formulation of new ideas (POV Madlib) that would serve as a model for future development.

4. RESULTS

4.1 Questionnaire Results

According to the 137 respondents that completed the questionnaire in 2022, Most of the respondents were from East Java (70%) and stated that they had been to Malang's southern coast in a group. The Friends segment (47%) dominates the criterion for this group, followed by Family (44,5%), and a minimum of 4 passengers per vehicle. The responders from the sector of couples and solo travelers make up the remaining category. Most of the group preferred to spend just one day traveling round-trip (64%), while the others preferred to spend an additional two days in Malang City or Batu before returning home (25 %).

4.2 Empathize Stage Results

Four personas representing the four research focus segments (going with family, friends, a partner, and alone) were produced using the Deep Interview using data from the questionnaire.The user persona, empathy map, and user journey mapping outcomes are derived from this empathy approach and are summarized as follows:

Table 1 Summary of Empathy Map Similarities for all Segments

Pain	**Gain**
Their vacation is ruined because there are planned activities completely changed and confusion if the supplies brought are exhausted	They want all luggage to be well planned and fulfilled
They don't know the type of facilities and activities in the destination	They don't want to waste time on vacation
They get lost on a dark road on the way and there is no pointer and good road access	They want to find ride locations and facilities in the tourist area / return direction easily and safely
They see that the condition of public facilities provided in the destination is not feasible	They found a well-managed Public Facility
They are confused about doing activities on the beach because of the limited rides and types of activities	They have more time to gather and chat with family, it is helpful if there are alternative activities offered without having to swim or play in the water
Do	
They usually prepare all supplies well	
They usually look for information on vacation destinations via the internet	
They usually use GPS / Google Maps to search for travel routes	
They usually use Public Facility Infrastructure such as Toilets and Places of Worship in Tourist Attractions	
They Enjoy Spending Time by the Beach	
Think	**Feels**
They are hesitant and afraid of being lied to because the average price of necessities in tourist attractions is more expensive, hoping that there are stalls	They will be annoyed if there are important items left behind and needed and worried if the logistics, they carry run out on the trip

selling various emergency needs	
They hope to visit other more comfortable destinations that felt refreshing and healing	Alternative destinations will make the holiday feel better
They hope that road infrastructure and directional indicators will make it easier for motorists to get to their destinations.	They feel frightened, confused when looking for destinations with quite stressful trips
They hope that the infrastructure of public facilities can be managed by the cooperation of the private sector and the government	They regret the potential of South Malang Beach which still lacks support for regional development
They want a shady gathering place, close to public facilities with a good view	They regretted the travel time taken if only to sit sitting enjoying the view

Table 2 Summary of Family Segment Empathy Map

Think	**Feels**
They hope to visit other quieter beach destinations	They don't know what to do because it's all in line and crowded
They hope for a temporary resting place on the way	They feel impatient when they go to their destination and feel fatigue when they sit for too long on the way
They hope to find food vendors at holiday destination locations	They must travel from the tourist complex to get a good and decent meal
They hope to find a seller of souvenirs typical of southern Malang in addition to fresh fish	They feel tired if they must continue their journey to visit Batu City / Malang which provides a lot of souvenirs.
Do	
They usually take vacations during high season	
They usually use 4-wheeled vehicles	
They eat after they finish their holiday activities	
They Always buy souvenirs to give to neighbors and close relatives	
Pain	**Gain**
They lost their vacation time when the Beach was Crowded with Visitors	They want to refresh away from the hustle and bustle of the city and see the scenery
They do not like long trips that tikes much time	They have more time to get together and chat with family
They didn't find any food vendors at the holiday destination location	They find food vendors at holiday destination locations
They did not find any sellers of typical southern souvenirs other than fresh fish	They can bring fresh fish from Sendang Biru Fish Auction Centre

Table 3 Summary of Friend Segment Empathy Map

Think	**Feels**
They prefer to bring cheap rental equipment from the city	They are disappointed if the rental supplies provided in tourist attractions are not suitable for use
They hope that the location of tourist destinations is safe and secure	They feel sorry for friends who can't enjoy the holidays
They hope for an emergency post / kiosk that provides tire patches and gasoline contents when something untoward happens	They feel scared and restless throughout the journey for which there is no settlement
Do	
They usually use car rental services and camping equipment rental	
They usually do camp activities on the beach in groups	
They usually travel in groups	
Pain	**Gain**
They can't enjoy the planned company	They will be helped by good and adequate camping equipment / vehicle rental information
They do not feel safe when carrying/leaving valuable personal luggage	They feel safe if there are friends guarding their luggage
They have trouble if there is a group left behind / if one of the vehicles has problems	They will be helped by good coordination and communication between groups, as well as vehicles that are comfortable and in excellent condition for long trips

Table 4 Summary of Couples Segment Empathy Map

Think	**Feels**
They hope to find out the latest information from the managers of South Malang Beach and the situation in real time	They feel fatigue on the way to and from home
They prefer to bring cheap rental equipment from the city	They are disappointed if the rental supplies provided in tourist attractions are not suitable for use
They hope for a temporary resting place on the way	They feel impatient when they go to their destination and feel fatigue when they sit for too long on the way
They hope for an emergency post / kiosk that provides tire patches and gasoline contents when something untoward happens	They feel scared and restless throughout the journey for which there is no settlement
They hope that the location of tourist destinations is safe and secure	They were alarmed by the state of the carry-on goods
They hope to find food vendors at holiday destination locations	They must travel from the tourist complex to get a good and decent meal
Do	
They visit South Malang Beach during the Rainy season	
They usually use camping equipment rental services	

They usually use 2-wheeled vehicles	
They usually travel in groups	
They usually do beachside activities in groups with other couples	
They eat after they finish their holiday activities	
Pain	**Gain**
They experienced a deterioration in their travel schedules due to having to temporarily stop on the trip	They want to know the good weather conditions for traveling
They can't enjoy the planned company	They will be helped by good and adequate camping equipment rental information
They do not like long and long trips	They feel an adventure
They have trouble if there is a group left behind / if one of the vehicles has problems	They will be helped by good coordination and communication between groups, as well as vehicles that are comfortable and in excellent condition for long trips
They do not feel safe when carrying/leaving valuable personal luggage	They feel safe if there is a guarantee to keep their luggage
They didn't find any food vendors at the holiday destination location	They find food vendors at holiday destination locations

Table 5 Summary of Solo Traveler Segment Empathy Map

Think	**Feels**
They hope for a temporary resting place on the way	They feel afraid that the driver will be impatient when heading to the destination
They wish there was holiday documentation	They enjoyed the holiday accompanied by a local guide
They hope that the location of tourist destinations is safe and secure	They were alarmed by the state of the carry-on goods
They hope to find food vendors at holiday destination locations	They must travel from the tourist complex to get a good and decent meal
Do	
They usually use travel agents and remind drivers politely to be careful	
They usually already have a guide from a travel agent to accompany the tour	
They usually do their own beachside activities	
They eat after they finish their holiday activities	
Pain	**Gain**
They don't like it when the driver is reckless	They can rest to gather energy along the way
They are confused if the guides are less interactive and informative	They will be satisfied if the guide is supple and friendly
They do not feel safe when carrying/leaving valuable personal luggage	They feel safe if there is a guarantee to keep their luggage
They didn't find any food vendors at the holiday destination location	They find food vendors at holiday destination locations

4.3 Define Stage Results

1. Value Proposition Canvas

The Value Proposition Canvas is used in this investigation to evaluates how well the product fits the demands of the customer. Begins by classifying the customer segment into 3 layers, including: Broad tourist visitors, Tourists in southern Malang, and the deepest layer is representing Ocean Farm visitors. That customer segment is then tested for compatibility analysis with 3 layers as well as in terms of products, which consist of southern Malang tourism infrastructure on the outermost part, then Sidoasri Beach Tourism in the middle, and Ocean Farm floating net cages in the deepest part of Value Proposition Canvas.

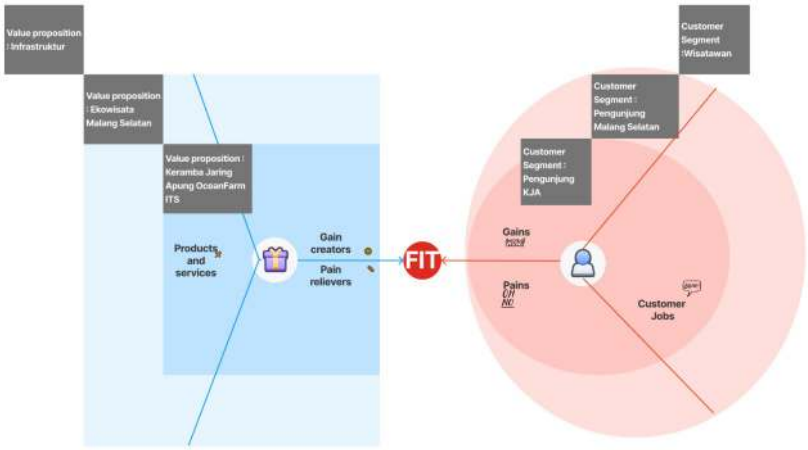


Figure 1 Value Proposition Canvas Layer Mapping

The following is the result of matching Values on the first layer of VPC, that represents the relationship between the needs of Ocean Farm visitors and Ocean Farm products is described in the followings:

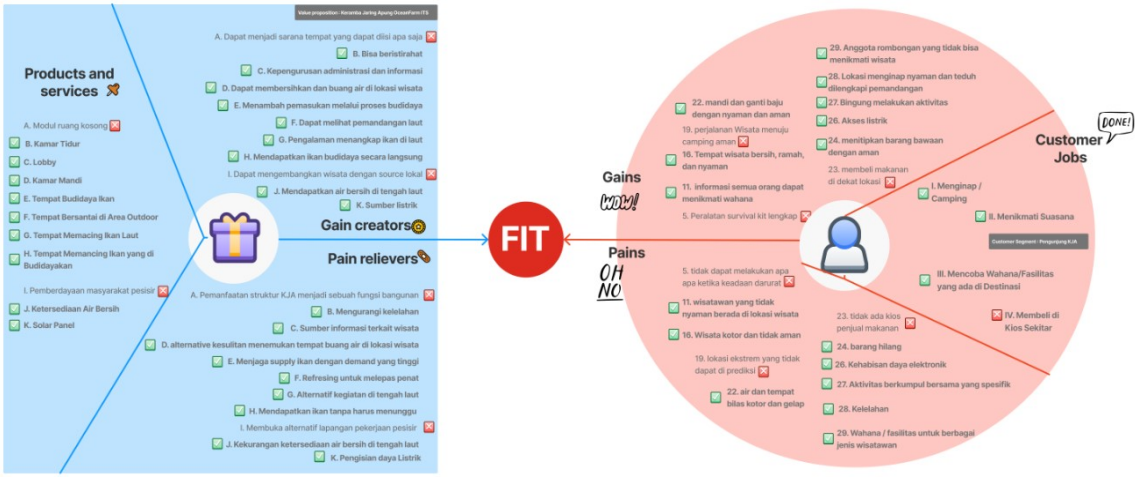


Figure 2 Value matching on the first layer of Value proposition canvas

Table 6 Product & Market Fit; Offshore Floating Residential Tourism Building and OCEAN Farm ITS Visitors

Index Relationship	Analysis Results
I-28 - B	Travelers can stay &rest comfortably and shaded with sea views in Ocean Farm bedrooms to reduce fatigue.
II-16 - F	Tourists can see a clean and comfortable sea view, in a place to relax in the outdoor area to unwind.
III-11, 29 - E G H	All tourists can be informed and immediately enjoy the experience of catching fish in the sea and at the Ocean farm as an alternative to mid-sea activities, and can immediately pick up fish without waiting.
III-24 - C	Tourists can leave their luggage safely at Ocean Farm Lobby when doing administration at the KJA location so that the goods are not lost.
III-26 - K	Tourists get access to electricity from Ocean Farm solar panels to facilitate electronic equipment that runs out of power.
III-27,29 - C	Travelers can get information related to tourism in the Ocean Farm lobby as a source of information related to rides and facilities at Ocean Farm
III-22 - D J	Tourists can take a bath and change clothes comfortably and safely in ocean farm bathrooms equipped with lighting and clean water as an alternative place to defecate at Sidoasri tourist sites

Table 7 Product & Market Non-Fit; Offshore Floating Residential Tourism Building and OCEAN Farm ITS Visitors

Necessity	Analysis Results
5	Tourists have not received survival equipment to prepare for emergencies at the KJA location
19	Tourists have not yet obtained the facilities to Go to Ocean Farm because currently Ocean Farm is still not installed and is conducting testing in its actual location. so access to Ocean Farm is not yet available
23	Tourists haven't gotten any food vendor stalls at Ocean Farm
30	Tourists need alternative facilities that are interesting and can be enjoyed by various types of tourists

The following is the result of matching Values on the second layer of VPC, that represents the relationship between the needs of South Malang Beach Visitors and Ocean Farm products. These results will later become the value proposition of Ocean Farm that will answer the needs of South Malang Beach visitors is described as follows.

The link between V26 – K (yellow line), which represents the connection between South Malang tourists' wants and Ocean Farm goods, is depicted in Figure 3. This connection shows how visitors to Ocean Farm may obtain power since Ocean Farm has solar panels that provide electrical access. A gray line also denotes the connection between southern Malang visitors and the Sidoasri Beach, specifically the connection between VIII-21 and U, which implies that visitors can worship at the prayer room nearby.

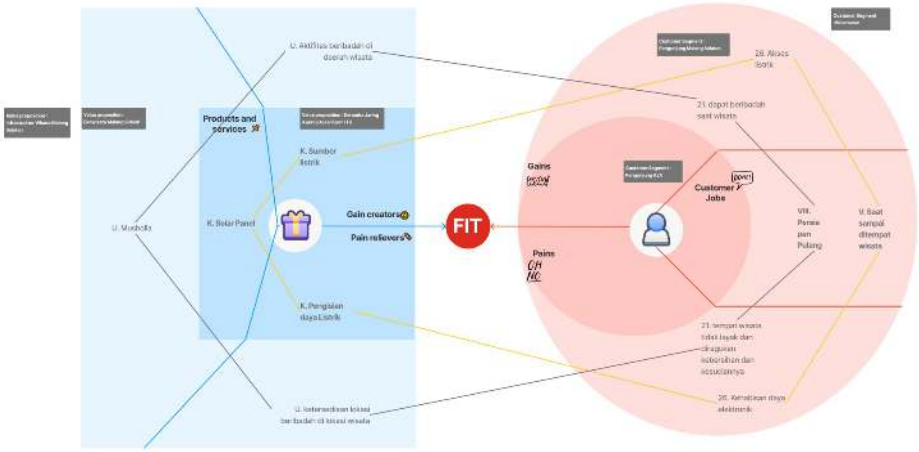


Figure 3 Value matching on the cross layer of Value proposition canvas

The needs of southern Malang tourists that could reach the fit state Sidoasri Beach, will be the basis ideas for developing the potential Ocean Farm through the needs of tourists that might be applied within Ocean Farm. These needs can be seen in the table below:

Table 8 Product & Market Non-Fit; Destination and Visitors

Necessity	Analysis Results
9	Tourists doen not got access to easy and up-to-date information related to the tourist area of South Malang Beach because often the density of visitors makes traffic jams and uncomfortable to travel
10	Tourists have not received information and guidance regarding the activities and locations of tourist area facilities because they are often confused and lost when at tourist sites
17	Tourists have not found the infrastructure of the tourist counter due to confusion when entering the tourist area
18	Tourists have not found parking lot infrastructure with guarding because the vehicle was away from surveillance
20	Users do not find trash cans due to difficulty in disposing of provisions and luggage
25	Users do not find carry by by other than fresh fish because it is easier to carry and it has become a culture to give to families as a reminder of memory

2. HMW Question and POV Madlib

The HMW questions serves as a preliminary step for a brainstorming session to produce ideas for the solution. The former steps of empathize and define, generating comprehension for the perspectives and questions of How Might We (HMW). Here are the HMW Question and POV Madlib for Ocean Farm product development that couldn't find a fit state that suits Ocean Farm visitor segmentation, also OceanFarm product development that Farm through the needs of tourists that might be applied within Ocean Farm.

Table 9 Question on Ocean Farm that not in a fit state yet

Necessity index	POV MADLIB	HMW QUESTION
5	Tourists have not received survival equipment to prepare for emergencies at the KJA location	How do we make it easier to prepare survival and camping equipment for groups so that the itinerary is smooth and able to anticipate emergency activities?
19	Tourists have not yet obtained the facilities to Go to OceanFarm because currently OceanFarm is still not installed and is conducting testing in its actual location. so access to OceanFarm is not yet available	How do we provide supporting infrastructure for camping tours for users to feel safe in extreme locations and conditions?
23	Tourists haven't gotten any food vendor stalls at OceanFarm	How do we provide quality food vendors close to tourist locations for users to feel comfortable?
30	Tourists need alternative rides that are interesting and can be enjoyed by various types of tourists	How do we provide alternative rides for users to attract and can be enjoyed by tourists?

Table 10 Question on Ocean Farm that could be developed to fit Visitor Necessities

Necessity index	POV MADLIB	HMW QUESTION
9	Tourists have not got access to easy and up-to-date information related to the tourist area of South Malang Beach because often the density of visitors makes traffic jams and uncomfortable to travel	How do we provide information easily and up to date on the Malang Southern Beaches area for tourists so that there is no overcrowding of visitors?
10	Tourists have not received information and guidance regarding the activities and locations of tourist area facilities because they are often confused and lost when at tourist sites	How do we provide information on activity guides, facilities, and locations of tourist areas for users so as not to be confused and lost?
17	Tourists have not found the infrastructure of the tourist counter due to confusion when entering the tourist area	How do we provide tourist counter infrastructure for users so as not to be confused when entering the tourist area?
18	Tourists have not found parking lot infrastructure with guarding because the vehicle was away from surveillance	How do we provide parking infrastructure for users to feel safe vehicles away from surveillance?
20	Users do not find trash cans due to difficulty in disposing of provisions and luggage	How do we provide trash cans for users so that they can dispose of their provisions and luggage responsibly?
25	Users do not find sovenirs other than fresh fish that easier to carry, and it has become a culture to give to families as a reminder of memory	How do we provide souvenirs other than fresh fish for users so that they can make memories for the family?

4.4 Ideation Stage Results

The HMW questions serves as a preliminary step for a brainstorming session to produce ideas for the solution. Brainstorming is the act of generating solutions to problems by comprehending the perspectives and questions of How Might We (HMW). Results of the brainstorming were obtained from answering the conclusions of the HMW Question which were divided into Ideas as follows:

1. Development of Ocean Farm:
   a. Survival Kit for Tourism

Provides first aid supplies, evacuation supports including buoys and other facility, warning signs during the tours of offshore floating building. It will also provide tourists with a comprehensive guide, supplementary insurance, and a luggage check as a form of service and emergency management. A coastal community clinic will be made available as an emergency service for both locals and visitors.

   b. OceanTrans

A beach tourist organization run by the local community that provides coastal transportation services. This service unit coordinates access to transportation, logistics, and to supports any mid-sea sports.

   c. Aquaral Kitchen

Restaurant management in the Floating Offshore Building which can be used as a semi-outdoor Restaurant that offers beverages and a ready-to-eat buffet with a variety of cuisine produced from aquaculture harvest. Tourists can directly feel the fishing experience, savor the fresh fish caught at the barbeque. Business profit sharing in the form of a food-court that involves local community could also contribute variations in the current employment of local residents, and it must pay attention to the highest price maximum to maintain product price stability between merchants.

   d. OceanFarm Module Development

The quality and distinctiveness of South Malang Beach tourism can be enhanced by these offshore structures that are connected to one another in one location. This module may include a villa, a restaurant or food court, a playground, a floating museum (edu center), a cafe, a coast

guard post, as well as serve as a rest area or launching point for various water sports, including canoeing, parasailing, and banana boating, etc.

2. Potential fulfillment of tourist needs with offshore floating residential buildings

a. Information Centre

This information center serves to assist tourism management in the form of public communication. It also facilitates the relationship between the beach and the Ocean Farm building and the rest of Malang Selatan Beach Area. Public communication can be done through social media with live reports and promotions related to Sidoasri Beach and Ocean Farm by maximizing various photos and videos related to marine tourism.

b. Destination Branding

The goal of destination branding is to discover and enhance the distinctiveness of tourist destinations to enhance their reputation, foster trust, and offer the finest services to visitors. One way is to create totems or markers and place them in strategic location. Visible areas and essential location should post posters and signposts that provide instructions posters of facilities. Additionally, the striking entry counter that offers offline/online maps that can be accessed and integrated with social media and digital treasures.

c. Beach Parking Area

Provision of parking space with 24-hour security and CCTV for vehicles.

d. Coastal Waste Management

Opening respectable waste management employment is one way to give coastal communities more influence. using eye-catching advertising and signs to position garbage cans in strategic locations near active areas and crowds.

e. Floating Souvenir Center

Together with the local government, creating the Ocean Farm module for the center by southern Malang. To display locally produced drinking and eating food, handicrafts, and group pictures as a souvenir of exploring Sidoasri's shore.

6. CONCLUSIONS

A prototype technique was used to create the Offshore Floating Residential Building for the ITS Ocean Farm Pilot Project. The study attempts to identify the requirements, experience, behavior, and tourist profile. In August 2022, construction blueprints will be set up on Sidoasri Beach. Prototype testing was carried out to visitors to South Malang Beach. According to the test's demographic findings from 137 respondents who completed the questionnaire in 2022, Group tourists consisted of 91.5 percent of southern Malang's visitors with a tendency for one day trips in mind (64 percent), which contradicts with the Ocean Farm module's design that was aimed to made for solo travelers. Researchers will further examine the results of this questionnaire in relation to the requirements of potential customers for offshore floating residential tourism. This empathy method is applied to seven personas that best reflect test participants and categorized by of four distinct types of tourists, each with different needs: solitary travelers, couples, families, and groups of friends.

Family segments requires Time and Place to gather with family, Information on the complex of tourist areas & facilities, also guaranteed security & safety when traveling. Traveling with friend’s segments requires a Quality Time Place with friends, clear of information about the complex, tourist areas & facilities. Traveling with a partner segment tends to go with other couples in a group and has the same needs as the category of traveling with friends with a higher level of security awareness. Solo Travelers have a need for freedom to adventure and visit new places. The

results of the empathy stage formulated 29 core problems that were felt by various tourists visiting South Malang Beach in general.

Then it is carried out and analyzed its compatibility with offshore floating residential products through VPC to produce suitable products and markets. From the results of the VPC, several problem topics were found: 1. the needs of visitors to the KJA that have not been met, and 2. the needs of tourists from southern Malang which may be solved by using the KJA. The results of the VPC were matched and re-selected in relation to 29 core problems perceived by the user and the results obtained were 2 groups of ideations, as follows.

A. The development of OceanFarm that can be provided includes: 1. Survival Kit for Tourism as a form of emergency service and anticipation, 2. OceanTrans in the form of a coastal transportation service unit, 3. Aquaral Kitchen in the form of restaurant management in KJA with fishing and BBQ facilities, 4. Development OceanFarm module with a combination of module functions with various uses.

B. Tourist needs that cannot be met by ocean farms can be used as ideation material as a basis for recommendations for object development for Offshore Floating Building, including: 1. Information Center that can assist tourism management in the form of public communication, 2. Destination Branding as a form of effort to explore and grow the uniqueness of tourist sites to improve a positive image, 3. Provision of open land for motorbike and car parking with 24-hour security and CCTV cameras, 4. Coastal Waste Management Movement by providing coastal waste management sites, 5. Offshore Souvenir Center as a form of collaboration with local residents who show local coastal commodities in Sidoasri in collaboration with the local government.

This research contributes both in academic and practical aspects. Academically, this research presents the stages for validating ideas and prototypes of Offshore Residential Buildings. In addition, this study also presents an interview protocol that can be used as a guide in exploring user personas. Practically, this research generates the idea of destination facilities that can be further developed to meet the needs of tourists through the Value Proposition Canvas. The findings from this study are expected to help the management of similar businesses to determine strategies to attract tourists and pay attention to customer needs.

REFERENCES

Abecasis, R. C., Schmidt, L., & Longneck, N. (2013). Implications of community and stakeholder perceptions of the marine environment and its conservation for MPA management in a small Azorean island. *Ocean & Coastal Management, Volume 84*(ISSN 0964-5691), 208-219.

Brown, T. (2008). *Design Thinking Dalam Harvard Business Review.* Harvard Business School Publishing Corporation.

Buitargo, N. R., A. W., A. E., G. A., A. M., & E. P. (2019). Coastal Scenery: An Introduction. In *Coastal Research Library, Vol. 26* (pp. 1-16). Springer.

California Environmental Associates. (2018). *Trends in Marine Resources and Fisheries Management in Indonesia- A 2018 Review.* The David and Lucile Packard Foundation.

Chae, D. -R., Wattage, P., & Pascoe, S. (2012). Recreational benefits from a marine protected area: A travel cost analysis of Lundy. *Tourism Management, 33*(4), 971-977.

Chen, F., Liu, J., Wu, J., Sjafrie, N. D., Rahmadi, P., & Putranto, R. Y. (2021). Measuring the relationship among stakeholders from value-satisfaction-demand in the development of ecotourism of Marine Park. *Marine Policy*.

Godovykh, M., & Tasci, A. D. (2020). Customer experience in tourism: A review of definitions, components, and measurements. *Tourism Management Perspectives*.

Hanafiah, M. H., Jasmi, A. F., Razali, A. H., & Sulaiman, M. S. (2019). The Structural Relationships Of Experience Quality, Tourist Satisfaction And Destination Loyalty: The Case Of Pangkor Island, Malaysia. *Journal of Nusantara Studies, 4 (1)*(ISSN 0127-9386), 186-210.

Kemenparekraf / Baparekraf Republik Indonesia. (2019). *KAJIAN DAMPAK SEKTOR PARIWISATA TERHADAP PEREKONOMIAN INDONESIA*. Retrieved 01 09, 2022, from https://kemenparekraf.go.id/post/kajian-dampak-sektor-pariwisata-terhadap-perekonomian-indonesia

Kementerian Kelautan dan Perikanan Republik Indonesia dan Proyek Sustainable Ecosystems . (2018). *Kondisi Laut: Indonesia.* Jakarta: USAID.

Kementrian Kelautan dan Perikanan Republik Indonesia. (2020). *Dorong Kemandirian Desa, KKP Luncurkan Program Sinergitas Dewi Bahari di Lombok Timur*. Retrieved December 09, 2022, from https://kkp.go.id/djprl/artikel/34569-dorong-kemandirian-desa-kkp-luncurkan-program-sinergitas-dewi-bahari-di-lombok-timur

Liedtka, J. (2014). Perspective: Linking Design Thinking with Innovation. *Journal of Product Innovation Management, 36*(6), 925-938.

Lise, W., & Tol, R. (2000). Impact of Climate on Tourist Demand. *Climatic Change, 10*(2139/ssrn.278516), 55.

Middleton, V. T., Fyall, A., Morgan, M., & Ranchhod, A. (2009). *Marketing in Travel and Tourism.* Routledge.

Osterwalder, A., Pigneur, Y., Bernada, G., & Smith, A. (2014). *Value Proposition Design: How to Create Products and Services Customers Want* (1 ed.). New Jersey: John Wiley & Sons Inc.

Overmyer, T., & Carlson, E. B. (2019). Literature Review: Design Thinking and Place. *Journal of Business and Technical Communication*, 1-6.

Priambudi, R., & Karningsih, P. D. (2018). Pengembangan Rencana Bisnis Oceanfarm ITS dengan Lean Canvas dan Value Engineering. *Undergraduate Thesis*. Surabaya, Jawa Timur, Indonesia: Institut Teknologi Sepuluh Nopember.

Tonkinwise, C. (2017). A taste for practices: Unrepressing style in design thinking. *Design Studies, 32*(6), 533-545.

Yani Purnawanti, N. S. (2018). Analysis of static structural of ocean FARMITS offshore cage due to environmental load. *MATEC Web of Conferences 177, 01023.* MATEC.

USER EXPERIENCE DEVELOPMENT OF LOCAL BRAND FOOTWEAR POST-PANDEMIC ON THE "INDONESIA FOOTWEAR NETWORK" PLATFORM USING DESIGN THINKING

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ABSTRACT

The decline in the global footwear industry due to the impact of the COVID-19 pandemic by up to 70% has caused the Indonesian Footwear Industry Development Center (BPIPI) to take the initiative to create the Indonesia Footwear Network (IFN) digital platform to respond to changes in the national footwear industry structure. This IFN platform aims as a liaison to facilitate interaction between entrepreneurs and consumers in footwear. However, since the IFN partner registration launch has not met the target user profile, BPIPI has collected feedback on complaints obtained when using IFN. However, these complaints can still not provide a detailed description of the problem. Therefore, it is necessary to identify the needs of the target users of IFN, especially local brands, through the design thinking method. The design thinking method is a five-stage method starting with the empathize, define, ideation, prototype, and test stages. The empathy and idea stages use to understand stakeholders, and the idea, prototype, and testing stages use to create recommendation development ideas for IFN. The result of this research is an analysis of the needs of 4 local brand personas, which resulted in several ideas and recommendations for developing IFN in the form of information architecture, adding features, and redesigning the interface.

Keywords: User Experience, Design Thinking, Footwear Industry, Indonesia Footwear Network.

1. INTRODUCTION

The Indonesian Footwear Industry Development Center (BPIPI) took the initiative to create Indonesia Footwear Network (IFN) as a digital platform to facilitate the transformation of the national apparel industry because of the collapse of the global apparel industry caused by the impact of the COVID-19 pandemic to 70% (APICCAPS, 2020). IFN platform aspires to be a connecting facility to enable contact between business owners and consumers of footwear, ranging from local suppliers of materials and materials, manufacturing industries, services, equipment, and machinery, to associations or communities, as well as local brands.

There have been 80 partners that have emerged after the IFN's initial release from August 2020 through December 2021. The current partner count is below the BPIPI objective and indicates that there are about 18,867 units of Indonesian businesses that can interact through IFN. Based on these data, this phenomenon still does not meet the target profile of the national footwear industry players. BPIPI has attempted to gather input from IFN users who have raised issues with the application's reluctance to use and suggestion. However, this complaint can still not provide a detailed description of the problem (BPIPI, 2021).

IFN is under the Ministry of Industry's authority in the footwear industry sector. It is necessary to have exceptional support related to its growth because IFN is a non-profit platform. The IFN platform will be improved following user demands while also considering the platform's primary function as a national ecosystem for the footwear industry to enhance the user experience on the IFN platform and offers a recommendation for further development.

2. LITERATURE REVIEW

User experience is a perception and response from users as a feedback relationship after using a particular product or system. *User Experience* is the procedure used to determine what should be considered while establishing a connection with something that was assumed when purchasing a product (Winter, 2015). User Experience Design creates and synchronizes elements that improve the user's experience with the targeted business while influencing their perception and behavior (Unger & Chandler, 2012).

A digital platform based on the web-based User Experience is presently being studied in this paper. Digital platforms can supply information using digital resources and serve as a liaison to let different parties engage using digital technology (Ratten, 2022). Websites do as storage media, often facilitating hosting, sharing free resources and information, and supporting do-it-yourself services. Website addresses are advertised on TV, billboards, and business cards exchanged via email and SMS and used to increase ego. It is understandable that websites evoke emotions, stimulate discussion among users, generate revenue, and alert search engines and users" (Weideman, 2009).

The concept of the ecosystem was initially adopted in the management literature to describe how systems or networks of organizations compete. In this setting, organizational ecosystems must adapt and evolve together to survive and seek dominance (Moore, 1993). The metaphor was then adapted to describe groups of interdependent organizations structured in constellations rather than traditional value chains and the associated strategies required for these organizations to create and capture value sustainably to maintain the viability of collaboration (Bonina, Koskinen, Eaton, & Gawer, 2021). When such platform-based ecosystems are primarily based on internet-based or data-driven technologies, they can be considered "digital" (Constance & Ruth, 2018). Governmental approaches such as the development of safeguards and provision of resource limits have implications for development, especially in the form of responsive, economical, and large-scale platform management. In addition, digitally mediated governance can quickly form and develop. It can be immediately effective because it is centrally controlled (Bonina, Koskinen, Eaton, & Gawer, 2021).

The user experience is the impact of the interaction between the user and the product of the digital platform. In this study, the user is a registered partner, and IFN serves as the digital platform. IFN is a web-based digital platform. The platform is a website base because it is an easy and free storage medium to share information—the type of platform that IFN is an ecosystem platform that focuses on the footwear ecosystem. One of the studies is the platform management strategy

through the government; It is similar to BPIPI from the unit within the Ministry of Industry that oversees the IFN program and serves as its manager.

3. METHODS

The Design Thinking method is a comprehensive method of creative problem solving that involves the user in the thinking process and makes the user's perspective the primary consideration of the problem-solving process (Brown, 2008). In this study, the five stages of the Design Thinking model according to the Stanford Hasso-Plattner Design Institute (Stanford Design School, 2008) were used: emphatize, define, ideate, prototype, and test (Hasso, 2010). This model is used because it is a reliable framework for designing something based on user needs, which in this case describes the design process for improving the IFN user experience. This study uses qualitative data collection using Forum Group Discussions and In-Depth interviews with the footwear industry players.

The research tools used in this research are; user personas to find out various possibilities from individuals by using scenarios, user journey mapping to map each user's journey in completing several scenarios, empathy map to help understand and perceive team member observations, point of view to define the right challenges for the team to overcome in the ideate stage (IDEO, 2011), How Might We question to create questions that provoke meaningful and relevant ideas. Then processed with affinity shows the scope of the problem and reveals in one place all the problems, concerns, and critical elements of the user's life that are relevant to their focus (Holtzblatt & Beyer, 2017). From the results of the affinity diagram, it will become ideation which experts will later interview to determine the recommendation ideas

4. RESULTS

The first stage in design thinking is the empathize stage, which is the stage in collecting data by exploring problems from the perspective of IFN users. This stage is done by compiling questions for interviews starting from determining the objectives and framework of the interview. The results obtained from this stage are empathy map, user persona, and user journey mapping. The results of the FGD show that local brands still maintain their brands during sales that fell by up to 70%. It is increasingly difficult to compete in the footwear market because local brands must compete with imported footwear brands whose prices are much lower. Several local brands began to develop by taking a more segmented market and diversifying their business to other types of fashion products. Therefore, local brand representatives were chosen to be conducted in-depth interviews with local footwear brands. The results of the in-depth interview are four personas of local footwear brands. The following is a table of empathizing results:

Table 1. User Persona, Empathy Map, and User Journey Map for Empathy Stage Result

User Persona	Empathy Map	User journey Map
Persona 1 is a 35-year-old woman. He is the Co-Founder of a local sports shoe brand (skateboard). He is a communications graduate. The goal is to build a solid brand to be a	Persona 1 finds it difficult to find a vendor that meets their needs but cannot be produced because a minimum order must be fulfilled. That Persona 1 feels overwhelmed in managing all social media and e-commerce accounts. Besides taking	Persona 1 wants to expand its shoe market and seeks vendor/manufacturer information on footwear that fits its brand needs. She looked for information on the internet and found news related to improving the performance of the footwear industry through BPIPI. She

sustainable business for her children.	care of sales, she also takes care of promotions alone. This condition causes Persona 1 to often miss out on new information related to the footwear industry. She hopes to find a vendor that fits his needs easily and quickly, both production vendors and marketing vendors/agencies. If his social media accounts are still handled by herself, he will feel happy if her social media accounts can be directly integrated. She also hopes to keep up with the latest information about elated to the footwear industry.	wanted to become an IFN partner. However, She was confused about the registration process, starting from the registration form and the lengthy verification process. Persona 1 also feels dissatisfied with updating its partner profiles because it updates profile content on a different page from its IFN web page, and there is no link between the two. She also cannot distinguish between a business profile and a product profile. The distribution of partners also does not provide much information because the location of partners is not suitable. However, Persona 1 still finds it helpful when they have found a partner. It is easy to contact them directly because their contact information can be directed directly to other communication platforms.
Persona 2 is a 35-year-old woman who graduated from Yogyakarta State University with cultural engineering education. A founder of a local brand of custom boots. He wants to be the top-of-mind custom boots in Indonesia.	Persona 2 is worried about photographers for shoe products that are difficult to produce suitable photos. At the same time, in presenting promotional content and information to the public, it is necessary to have a clear visual image and an emotional approach. Besides photography services, many boots-making vendors are less trustworthy and do not respect each other. The footwear industry's lack of up-to-date information, especially services and vendors, has resulted in Persona 2 doing all the research independently. She hopes that there will be fast and accurate disclosure of information so that he can find suitable partners and can establish continuous relationships both with partners and with customers.	Persona 2 was having vendor difficulties. From that problem, Persona 2 received a recommendation regarding IFN and immediately registered, but She felt lazy when he had to fill out lengthy registration forms and verification that took time. According to her, this is impressive. The experience of updating profiles is also tedious, with stacked views and too much information. The creative storefront feels the same. Many partners have not written a clear description of their business, so the partner search process becomes less than optimal.
Persona 3 is a 23-year-old woman. He graduated from S1 Business Management and is	Persona 3 is preparing jobs for local designers and artisans to collaborate. However, she found it difficult to find designers and	Persona 3 is passionate about expanding its market, promotions, and relationships. She is active in promoting and building relationships with footwear activists, one

pursuing a Masters in Innovation Design Management. She is the co-founder of a local soap brand for women. He aims to create jobs and collaborate with local vendors and designers.	artisans. As a designer, Persona 3 felt unable to develop because too many designs could not be made. After all, the desired raw materials could not be produced. She thinks that the products he sells have disparities from each other in terms of sales. Persona 3 hopes to continue to develop with local designers and artisans, discuss with each other and establish relationships with fellow footwear industry players.	of which is by registering for IFN. Registration went smoothly, but Persona 3 had difficulty updating its profile. She feels that the display is unseen and doesn't know which steps to take first to update her profile. According to Persona 3, the user experience after registering on this platform is considered normal, the same as looking for information on other platforms; there has been no impact and continuation of the relationship between IFN partners.
Persona 4 is a 28-year-old male. He is one of Panna Footwear's founders and an S1 and S2 Accounting graduate from Padjadjaran University. He aims to make local brands the best from others, to be different, and to be the choices of local shoe brands.	Since the pandemic, Persona 4 finds it increasingly difficult to sell through offline stores. He feels that consumers are now pickier because they know the HPP of a product but do not know the other costs that need to be incurred to build a business brand. Udin spends a lot of time and money collecting customers. He does not dare to use digital marketing services for fear of increasing market response, and the amount of available stock is insufficient. Currently, he is happy because he has a production partner who matches the design he wants. He hopes to meet with other footwear industry partners in offline events to get updates on current trends and conditions.	Persona 4 had difficulty getting the latest insights from consumers because of the rapidly changing trends. This is also not obtained even though he has registered at IFN. The number and variety of partners who are members are not many. However, since updating and posting his profile on the creative storefront, Udin is happy because he was contacted by several partners to be invited to discuss and share stories about the footwear industry.

Whereas Persona Brand claims that the inability to register and update partner profiles is now the issue that IFN encounters most frequently. Consumers want a quick and simple partner registration procedure and a more consistent customer management system to update their profiles after enrolling partners simply. The IFN Information & Promotion Forum Needs, Partner Registration Form, Registration Verification, Content Management System, and Creative Storefront were identified as the five needs for local footwear businesses from the results of the empathy stage. To broaden the problem-solving perspective, HMW Questions are used to assist in the brainstorming ideation process. The results of the HMW Questions are as follows:

1. How to create an information portal, and what are the advantages of joining the IFN platform?
2. How to make an easy registration form with a line of business?
3. How to speed up the IFN partner registration verification process?
4. How to update the content management system more easily linked in one web page?

5. How to add the feature of uploading more photo content and descriptions independently?
6. How to improve the arrangement of creative storefronts that are informative, attractive, easy to access business contacts, and adapted to each type of business?

The ideation results obtained are a total of 32 ideations, which are then sorted and grouped into several recommendations for development to be carried out. The results of the ideation development obtained are as follows:

1. Changes and Adjustments of IFN Home view
   a) Seasonal Custom Web Carousel: A web banner portal that serves as a means of promotion and information related to IFN. This web banner content can later be used and connected to BPIPI social media and other publications.
   b) Cards Slider: For types of footwear industry: Cards with a collection of information on types of footwear industry categories are used to direct users to choose which partners to look for directly. These cards consist of nine categories: Raw Materials, Local Brands, Manufacturing, Services, Associations, Communities, Accessories, Machinery/Equipment, and Uncategories for other partners not mentioned.
   c) IFN Profile Transfer: The location of IFN descriptions and explanations that were originally in the partner distribution menu have to move to the home page.
   d) Creative Storefront Snippet: Visitors can immediately browse through the joined partners through the creative storefront snippet, which can bring up a description pop-up that can be forwarded to the partner's profile page.
   e) Call To Action–Register Partners: A single column that provides an invitation to join as an IFN partner and explains the benefits of joining IFN. There is a register now button to redirect to the registration page.
   f) IFN Partner Testimonials: A slider feature that displays information on the testimonials of partners who have joined IFN as a form of increasing trust and reference for visitors to consider joining IFN.
   g) Video Partner of The Month: Contains partners showing the latest video updates for that month. This video will later lead to a creative storefront page with selected profiles that can tell updates regarding their business. It can be in the form of storytelling about products and varied content or the form of unique content from each brand every month.
   h) Latest News Snippets from IFN Labs: Some of the latest news articles as a form of sharing the latest information on the footwear industry.
   i) Navigator and Footer Updates: Updates on the website navigator and footer to make it easier and strengthen the identity of the IFN itself.
2. Quick Register System
   The quick register system is a registration system that optimizes registration by filling in the name, e-mail, and contact that can be contacted only to be able to join IFN. Then verification can be directly received as a username and password, which can make partners join (can also log in/log in using Google APIs).
3. Registration Form Adjustment
   Clustering the registration form into three stages: Data in Charge, Business Category, and Business Profile. The need for filling out profiles, product photos, and others will be carried out in the direct partner profile.
4. Creative Storefront Display Adjustments

A Creative storefront display that will be customized focuses on the differentiator of each partner. Partner profiles provide information related to partner business companies, licenses/certifications, and other information. Explanation of partner is the product/service portfolio. Moreover, it can also provide reviews and recommendations from other partners. In updating creative storefront content, partners can directly edit their business profiles.

6. CONCLUSIONS

The development of the IFN platform using design thinking found four types of local footwear brand personas with different kinds of shoes. The experience gained from each persona has its uniqueness. However, it has several complaints and the exact needs related to IFN Information & Promotion Forum Needs, Partner Registration Forms, Registration Verification, Content Management System, and Creative Storefront. In this study, ideation results were obtained in the form of (1) Changes and Adjustments to the IFN Home screen, (2) Quick Register System, (3) Adjustments, Registration Forms, and (4) Creative Storefront Display Adjustments. This research only focuses on determining user experience ideation and user interfaces for local footwear brand partners. Matters related to website development needs need further research and discussion.

REFERENCES

APICCAPS. (2020). *World Footwear Yearbook.* Portuguese: world footwear.

Bonina, C., Koskinen, K., Eaton, B., & Gawer, A. (2021). Digital platforms for development: Foundations. *Information Systems Journal*, 896-902.

BPIPI. (2021). *Annual Report - BPIPI.* Sidoarjo: BPIPI.

Brown, T. (2008). *Design Thinking Dalam Harvard Business Review.* Harvard Business School Publishing Corporation.

Constance, H. E., & Ruth, R. S. (2018). Dynamic and integrative capabilities for profiting from innovation in digital platform-based ecosystems. *Research Policy Volume 47, Issue 8*, 1391-1399.

Hasso, P. (2010). *An Introduction to Design Thinking: Process Guide.* Hasso Plattner Institute of Design at Stanford University.

Holtzblatt, K., & Beyer, H. (2017). *Contextual Design || The Affinity Diagram* (1 ed.). Morgan & Claypool.

IDEO. (2011). *Human-Centered Design Toolkit, 2nd and.* Palo Alto: Authorhouse. Retrieved from IDEO.

Moore, J. F. (1993, 05). *Predators and Prey: A New Ecology of Competition*. Retrieved from Harvard Business Review: https://hbr.org/1993/05/predators-and-prey-a-new-ecology-of-competition

Ratten, V. (2022). Digital platforms and transformational entrepreneurship during the COVID-19 crisis. *International Journal of Information Management*, 102534.

Unger, R., & Chandler, C. (2012). *A Project Guide to UX Design: For user experience designers in the making field.* Berkeley: New Riders.

Weideman, M. (2009). *Website Visibility, The theory, and practice of improving rankings.* Inggris: Elsevier Science.

Winter, J. (2015, 08 13). *What is User Experience?* Retrieved from User Testing: https://www.usertesting.com/blog/2015/08/13/what-is-userexperience

A CONCEPTUAL MODEL FOR THE INVESTIGATION OF THE RELATIONSHIP AMONG SUPPLY CHAIN INTEGRATION, SUPPLY CHAIN RESILIENCE AND OPERATIONAL PERFORMANCE

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ABSTRACT

Firm competition is no longer determined on an individual basis but between each Supply Chain (SC). Supply Chain Integration (SCI), which is which is the extent to which a firm strategically collaborates with not only intra-organization but also its supply chain partners, is believed to be one of the most important aspects of supply chain management (SCM) by providing a vital role in developing positioning advantages connected to enhancing firm performance. On the other side, SCM faced serious challenges of disruption that brought negative impact to supply chain performance and firm performance. To deal with it, the firm needs to build Supply Chain Resilience (SCRE) capabilities. However, not only a few empirical studies have examined the relationship among SCI (internal, customers and suppliers), SCRE and firm operational performance but also inconsistent results. Therefore, utilizing a literature review and by also considering the recommendation of existing research, this study is a proposed model to measure the relationship SCI, SCRE and firm operational performance.

Keywords: supply chain integration, supply chain management, supply chain resilience, operational performance.

1. INTRODUCTION

In recent industrial developments, firm competition is no longer determined on an individual basis but between one supply chain (SC) and others (Christopher, 2000; Pujawan, 2017). Activities in SC-which generally include the flow of goods, the flow of money and the flow of information need to be managed with methods, tools or management approaches commonly known as Supply Chain Management (SCM). Mentzer (2001) defines SCM as strategic, systematic and tactical coordination throughout the business functions within a particular firm and the entire business from suppliers to manufacturers to customers in SC to improve the long-term performance of the firm and the SC as a whole. Therefore, SCM does not only focus on internal affairs within a firm but also external affairs concerning business partners.

Supply Chain Integration (SCI) is considered one of the most important aspects of SCM (Huo, 2012). SCI had identified as a determinant of a firm's ability to collaborate with supply chain partners is required service performance (Zhang *et al.*, 2013). A report released by the CDP Global Supply Chain Report in 2019 showed that companies that have merged with suppliers have seen more than 50% of these suppliers improve their sustainability performance. This collaboration and integration allow companies to strategically develop their operations to better

meet customer needs. Notably, 73% of customers are willing to leave their previous suppliers based on performance (CDP Supply Chain Report, 2019). Globalization, which increases demand for various types of products while also shortening product life cycles, and outsourcing, which firms prefer to buy than make, became a motivation for companies to integrate their SC (Näslund *et al.*, 2012; Vitasek, 2016).

In the context of integration in SCM, Stevens (1989) describes the stages of integration, beginning with strengthening internal integration and progressing to external integration. Nonetheless, there is little empirical evidence of the relationship between internal and external integration (customer and supplier integration (Yu *et al.*, 2013). As a result, research to obtain empirical evidence of the relationship between each dimension in SCI is encouraged SCI (Huo, 2012; Yu *et al.*, 2013; Liu *et al.*, 2018; Errassafi *et al.*, 2019). However, the empirical evidence is inconsistent from one study to another.

Today SCM faces serious challenges of disruption, both due to natural disasters and repeated man-made disasters (Katsaliaki et al., 2021). The big earthquake and tsunami in Japan in 2011 forced the manufacturing industry that produces electronic components for automotive to stop operating (BBC, 2011). Floods hit factories in Thailand, which produce about a quarter of the world's hard drives, leaving personal computer makers scrambling. The latest disruption to SCM that has an impact on the economy in most countries in the world and disrupts global SC is the Coronavirus disease-19 (Covid-19) pandemic (Erhie, 2020; Kilpatrick & Bartet, 2020).

To deal with uncertainty, opportunities and impacts due to disruption in SC, companies need to build Supply Chain Resilience (SCRE) capabilities (Yu *et al.*, 2019). This has become one of the impetuses for academics and practitioners in investigating disruption management in SC through the development of SCRE (Ambulkar *et al.*, 2015). One of the topics that have emerged is the investigation into the impact of the relationship between SCI and SCRE (Wieland *et al.*, 2013; Liu *et al.*, 2018). Despite its importance, there is still a need for more research to be conducted to gain a better understanding of the benefits of various aspects of SCI in relation to SCRE and how they interact with the performance of a firm. Therefore, employing a literature review and by also considering the recommendation of existing research, this study proposes a model to measure the relationship SCI, SCRE and firm operational performance.

2. LITERATURE REVIEW & HYPOTHESES DEVELOPMENT

2.1 Supply Chain Integration

The concept of SCI in SCM was first stated by Stevens (1989) by describing the stages of SCI in manufacturing companies. The literature defines SCI in various senses. Van Donk *et al.*, (2004) in the context of manufacturing companies state that SCI is the extent to which companies strategically collaborate with their supply chain partners. Flynn *et al.*, (2010) define SCI as the firm's operational capabilities to collaboratively manage inter-organizational processes with customers and suppliers, and intra-organizational processes among internal functions. Huo (2012) stated that SCI is a strategic collaborative process to manage processes within and outside the organization. Referring to the research of Chang, Kim, dan Frank (2016), supply chain integration (SCI) is defined as strategic process management that can play a role in creating a positional advantage associated with increasing firm performance that is consistent with the dominant flow of the latest SCI empirical characteristics such as information, technology, processes, and relationships.

Huo (2012) states that SCI is believed by many experts to be one of the most important aspects of supply chain management supported by several arguments. This argument is based on the concept of Resource-Based View (RBV), where companies must be able to utilize resources to

maintain competitiveness and competitive advantage (Barney, 2001). This opinion is strengthened by Liu dan Lee (2018) where RBV has been widely used in research related to logistics to evaluate the contribution of various resources to firm performance. Previous studies have shown that integration can be treated as a resource that helps companies adapt to environmental changes and quickly respond to disruptions (Hohenstein *et al.*, 2015) potentially increasing a firm's ability to solve customer problems and, thereby, increase service satisfaction. RBV can be used to determine the contribution of various types of integration to firm performance. Another argument states that SCI can be seen as a strategic resource that can generate competitive advantage and increase firm performance (Van Donk et al., 2004). According to Asgari, Hamid, dan Aleebrahim (2017) supply chain integration provides operational visibility, coordination plans, and efficient flow of goods which reduces the time interval between customer requests for products/services and their delivery as well as the ability to provide the required quantity of goods in the right place and time. appropriate.

To determine the size and type of integration in SCM experts have several opinions. The most widely used opinion is that SCI consists of multi-dimensional measurements. Flynn et al., (2010) stated that SCI can be divided into 3 dimensions, namely internal integration (II), customer integration (CI) and supplier integration (SI). Customer integration and supplier integration can be referred to as external integration.

2.2 Supply Chain Resilience

SCRE has the meaning not only to enable companies to identify and reduce vulnerabilities before they occur but also to react and recover quickly at a cost-effective post-disturbance) (Christopher *et al.*, 2004; Ali *et al.*, 2017). Some researchers argue that SCRE consists of several (Christopher *et al.*, 2004; Liu *et al.*, 2018; Chowdhury *et al.*, 2019). Christopher and Peck (Christopher *et al.*, 2004) argue that SCRE has four dimensions: SC re-engineering, collaboration, agility and SC risk management culture. Jüttner and Maklan (Jüttner *et al.*, 2011) suggest that SCRE involves flexibility, speed, visibility, and collaboration. Flexibility represents a firm's ability to adapt to a disruption. Velocity refers to the speed with which a firm's coping strategy can execute. Visibility reflects the firm's knowledge of supply chain conditions. Finally, collaboration describes the relationship between an organization and its supply chain partners. In brief, all of the above dimensions of SCRE are important and sometimes overlap (Liu *et al.*, 2018). SCRE is considered to have a single dimension, as recommended by many researchers (Ambulkar *et al.*, 2015; Gölgeci *et al.*, 2015; Yu *et al.*, 2019).

2.3 Operational Performance

One of the most challenging activities for companies is choosing the right performance measures. Neely (2007) states that performance measurement has a very broad meaning depending on the subject and many other parties who have different functional backgrounds in their approach. Huo (2012) states that the literature on business and firm performance suggests various opinions about firm performance. Chen and Paulraj (2004) expressed the opinion that financial performance should be the main measure of SC performance because it is based on the profit motive of shareholders. Measurement through financial performance can be measured through sales growth (growth in sales), growth in profit (growth in profit), growth in market share (growth in market share), rate of return on investment (ROI) and growth in ROI (Flynn *et al.*, 2010; Yu *et al.*, 2013; Lii *et al.*, 2016). From the point of view of firm operations, performance measurement is usually determined through the effectiveness and efficiency of processes within the organization

(Neely, 2007). In this study, the firm's performance is limited only to the firm's operational performance.

2.4 Relationship Internal integration and external integration

Previous studies have shown that there is a positive relationship between the dimensions contained in the SCI. Huo's research (2012) shows that internal integration has a positive effect on external integration (Customer Integration and Supplier Integration) in manufacturing companies in China. Internal integration has also been shown to have a significant positive effect on customer integration and logistics integration (Liu and Lee, 2018). Empirical evidence is also obtained from studies on medium and large Moroccan manufacturing companies which state that there is a significant positive relationship between internal integration and customer integration, and internal integration with supplier integration (Errassafi et al., 2019). The relationship between internal integration and external integration is also strengthened by the research of Freije et al. (2021). Based on the explanation above, the proposed hypothesis is as follows:
H1: Internal integration has a positive effect on customer integration
H2: Internal integration has a positive effect on supplier integration

2.4 Relationship Supply Chain Integration and Supply Chain Resilience

SCRE can be influenced and strengthened by the integration of existing operations and businesses along the supply chain network so as to build redundancy, flexibility (Brusset *et al.*, 2017). Integration is also able to encourage appropriate decision making when disruption occurs and build supply chain resilience (Yu *et al.*, 2013). The level of integration is one of the element of the SCRE measurement (Chowdhury *et al.*, 2016). A study conducted by Siagian (2021) showed that in general SCI was able to affect SCRE. Furthermore, research shows a positive relationship between internal integration and SCRE in manufacturing companies in Indonesia (Tarigan *et al.*, 2021), logistics companies in Taiwan (Liu and Lee, 2018). A different opinion was conveyed by the findings of Liu and Lee (2018) which stated that logistics collaborator integration did not have a direct effect on SCRE. The results of the research by Wieland *et al.* (2013) also stated that there was no significant relationship between integration and SCRE. Therefore, the opinion which states that there is a significant positive effect of the 3 dimensions of integration on SCRE was chosen in this study. Based on the explanation above, the proposed hypothesis is as follows:
H3A: Internal integration has a positive effect on SCRE
H3B: Customer integration has a positive effect on SCRE
H3C: Supplier integration has a positive effect on SCRE

2.5 Relationship Supply Chain Integration and Firm Operational Performance

Through meta-analysis research, Ataseven and Nair (2017) investigated 40 scientific journal articles on similar topics. The results showed that, empirically, the 3 dimensions of integration (internal, customer and supplier) has a positive influence on the firm's performance and finances. Errassafi's research (2019) proves that internal integration, customers and suppliers have a positive effect on operational performance. These results are in line with research by Huo (2012) and Donkor (2021) which conclude that from the 3 dimensions of SCI, internal integration has the greatest influence on firm performance. In contrast, referring to research by Flynn (2010), Leuschner *et al.*, (2013) and Duhaylongsod *et al.*, (2019), no direct relationship was found between supplier integration and firm performance. Studies by Devaraj *et al.*, (2007), Leuschner *et al.*, (2013) and Ataseven *et al.*, (2017) provide evidence that customer integration has no positive

and significant effect on the firm's operational performance. There is also no evidence of a positive relationship between integration and firm performance (Liu, Shang, et al., 2018).
Based on the differences in the two perspectives regarding the relationship between integration and firm performance, the argument that there is a positive relationship between integration and firm performance is chosen in this study, so the hypotheses proposed are as follows:
H4A: Internal integration has a positive effect on firm performance
H4B: Customer integration has a positive effect on firm performance
H4C: Supplier integration has a positive effect on firm performance

2.6 Relationship Supply Chain Integration and Firm Operational Performance

The Systematic Literature Review (SLR) conducted by Ifthikar (2021) on 56 journal articles between 2000-2019 supports the evidence of a positive relationship between SCRE and firm performance. Liu and Lee's (2018) study on 3PL companies in Taiwan shows that having SCRE has the ability to detect disturbances and threats, so that they are able to find solutions to problems and meet customer needs. SCRE is also related to the firm's ability to adapt to fluctuations in customer demand, uncertainty, solve problems quickly and ultimately increase customer satisfaction and competitive advantage (Siagian et al., 2021; Tarigan et al., 2021). Manufacturing companies in China that have high SCRE levels have a positive impact on good firm financial performance as well (Yu et al., 2019). Results Based on the results of the research above, the proposed hypothesis is as follows:
H5: SCRE has a positive effect on firm performance

Figure 1 displays a conceptual model.

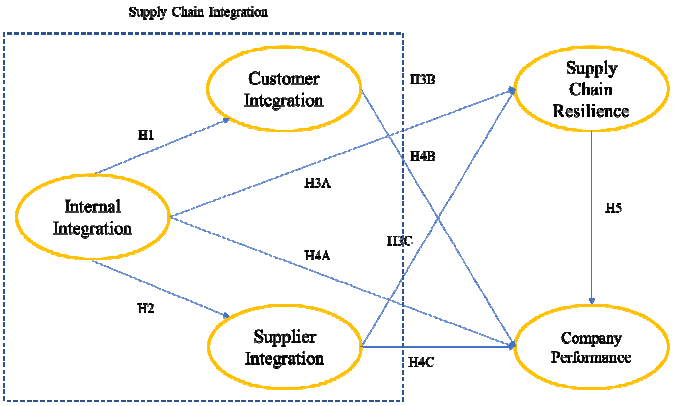


Figure 1 The Conceptual Model

3. METHODS

3.1 Selection of the sample

Indonesian manufacturing companies are selected as the population of this study with definition by Central Bureau of Statistics (Indonesia) (2017). Purposive sampling is used in this study in order to get an overview of the characteristics of the population (Groebner *et al.*, 2011). Referring to previous research (Yu et al., 2013; Chowdhury et al., 2019; Errassafi et al., 2019; Freije et al., 2021) the criteria for eligible respondents for this study involve practitioner in manufacture's supply chain. At least 54 practitioners will be required for this study according Hair's (Hair *et al.*, 2014) and Cohen's (1992) recommendation.

3.2 Survey measures and items

The questionnaire covered four topics: background information about the business and respondent, SCI, SCRE, Operational Performance. Table 1 presents the measurement items of SCI, SCRE and operational performance. In all, 21 items were used to measure the SCI of manufacture companies, based on the works of previous researchers (Huo, 2012; Lii *et al.*, 2016; Donkor *et al.*, 2021; Freije *et al.*, 2021). Five items were selected as measure of SCRE based on existing works (Ponomarov *et al.*, 2009; Wieland *et al.*, 2013; Ambulkar *et al.*, 2015; Yu *et al.*, 2019; El Baz *et al.*, 2021). 8 questions were choosen as measure operational performance based on previous literatures (Yew *et al.*, 2011; Alfalla-luque *et al.*, 2015; Liu *et al.*, 2018; Errassafi *et al.*, 2019).

3.3 Analytical methods

To test the research hypotheses, a partial least squares structural equation modeling (PLS-SEM/PLS) method was used. PLS-SEM was chosen by considering various reasons according to previous literature (Hair et al., 2014; Ghozali et al., 2015; Haryono, 2017; J. F. Hair et al., 2019).

Table 1. Measurement items

Internal Integration	
The level of using enterprise application integration among internal functions.	II.1
Enterprise application integration among internal functions.	II.2
Integrative inventory management.	II.3
Real-time searching of the level of inventory.	II.4
The utilization of periodic interdepartmental meetings among internal functions.	II.5
The use of cross functional teams in new product development.	II.6
Real-time integration and connection among all internal functions from raw material management through production, shipping, and sales	II.7
Customer Integration	
The level of linkage with our major customer through information networks.	CI.1
The establishment of online ordering systems with our major customer.	CI.2
Our major customer shares demand forecast with us.	CI.3
We share our available inventory with our major customer.	CI.4
We share our production plan with our major customer	CI.5
The degree of collaboration with customers in product development and process improving	CI.6
The establishment of strategic partnership with our major customer.	CI.7
Supplier Integration	
The level of information exchange with our major supplier through information networks.	SI.1
The establishment of online ordering systems with our major supplier.	SI.2
Our major supplier shares their production capacity with us.	SI.3
We share our inventory levels with our major supplier.	SI.4
We share our production plans with our major supplier.	SI.5
The degree of collaboration with major supplier in product development and process improving	SI.6
The level of strategic partnership with our major supplier.	SI.7
SCRE	
Our supply chain is adequately responds to unexpected disruptions	SCRE.1
Our supply chain is quickly return to its original state after being disrupted	SCRE.2
Our supply chain copes with changes brought by unexpected disruption)	SCRE.3
Our supply chain is well prepared to deal with financial risk	SCRE.4
Our supply chain has ability to maintain a level of control over structure and function	SCRE.5
Operational Performance	
The firm produces products with low inventory holding costs	CP.1
The firm produces products with low overhead cost	CP.2
The firm is able to rapidly change changes in market demand	CP.3
The firm is able to rapidly change production volume	CP.4

The firm maintain on time delivery level to customers	CP.5
The firm maintain delivery accuracy level to customers	CP.6
The firm produces consistent quality products with low defects	CP.7
The firm produces high quality products that meet customer needs	CP.8

5. CONCLUSIONS

Many scholars have addressed the vital role of SCI, SCRE and operational performance of firm. Despite its importance, there is still a need for more research to be conducted to reveal relationship among those variables. With this regard, it is planned to conduct empirical research based on proposed model. It will allow to provide empirical result that analyze relationship not only dimension in SCI but also impact to SCRE and operational performance of firm.

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REFERENCES

Alfalla-luque, R., Marin-garcia, J.A. and Medina-lopez, C. (2015) "Int . J . Production Economics An analysis of the direct and mediated effects of employee commitment and supply chain integration on organisational performance $," *Intern. Journal of Production Economics*, 162, pp. 242–257. doi:10.1016/j.ijpe.2014.07.004.

Ali, A., Mahfouz, A. and Arisha, A. (2017) "Analysing supply chain resilience: integrating the constructs in a concept mapping framework via a systematic literature review," *Supply Chain Management: An International Journal*, 22(1), pp. 16–39. doi:10.1108/SCM-06-2016-0197.

Ambulkar, S., Blackhurst, J. and Grawe, S. (2015) "Firm's resilience to supply chain disruptions: Scale development and empirical examination," *Journal of Operations Management*, 33–34, pp. 111–122. doi:10.1016/j.jom.2014.11.002.

Asgari, A., Abdul Hamid, A.B. and Ale Ebrahim, N. (2017) "Supply Chain Integration: A Review and Bibliometric Analysis," *International Journal of Economics & Management Sciences*, 06. doi:10.4172/2162-6359.1000447.

Ataseven, C. and Nair, A. (2017) "Assessment of supply chain integration and performance relationships: A meta-analytic investigation of the literature," *International Journal of Production Economics*, 185(December 2015), pp. 252–265. doi:10.1016/j.ijpe.2017.01.007.

Badan Pusat Statistik (2017) *Badan Pusat Statistik*. doi:10.1055/s-2008-1040325.

Barney, J.B. (2001) "Resource-based theories of competitive advantage: A ten-year retrospective on the resource-based view," *Journal of Management*, 27(6), pp. 643–650. doi:10.1177/014920630102700602.

El Baz, J. and Ruel, S. (2021) "Can supply chain risk management practices mitigate the disruption impacts on supply chains' resilience and robustness? Evidence from an empirical survey in a COVID-19 outbreak era," *International Journal of Production Economics*, 233(October). doi:10.1016/j.ijpe.2020.107972.

BBC (2011) *Japan earthquake_ Production halted at factories - BBC News*.

Brusset, X. and Teller, C. (2017) "Supply chain capabilities, risks, and resilience," *International Journal of Production Economics*, 184(October 2015), pp. 59–68. doi:10.1016/j.ijpe.2016.09.008.

CDP Supply Chain Report (2019) *Cascading Commitments: Driving ambitious action through supply chain engagement*. Available at: https://www.cdp.net/en/research/global-reports/global-supply-chain-report-2019.

Chang, W. *et al.* (2016) "Supply chain integration and firm financial performance: A meta-analysis of positional advantage mediation and moderating factors," *European Management Journal*, 34, pp. 282–295.

Chen, I.J. and Paulraj, A. (2004) "Towards a theory of supply chain management : the constructs and measurements," *Journal of Operations Management*, 22, pp. 119–150. doi:10.1016/j.jom.2003.12.007.

Chowdhury, M.M.H. and Quaddus, M. (2016) "Supply chain readiness, response and recovery for resilience," *Supply Chain Management*, 21(6), pp. 709–731. doi:10.1108/SCM-12-2015-0463.

Chowdhury, M.M.H., Quaddus, M. and Agarwal, R. (2019) "Supply chain resilience for performance: role of relational practices and network complexities," *Supply Chain Management*, 24(5), pp. 659–676. doi:10.1108/SCM-09-2018-0332.

Christopher, M. (2000) "The Agile Supply Chain: Competing in Volatile Markets," *Industrial Marketing Management*, 29(1), pp. 37–44. doi:https://doi.org/10.1016/S0019-8501(99)00110-8.

Christopher, M. and Peck, H. (2004) "Building the Resilient Supply Chain," *The International Journal of Logistics Management*, 15(2), pp. 1–14. doi:10.1108/09574090410700275.

Cohen, J. (1992) "Statistical power analysis," *Current directions in psychological science*, 1(3), pp. 98–101.

Devaraj, S., Krajewski, L. and Wei, J.C. (2007) "Impact of eBusiness technologies on operational performance: The role of production information integration in the supply chain," *Journal of Operations Management*, 25(6), pp. 1199–1216. doi:10.1016/j.jom.2007.01.002.

Van Donk, D.P. and Vaart, T. (2004) "Business conditions, shared resources and integrative practices in the supply chain," *Journal of Purchasing and Supply Management*, 10, pp. 107–116. doi:10.1016/j.pursup.2004.09.002.

Donkor, F., Papadopoulos, T. and Spiegler, V. (2021) "The supply chain integration – Supply chain sustainability relationship in the UK and Ghana pharmaceutical industry : A stakeholder and contingency perspective," *Transportation Research Part E*, 155(July), p. 102477. doi:10.1016/j.tre.2021.102477.

Duhaylongsod, J.B. and De Giovanni, P. (2019) "The impact of innovation strategies on the relationship between supplier integration and operational performance," *International Journal of Physical Distribution and Logistics Management*, 49(2), pp. 156–177. doi:10.1108/IJPDLM-09-2017-0269.

Erhie, E. (2020) "Impact of COVID-19 on the supply chain industry," *PricewaterhouseCoopers Limited* [Preprint]. Available at: http://www.pwc.com/ng/covid-19.

Errassafi, M., Abbar, H. and Benabbou, Z. (2019) "The Mediating Effect of Internal Integration on the Relationship between Supply Chain Integration and Operational Performance: Evidence from Moroccan Manufacturing Companies," *Journal of Industrial Engineering and Management*, 12(2), p. 254.

Espino-Rodríguez, T.F. and Taha, M.G. (2022) "Supplier innovativeness in supply chain integration and sustainable performance in the hotel industry," *International Journal of Hospitality Management*, 100. doi:10.1016/j.ijhm.2021.103103.

Flynn, B.B., Huo, B. and Zhao, X. (2010) "The impact of supply chain integration on performance: A contingency and configuration approach," *Journal of Operations*

Management, 28(1), pp. 58–71. doi:10.1016/j.jom.2009.06.001.

Freije, I., de la Calle, A. and Ugarte, J. V. (2021) "Role of supply chain integration in the product innovation capability of servitized manufacturing companies," *Technovation* [Preprint], (xxxx). doi:10.1016/j.technovation.2020.102216.

Gölgeci, I. and Ponomarov, S.Y. (2015) "How does firm innovativeness enable supply chain resilience? The moderating role of supply uncertainty and interdependence," *Technology Analysis and Strategic Management*, 27(3), pp. 267–282. doi:10.1080/09537325.2014.971003.

Groebner, D.F. *et al.* (2011) "Business Statistics: A Decision Making Aproach. 8th ur." New Jersey: Pearson Education, Inc.

Hair, J.F., Sarstedt, M. and Ringle, C.M. (2014) *A PRIMER ON PARTIAL LEAST SQUARES STRUCTURAL EQUATION MODELING (PLS-SEM)*. SAGE Publications. doi:10.1007/978-3-319-05542-8_15-2.

Hohenstein, N.-O. *et al.* (2015) "Research on the phenomenon of supply chain resilience," *International Journal of Physical Distribution & Logistics Management*. Edited by P. Maria Jesus Saenz and D. Xenophon Koufteros, 45(1/2), pp. 90–117. doi:10.1108/IJPDLM-05-2013-0128.

Huo, B. (2012) "The impact of supply chain integration on firm performance: An organizational capability perspective," *Supply Chain Management*, 17(6), pp. 596–610. doi:10.1108/13598541211269210.

Iftikhar, A., Purvis, L. and Giannoccaro, I. (2021) "A meta-analytical review of antecedents and outcomes of firm resilience," *Journal of Business Research*, 135(June), pp. 408–425. doi:10.1016/j.jbusres.2021.06.048.

Jajja, M.S.S., Chatha, K.A. and Farooq, S. (2018) "Impact of supply chain risk on agility performance: Mediating role of supply chain integration," *International Journal of Production Economics*, 205(September), pp. 118–138. doi:10.1016/j.ijpe.2018.08.032.

Jüttner, U. and Maklan, S. (2011) "Supply chain resilience in the global financial crisis: an empirical study," *Supply Chain Management: An International Journal*, 16(4), pp. 246–259. doi:10.1108/13598541111139062.

KEMENPERIN (2013) *Banjir, Industri Merugi Triliunan Rupiah*.

Kilpatrick & Bartet (2020) "Supply-Chain_POV_EN_FINAL-AODA.pdf," *Deloitte* [Preprint]. Available at: https://www.reuters.com/article/us-china-health-doctor-exclusive/exclusive-coronavirus-outbreak-may-be-.

Leuschner, R., Rogers, D.S. and Charvet, F.F. (2013) "A meta-analysis of supply chain integration and firm performance," *Journal of Supply Chain Management*, 49(2), pp. 34–57. doi:10.1111/jscm.12013.

Lii, P. and Kuo, F.I. (2016) "Innovation-oriented supply chain integration for combined competitiveness and firm performance," *International Journal of Production Economics*, pp. 142–155. doi:10.1016/j.ijpe.2016.01.018.

Liu, C.L. and Lee, M.Y. (2018) "Integration, supply chain resilience, and service performance in third-party logistics providers," *International Journal of Logistics Management*, 29(1), pp. 5–21. doi:10.1108/IJLM-11-2016-0283.

Mentzer, J. *et al.* (2001) "Defining Supply Chain Management," *Journal of Business Logistics*, 22. doi:10.1002/j.2158-1592.2001.tb00001.x.

Munir, M. *et al.* (2020) "Supply chain risk management and operational performance: The enabling role of supply chain integration," *International Journal of Production Economics*, 227(February), p. 107667. doi:10.1016/j.ijpe.2020.107667.

Näslund, D. and Hulthen, H. (2012) "Supply chain management integration: A critical analysis," *Benchmarking*, 19(4), pp. 481–501. doi:10.1108/14635771211257963.

Neely, A. (2007) *Business Performance Measurement: Unifying Theory and Integrating Practice*. Cambridge University Press. Available at: https://books.google.co.id/books?id=EnFsx6svfL8C.

Ponomarov, S.Y. and Holcomb, M.C. (2009) "Understanding the concept of supply chain resilience," *The International Journal of Logistics Management*, 20(1), pp. 124–143. doi:10.1108/09574090910954873.

Pujawan, I.N. (2017) *Mahendrawathi*, *Supply Chain Management*.

Render Heizer, Jay., B. (2004) *Principles of operations management*. Upper Saddle River, N.J.: Pearson/Prentice Hall.

Rungtusanatham, M. and Salvador, F. (2003) "Supply-chain linkages and operational performance A resource-based-view perspective 1084," *International Journal of Operations & Production Management*, 23(9). doi:10.1108/01443570310491783.

Siagian, H., Tarigan, Z.J.H. and Jie, F. (2021) "Supply chain integration enables resilience, flexibility, and innovation to improve business performance in covid-19 era," *Sustainability (Switzerland)*, 13(9), pp. 1–19. doi:10.3390/su13094669.

Stevens, G. (1989) "International Journal of Physical Distribution & Logistics Management Emerald Article: Integrating the Supply Chain," *International Journal of Physical Distribution & Logistics Management*, 19(8), pp. 3–8.

Tarigan, Z.J.H., Siagian, H. and Jie, F. (2021) "Impact of internal integration, supply chain partnership, supply chain agility, and supply chain resilience on sustainable advantage," *Sustainability (Switzerland)*, 13(10). doi:10.3390/su13105460.

Vitasek, K. (2016) *Map your way to an effective sourcing strategy*, *CSCMPs Supply Chain Quarterly*. Available at: https://www.supplychainquarterly.com/articles/1278-map-your-way-to-an-effective-sourcing-strategy (Accessed: January 5, 2022).

Wieland, A. and Wallenburg, C.M. (2013) "The influence of relational competencies on supply chain resilience: A relational view," *International Journal of Physical Distribution and Logistics Management*, 43(4), pp. 300–320. doi:10.1108/IJPDLM-08-2012-0243.

Yew, C., Boon-itt, S. and Wong, C.W.Y. (2011) "The contingency effects of environmental uncertainty on the relationship between supply chain integration and operational performance," *Journal of Operations Management*, 29(6), pp. 604–615. doi:10.1016/j.jom.2011.01.003.

Yu, W. *et al.* (2013) "The effects of supply chain integration on customer satisfaction and financial performance: An organizational learning perspective," *International Journal of Production Economics*, 146(1), pp. 346–358. doi:10.1016/j.ijpe.2013.07.023.

Yu, W. *et al.* (2019) "Dynamism, disruption orientation, and resilience in the supply chain and the impacts on financial performance: A dynamic capabilities perspective," *International Journal of Production Economics*, 218(July), pp. 352–362. doi:10.1016/j.ijpe.2019.07.013.

Zhang, M. and Huo, B. (2013) "The impact of dependence and trust on supply chain integration," *International Journal of Physical Distribution and Logistics Management*, 43(7), pp. 544–563. doi:10.1108/IJPDLM-10-2011-0171.

Zhuo, N., Ji, C. and Yin, N. (2021) "Supply chain integration and resilience in China's pig sector: case study evidences from emerging institutional arrangements," *Environmental Science and Pollution Research*, 28(7), pp. 8310–8322. doi:10.1007/s11356-020-11130-2.

GREEN SUPPLY CHAIN MANAGEMENT IMPLEMENTATION IN CONSTRUCTION PROJECTS

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ABSTRACT

In the green construction era, construction process should focus on environmental aspects including supply chain management system. Green Supply Chain Management (GSCM) in construction projects is one aspect of sustainable construction that will contribute to the efficiency of a construction process. Therefore, the study aims to identify the most dominant GSCM indicators and formulate strategies for optimizing the implementation of GSCM in construction projects. This research uses the Importance-Performance Analysis (IPA) method with the interpretation of IPA in the form of a graph with four quadrants showing the level of importance and performance. The results showed that the dominant/influential indicators in the application of GSCM in construction projects are included in the facilitator variables of green practice, green design, green purchasing, green construction, and green recycling. The strategy for optimizing the implementation of GSCM in construction projects can be formulated, namely by conducting regular monitoring and evaluation of the efforts that have been made and establishing common concepts that can be carried out from the initial stage to the end of the construction project implementation with a focus on the main ideas that have been agreed upon by the stakeholders.

Keywords: Sustainable Construction, Green Supply Chain Management, Importance-Performance Analysis.

1. INTRODUCTION

Current green construction of infrastructure implementation not only focus on social and economic aspects but also on environmental aspects. This is very important to note because the supply chain's waste and emissions have become a substantial source of environmental issues such as global warming and acid rain (Bloemhof-Ruwaard, 1996). Supply chain management is seen as a more effective way to generate value for consumers and as an innovation tool for continuous improvement, as well as an integrated system to encourage industrial development and increase profitability (Pryke, 2009).

Sustainable construction was developed as part of the concept of sustainable development with the principle of meeting current needs without compromising future generations' needs (UK Parliament, 2005). A green construction supply chain will contribute to the efficiency of a construction process for strategic matters as a starting point for improving the achievement of green construction or sustainable construction. Green supply chain management entails traditional supply chain management practices that are integrated with environmental criteria (environmental) or

environmental problems in every product purchase decision, as well as long-term supplier relationships (Gilbert, 2000).

How is the development of Green Supply Chain Management (GSCM) in the construction area? Wang (2010), conducted a study of supplier selection by contractors based on the criteria level by the GSCM concept. In addition, Ojo et al. (2014) examined the obstacles that led to the implementation of GSCM in the construction sector. In Indonesia through the Minister of PUPR, Basuki stated that one of the focuses of the Ministry of PUPR is the utilization of the green construction supply chain, as a starting point for improving the realization of sustainable construction. This is due to the application of environmentally friendly processes at every stage. In addition, the green construction supply chain can also improve the quality of the construction products produced (Cakti, 2021).

Based on the description above, the research aims to identify the most dominant/influential of Green Supply Chain Management (GSCM) indicators on construction projects from the variable attributes in GSCM Practice and formulate strategies to optimize the implementation of GSCM in construction projects.

2. LITERATURE REVIEW

Gilbert in Diabat and Govindan (2011) describes Green Supply Chain Management (GSCM) as a process of entering environmental criteria or standards in a company's decision to purchase and long-term relationship with suppliers. In addition, Blanchard (2019) defines GSCM as a reference for controlling the source of raw materials for manufacturing, transportation and remanufacturing/recycling processes, which aims to increase the effect of construction project performance on the company's environment. According to several definitions of the green supply chain management, it is possible to conclude that the green supply chain in construction projects is an implementation that involves environmental concepts that include reducing, recycling, reusing, and replacing materials in the supply chain process. starting from the design, procurement, construction process, and operation to the demolition process.

Although construction project activities, in general, have used the best techniques, they always have negative implications for the environment efficiently. The existence of Green Supply Chain Management (GSCM) needs to be implemented to limit waste in the construction project system to save energy and prevent the dissipation of materials that are harmful to the environment. The focus of GSCM when it began to be developed was on descriptive work and good practice elements such as construction awareness, understanding the theory of basic mechanisms to determine competitive improvement and improving the environment for improving GSCM relationships and practices. So that GSCM is also defined as supply chain management to lessen the environmental impact of industrial supply chain activities (Sarkis, Spiens, & Kovács, 2012).

Every activity carried out by the company can harm the environment, therefore the company applies GSCM practices (Balasubramanian & Shukla, 2017). According to Rostamzadeh et al. (2015), to reduce environmental impact, industries must implement green practices in their production processes and supply chains, since the environment is impacted at each stage of the manufacturing process (Walker et al., 2008). Balasubramanian and Shukla (2017), categorize GSCM practices as follows: the green design, purchasing, transportation, construction, and end-of-life management. Shurrab et al. (2019) divide GSCM practices as green practices, energy and water conservation, facilitating green practices, environmental education, and green purchasing. Ali et al. (2019) divide GSCM practices as the green design, procurement, production, warehousing, transportation, and recycling.

Table 1. Green Supply Chain Management (GSCM) practices

No	GSCM Practice	Source
	Green Design	(Balasubramanian & Shukla, 2017); (Shurrab dkk., 2019); (Ali dkk., 2019)
1	Provision for natural ventilation (GD1)	(Balasubramanian & Shukla, 2017)
2	Provision for natural lightning (GD2)	(Balasubramanian & Shukla, 2017)
3	Integration of photovoltaic panels (GD3)	(Balasubramanian & Shukla, 2017); (Shurrab dkk., 2019)
4	Consideration for an energy-efficient lighting system (GD4)	(Balasubramanian & Shukla, 2017); (Shurrab dkk., 2019)
5	Consideration for energy-efficient Heating, Ventilation and Air-Conditioning (HVAC) systems (GD5)	(Balasubramanian & Shukla, 2017); (Shurrab dkk., 2019)
6	Consideration of materials with high recycled content (GD6)	(Balasubramanian & Shukla, 2017); (Balasubramanian & Shukla, 2017); (Mitra, 2014)
7	Consideration of materials with low embodied energy (GD7)	(Balasubramanian & Shukla, 2017)
8	Provision for the use of prefabricated components (GD8)	(Balasubramanian & Shukla, 2017); (Mitra, 2014)
9	Consideration to reduce the use of hazardous materials (GD9)	(Balasubramanian & Shukla, 2017); (Mitra, 2014)
10	Provision for wastewater recycling systems (GD10)	(Balasubramanian & Shukla, 2017); (Mitra, 2014)
	Green Purchasing	(Balasubramanian & Shukla, 2017); (Shurrab dkk., 2019); (Ali dkk., 2019)
11	Purchasing recycled material (GP1)	(Balasubramanian & Shukla, 2017)
12	Purchasing nontoxic material (GP2)	(Balasubramanian & Shukla, 2017)
13	Purchasing eco-labeled material (GP3)	(Zhu dkk., 2005)
14	Suppliers must apply environmental management system (EMS) to take part in tenders (GP4)	(Balasubramanian & Shukla, 2017); (Ali dkk., 2019)

15	Suppliers must have ISO 14001 certification to take part in tenders (GP5)	(Balasubramanian & Shukla, 2017); (Zhu dkk., 2005)
16	Suppliers must have previous experience in providing green material to take part in tenders (GP6)	(Balasubramanian & Shukla, 2017)
17	Cooperation with suppliers for environmental objectives (GP7)	(Zhu dkk., 2005)
	Green Transportation	(Balasubramanian & Shukla, 2017); (Ali dkk., 2019)
18	Provision of accommodation to employees near project sites (GT1)	(Balasubramanian & Shukla, 2017)
19	Use of video conferencing (GT2)	(Zhu & Sarkis, 2007)
20	Employees are pushed to use public transport and shared transport (GT3)	(Balasubramanian & Shukla, 2017)
21	Materials are transported in full truckload quantities (GT4)	(Balasubramanian & Shukla, 2017)
22	Materials are transported in fuel-efficient vehicles (GT5)	(Balasubramanian & Shukla, 2017)
	Green Warehousing	(Ali dkk., 2019)
23	Effectively sell off used products and scrap components (GW1)	(Ali dkk., 2019)
24	Effectively sell excess capital equipment (GW2)	(Ali dkk., 2019)
	Green Construction	(Balasubramanian & Shukla, 2017); (Shurrab dkk., 2019); (Ali dkk., 2019)
25	Comprehensive waste management plan for projects (GC1)	(Balasubramanian & Shukla, 2017); (Shurrab dkk., 2019)
26	Use of prefabricated components in projects (GC2)	(Balasubramanian & Shukla, 2017); (Shurrab dkk., 2019)
27	Use of materials with low embodied energy and high recycled content (GC3)	(Balasubramanian & Shukla, 2017)
28	Reducing the use of hazardous materials (GC4)	(Balasubramanian & Shukla, 2017)

29	Automation is used for on-site construction (GC5)	(Balasubramanian & Shukla, 2017)
30	Fuel-efficient equipment/machinery are used in projects (GC6)	(Balasubramanian & Shukla, 2017); (Shurrab dkk., 2019)
31	Implementation of wastewater recycling technology (GC7)	(Shurrab dkk., 2019)
	Green Recycling	(Balasubramanian & Shukla, 2017); (Ali dkk., 2019)
32	Recover scrap from projects at the end of their lifecycle (GR1)	(Ali dkk., 2019)
33	Utilize waste produced by others in an innovative, useful, and effective way (GR2)	(Ali dkk., 2019)
34	Environmental impact assessment during end-of-life demolition of projects (GR3)	(Balasubramanian & Shukla, 2017)
35	Materials from demolished projects are recycled (GR4)	(Balasubramanian & Shukla, 2017)
	Facilitating Green Practices	(Balasubramanian & Shukla, 2017); (Shurrab dkk., 2019)
36	EMS & ISO Certification (FGC1)	(Balasubramanian & Shukla, 2017); (Shurrab dkk., 2019)
37	Environmental training (FGC2)	(Balasubramanian & Shukla, 2017); (Shurrab dkk., 2019)
38	Environmental auditing (FGC3)	(Balasubramanian & Shukla, 2017)
39	Green-related research and development (FGC4)	(Balasubramanian & Shukla, 2017)

3. METHODS

Based on the explanation of the background and the research, this study aimed to identify the most dominant/influential green supply chain management indicators on construction projects from variable attributes in GSCM Practice. descriptive research was conducted by compiling literature review, research questionnaires, and interview respondents on a construction project in Jakarta carried out by the state-owned construction company 59 respondents were involved in distributing the questionnaire, and 5 of 59 will conduct semi-structured interviews to formulate strategies to optimize GSCM attributes.

Based on the respondent's role in the project, 6 out of 59 respondents were Project Manager (PM), 6 out of 59 respondents were Site Engineering Manager (SEM), 6 out of 59 respondents were

Site Operation Manager (SOM), 4 out of 59 respondents were Site Administrative Manager (SAM), and 37 out of 59 respondents were staff engineers who are involved and understand supply chain management on a construction project. Based on the length of the respondent's involvement, there are 18 of 59 respondents < 5 years who have experience in construction companies, 17 of 59 who have experience for 5-10 years, 15 of 59 respondents who have experience for 10-15 years, and 9 out of 59 who work >15 years. Finally, based on the educational background of the respondents, 1 of 59 respondents is D3, 55 of 59 respondents is S1, and 3 of 59 respondents is S2.

The method used in this research is the Importance-Performance Analysis (IPA). This method displays a scatter plot from the Importance-Performance analysis with criteria in 4 quadrants. Importance-Performance Analysis uses a interval scale that adopted from Likert scale, using five ratings, each of which is given a importance level score on a scale of 1 (very unimportant) – 5 (very important), and a performance level score on a scale of 1 (very dissatisfied) – 5 (very satisfied). Furthermore, the Importance-Performance Matrix examines the average value of importance and performance, where the x-axis represents performance while the y-axis represents importance.



Figure 1. Cartesian importance-performance analysis quadrant

The Importance-Performance Analysis (IPA) interpretation presented in the graph has four quadrants, the Y (Importance) axis shows the consumers' perceived importance of the selected attributes, and the X (Performance) axis shows the performance in relation to the attributes.

4. RESULTS

Data analysis is carried out based on questionnaires that have been collected from construction projects of state-owned construction companies that have implemented sustainable construction. Of the 59 respondents, 43 knew about Green Supply Chain Management (73% respondent rate), and 16 respondents (27% respondent rate) did not know about Green Supply Chain Management. According to the validity test results, it is known that from 39 attributes there are two invalid attributes, namely GD3 and GT1, so both attributes were omitted. The 37 attributes of the GSCM variable will be tested using Importance-Performance Analysis.

Overall, the GAP Importance – Performance of the GSCM attributes can be concluded as follows:

Table 2. Importance and performance score

Attribute	Performance	Importance	Satisfaction (GAP)
FGC2	3,86	4,20	-0,34
GD1	3,97	4,29	-0,32
GD2	4,00	4,31	-0,31
FGC4	3,73	4,03	-0,31
GP3	3,92	4,19	-0,27
GD9	4,07	4,34	-0,27
GD4	3,92	4,17	-0,25
GC4	3,95	4,20	-0,25
FGC3	3,88	4,14	-0,25
GR3	3,75	3,98	-0,24
GD5	3,78	4,02	-0,24
GD10	3,80	4,02	-0,22
FGC1	3,90	4,10	-0,20
GC7	3,76	3,95	-0,19
GP2	4,03	4,19	-0,15
GD6	3,90	4,05	-0,15
GP4	3,92	4,03	-0,12
GR2	3,71	3,83	-0,12
GP5	4,07	4,17	-0,10
GC1	3,90	4,00	-0,10
GC3	3,90	4,00	-0,10
GC5	3,78	3,88	-0,10
GR1	3,80	3,86	-0,07
GP6	3,93	3,98	-0,05
GD8	4,03	4,07	-0,03
GD7	3,83	3,85	-0,02
GP1	3,56	3,58	-0,02
GP7	3,93	3,95	-0,02
GR4	3,90	3,92	-0,02
GC2	3,95	3,95	0,00
GC6	3,85	3,85	0,00
GT2	3,95	3,92	0,03
GT4	3,98	3,93	0,05
GT5	3,80	3,73	0,07
GW1	3,66	3,58	0,08
GW2	3,76	3,49	0,27
GT3	3,80	3,47	0,32

According to the table above, found that 29 attributes have negative values, which means that each of these attributes fallen short of expectations. Further analysis of these data is required to define the priority in the improvement effort for each existing attribute. The way to determine the current improvement priority scale is to use the Importance Performance Analysis (IPA) (as shown in Fig 2.) will be mapped into four quadrants.

After determining each attribute's position on the Importance-Performance diagram, a policy related to improvement priorities is then formed to improve GSCM Practice. The 37 GSCM Practice attributes used to assess user satisfaction are distributed across four quadrants. There are five attributes in quadrant I, 16 in quadrant II, 11 in quadrant III, and 5 in quadrant IV. However, the attribute distribution is dominated in quadrants 2 and 3. The following is the distribution of performance and importance data:

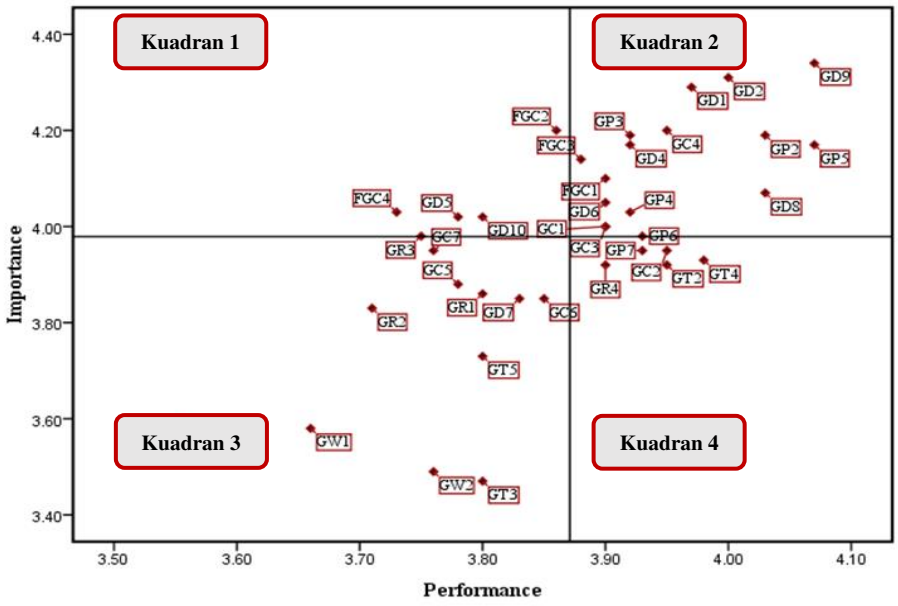


Figure 2. Important-Performance matrix result

- **Quadrant I – Concentrate Here** (GD5, GD10, GR3, FGC2, and FGC4): Attributes play an important role, but the level of performance is considered quite low. Attributes that fall into this quadrant must be improved by the way the company must make continuous improvements to enhance performance.
- **Quadrant II – Keep Up the Good Work** (GD1, GD2, GD4, GD6, GD8, GD9, GP2, GP3, GP4, GP5, GP6, GC1, GC3, GC4, FGC1, and FGC3): Attributes play an important role and have a high level of performance. Items in this quadrant support satisfaction, so it is mandatory to maintain performance achievements on construction projects.
- **Quadrant III – Low Priority** (GD7, GP1, GT3, GT5, GW1, GW2, GC5, GC6, GC7, GT1, and GR2): Attributes have a low level of importance and performance and are not a priority for project implementation.
- **Quadrant IV – Possible Overkill** (GP7, GT2, GT4, GC2, GR4): Attributes have low importance, and performance is too high, so key personnel consider reducing it to save costs.

When viewed from previous research, every company's activity can harm the environment. Therefore, the company applies GSCM practices (Balasubramanian, 2014). To reduce environmental impacts, industries must implement green practices in their manufacturing processes and supply chains (Rostamzadeh et al., 2015). The environment is impacted at each stage of the manufacturing process (Walker et al., 2008). Green design is an activity carried out to lessen the negative environmental impact of products and services over their lifetime (Rostamzadeh et al., 2015). The green design takes place from the point of purchase of materials which is part of the plan, how to manufacture products, and how to dispose of expired products. Ali et al. (2019), as also seen in the results of the green design attribute analysis (GD1, GD2, GD4, GD6, GD8, GD9) entered in quadrant II, which means attributes play an important role and have a high level of performance.

Green Purchasing is a practice in which stakeholders buy environmentally friendly materials, such as those that have the following characteristics: lack of hazardous materials, recyclability, and

reusability (Rostamzadeh et al., 2015). In addition, in the concept of sustainability it is necessary to pay attention to the process of purchasing materials with green buying starting from cost, quality, and reliability (Eltayeb et al., 2011). As also seen in the results of the green purchasing attribute analysis (GP2, GP3, GP4, GP5, GP6) entered in quadrant II which means attributes play an important role and have a high level of performance. In addition, the explanation of the concept of green transportation in the construction industry is intended to reduce the negative effects on the environment due to transportation activities (Bre, 2003). Ng et al. (2012) describes the transportation of materials as the initial amount of 6-8% carbon generated during construction, with GT1 results Provision of accommodation for employees close to the project site in quadrant II which explains that the attributes are important and have high performance.

From the results of Fig. 2 obtained, several attributes of the GSCM Practice variable have satisfaction minus (GAP) in quadrant I, which means there needs to be an increase in performance on attributes. So that the expected result of this research is to be able to formulate a strategy for optimizing the attributes of the GSCM variable. The evaluation of the Importance Performance Analysis results that have been obtained becomes a literature of semi-structured interviews with five expert respondents (PM/SEM/SOM/SAM) to formulate the most feasible optimization strategy for GSCM implementation carried out to improve the performance of GSCM Practice attributes so that GSCM attributes in construction projects are more optimal. Based on the results of interviews related to the strategies presented by the expert respondents, it can be seen that the consistency and commitment of the workers to carry out the concepts and goals that have been established, is the main theme. The next theme, the need for a unified vision of the project team is important in pursuing a strategy for launching ideas/concepts related to green supply chain management (GSCM).

6. CONCLUSIONS

Based on the Cartesian diagram of importance and performance analysis on the GSCM Practice variable, it can be seen what attributes are considered to be the most dominant/influential attributes of green supply chain management (GSCM). The indicators that are considered the most dominant/influential are seen from the results of the above-average attribute importance, the attributes included in the variables facilitating green practice, green design, green purchasing, green construction and green recycling. These attributes reflect the main indicators that are dominant/influential in the application of green supply chain management in construction projects. The strategy for optimizing the implementation of GSCM in construction projects can be formulated, namely by conducting regular monitoring and evaluation of the efforts that have been made and establishing common concepts that can be carried out from the initial stage to the end of the construction project implementation with a focus on the main ideas that have been agreed upon by the stakeholders.

7. REFERENCES

Ali, Y., Saad, T. bin, Sabir, M., Muhammad, N., Salman, A., & Zeb, K. (2019). Integration of green supply chain management practices in construction supply chain of CPEC. *Management of Environmental Quality: An International Journal* 31 (1), 185–200.

Balasubramanian, S. (2014). A structural analysis of green supply chain management enablers in the UAE construction sector. *International Journal of Logistics Systems and Management* 19 (2).

Balasubramanian, S., & Shukla, V. (2017). Green supply chain management: an empirical investigation on the construction sector. In *Supply Chain Management* 22 (1).

Blanchard, D. (2019). Supply Chain Management Best Practices: Best Practices. In *EAI/Springer Innovations in Communication and Computing*.

Bloemhof-Ruwaard, J. (1996). *Integration of Operational Research and Environmental Management* 229.
Bre. (2003). *Construction Site Transport*. Department of Trade and Industry: UK.
Cakti, A. (2021). Menteri PUPR Tekankan Pentingnya Rantai Pasok Konstruksi Hijau. *Antara*.
Diabat, A., & Govindan, K. (2011). An analysis of the drivers affecting the implementation of green supply chain management. *Resources, Conservation and Recycling* 55, 659–667.
Eltayeb, T. K., Zailani, S., & Ramayah, T. (2011). Green supply chain initiatives among certified companies in Malaysia and environmental sustainability: Investigating the outcomes. *Resources, Conservation and Recycling* 55 (5), 495–506.
Gilbert, S. (2000). *Greening supply chain: Enhancing competitiveness through green productivity.* (25th-27 May, ed.). Report of the Top Forum on Enhancing Competitiveness through Green Productivity held in the Republic of China.
Mitra, S. (2014). A Framework for Research on Green Supply Chain Management. *Supply Chain Forum: An International Journal* 15 (1), 34–51.
Ng, S. T., Wong, J. M. W., Skitmore, S., & Veronika, A. (2012). Carbon dioxide reduction in the building life cycle: A critical review. *Proceedings of the Institution of Civil Engineers: Engineering Sustainability* 165 (4), 281–292.
Ojo, E., Mbowa, C., & Akinlabi, E. (2014). Barriers in Implementing Green Supply Chain Management in Construction industry. *Iieom.Org*, 1974–1981.
Pryke, S. (2009). *Construction Supply Chain Management*. United Kingdom: Wiley-Blackwell.
Rostamzadeh, R., Govindan, K., Esmaeili, A., & Sabaghi, M. (2015). Application of fuzzy VIKOR for evaluation of green supply chain management practices. *Ecological Indicators* 49, 188–203.
Shurrab, J., Hussain, M., & Khan, M. (2019). Green and sustainable practices in the construction industry: A confirmatory factor analysis approach. *Engineering, Construction and Architectural Management*, 26 (6).
UK Parliament. (2005). Securing the future delivering UK sustainable development strategy. In *CM6467, London* 13 (6).
Walker, H., di Sisto, L., & McBain, D. (2008). Drivers and barriers to environmental supply chain management practices: Lessons from the public and private sectors. *Journal of Purchasing and Supply Management* 14 (1), 69–85.
Wang, D. (2010). Constriction of supplier selection criterion system of green supply chain. *ICLEM 2010: Logistics for Sustained Economic Development - Infrastructure, Information, Integration - Proceedings of the 2010 International Conference of Logistics Engineering and Management*, 387.
Zhu, Q., & Sarkis, J. (2007). The moderating effects of institutional pressures on emergent green supply chain practices and performance. *International Journal of Production Research*, 45, 18–19.
Zhu, Q., Sarkis, J., & Geng, Y. (2005). Green supply chain management in China: Pressures, practices and performance. *International Journal of Operations and Production Management*, 25 (5).

MULTI-INFORMATION DISPLAY (MID) INNOVATION FOR E-SCOOTER IN USER CONVENIENCE PERSPECTIVE

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ABSTRACT

The development of the transportation revolution from fossil fuels to electric vehicles accompanied by advances in digital technology has become a new requirement for one of the components in e-scooter, such as Multi-Information Display (MID). Multi-Information Display is an instrument panel that has an important role in a vehicle because there is a variety of information needed to stay safe while driving. The amount of information contained in the Multi-Information Display requires a good interface design to be easily read by the driver. As in the current Multi-Information Display of GESITS First Generation e-scooter. It has a fairly complex and unorganized sequence of information arrangement. From these problems, research was carried out by designing user interface on the Multi-Information Display of e-scooter to optimize user convenience while driving. This research uses Five Stages Design Thinking model which consists of empathize, define, ideate, prototype, and test. The test uses a feedback capture grid, convenience parameter score and System Usability Scale. This research found that user convenience parameters on a Multi-Information Display are including accuracy, safety, and reminder. Innovations are made with several features added and updated based on user preferences and needs. These features are then adapted to existing features and designed into a new Prototype Multi-Information Display interface that will increase user convenience in driving.

Keywords: Design Thinking, E-scooter, Human Machine Interface, Multi-Information Display, User Convenience, User Interface.

1. INTRODUCTION

The development of the revolution from fossil fuels to electric vehicles accompanied by advances in digital technology has become a new requirement for one of the components in electric motorcycles, namely Multi-Information Display (MID). Multi-information display is a product implementation of Human Machine Interface (HMI) in the automotive sector. This display system is attached to a combination meter to display various information which is going to make it easier for the driver to know the condition of the vehicle. Multi-Information Display on the instrument panel displays various information and messages when the ignition is in the ON position. Multiple messages help users operate the vehicle more comfortably. In addition, the information contained in the Multi-Information Display helps to let the driver know the periodic maintenance that the vehicle needs to be able to drive trouble-free.

The arrangement of information on the Multi-Information Display of GESITS First Generation e-scooter is very large and quite complex also has an irregular sequence of information. In addition, the display area does not fit with the frame on the motorcycle dashboard, giving the impression that it was affixed. Interface of Multi-Information Display also still looks less futuristic. It is not enough to represent the E-Scooter product which is one of the technologies of the future.

Previous research on the interface of Multi-Information Display, which is also commonly called as Speedometer, focused on psychological perspective. Bahalwan (2018) conducted a design psychology study related to the Motorcycle Speedometer interface design and the influence of the way people drive. This research was conducted to determine the psychological influence of the speedometer interface design of an automatic motorcycle in Indonesia. The research method used is the Brunswik's Lens Model and gestalt psychology as a basic reference for studying the psychology of users when using an automatic motorcycle on a daily basis. The results of this study indicate that the design of the existing automatic motorcycle speedometer greatly affects the user while driving. Due to the speedometer design which interprets the user to drive his vehicle at high speed, it is necessary to add a reminder to the motorbike speedometer, in the form of sound and vibration, if the user has driven the vehicle at a speed beyond normal limits.

Based on this, this research was conducted to analyze the factors that influence user convenience while using Multi-Information Display, specifically about the interface, that requires more attention. These factors then become the basic idea to make new design interface for Multi-Information Display of E-Scooter that will be suit to user convenience. Francois (2017) said that Human–machine interface design has moved from technology-centered and feature-driven approaches to human-centered design approaches. Among human-centered approaches, user-centered design (i.e. considering the users' perspective to achieve a usable system) has become the standard for automotive HMI design. That is why in this research Design thinking model is used because the perspective of design thinking can be considered as wider than the one of human centered design. Design thinking focuses on innovation and creation and is about a way of thinking for developing new products, services and solutions for social problems that match with the objectives of this research.

In the end, this research is providing a new perspective in designing Multi-Information Display with an approach that develops and provides potential recommendations and implementations of Multi-Information Display that is more in line with the needs of user nowadays.

2. LITERATURE REVIEW

A number of study have been conducted on automotive Human Machine Interface (HMI). Various HMI implementation have been studied, such as Head-Up Display (HUD), while research on MID/speedometer design, specifically for motorcycle, is very limited. most of the existing research discusses HUDs in cars which don't really discuss about interface design. The term MID is actually quite commonly used to indicate a part of a vehicle that has a lot of vehicle-related information. MID is a display system that is attached to a combination meter, to display various information. The display can be LCD (liquid crystal display) or dot MID. This system will make it easier for drivers to know driving conditions (Susanto, 2019). Multi-information display is a product of the application of the Human Machine Interface (HMI) in the automotive sector. HMI is a system that connects human and machine technology, through an interface that allows us to interact with digital systems. The use of the Human Machine Interface (HMI) on the Multi-

information display of electric vehicles allows drivers to see energy consumption in real time based on how much they accelerate the vehicle.

Research on HMI has been conducted in a number ways in terms of implementation, as done by Aziz (2016) who designed an interface system based on the human-machine interface (HMI) on the auto cow feeder machine plant model. The plant does not have a plant condition monitoring system so it is necessary to apply an HMI system. Testing of the monitoring system resulted that HMI was able to monitor the condition of the plant properly.

For designing MID, design thinking is used in this research like Razi (2018) who conducted a study to designing applications based on user target to facilitate the needs of information exchange on the case of lost and found for the urban community. This application model design acts as an intermediary in facilitating the needs of information exchange between the victims and the helper. This design uses design thinking method which consists of empathize, define, ideate, prototype and test.

Convenience is the state of being able to proceed something with little effort or difficulty. While drive a car, convenience become a must so we can drive safely. In addition to know further about user convenience, Spiteri (2018) conducted a research to explore the relationship between the principle of user convenience and social discovery systems. She found that Social discovery systems can address the primary barriers to creating catalogue records that meet user convenience: determining and reflecting the needs and cultural warrant of the users and maintaining the quality and integrity of the catalogue records. This research shows that user convenience perspective is needed to get design that not only match the user need but also make user feel convenience.

3. METHODS

In this research, the five stages Design Thinking model proposed by the Hasso-Plattner Institute of Design at Stanford (d.school) were used, namely: empathize, define, ideate, prototype, and test (Hasso, 2010). This model is used because it can be a reliable framework for designing things according to user needs, which in this case describes the process of designing a Multi-Information Display. In the steps carried out, the parameters/variables that affect convenience from the user's point of view will also be obtained and to measure how much influence changes in the Multi-Information Display user interface have on user convenience.

3.1 Participants

Twenty people (3 female, 17 male) participated as participants in this research that consist of two criteria, e-scooter users and general users (fossil-fueled vehicle). Participants ratio based on the criteria was 20% e-scooter users and 80% general users. This percentage is taken as a representation of the government's target in the electric vehicle ecosystem by 2025. The average age was 28,86 yr. Every participant had a legal driving license, at least 6 months of driving experience, and no visual impairments. 7 of the 20 participants then also become test participants consisting of two groups, those are two experts (1 expert on electric vehicle, 1 expert on UI/UX design) and five users (4 general users, 1 e-scooter user).

3.2 Instruments

MID simulator (designed in figma), google form (Feature Score, Convenience Parameter Score, and System Usability Scale), and smartphone device were used for this research. For in-depth interviews, 8 participants (40%) were interviewed indirectly (online) and 12 participants (60%) were interviewed in person. The overall duration of the interview was 18 hours 32 minutes with an average of 55 minutes per participant. During testing, 3 participants tested online and the

other 4 participants tested offline. The overall duration of the test was 5 hours 25 minutes with an average of 45 minutes per participant.

3.3 Procedure

The participants were first informed about the objectives of this research, namely, that it was intended to design a new kind of MID's interface that suit user convenience. For in-depth interview, 20 participants were shown the MID/speedometer according to the vehicle they are using and given brief information about the structure of the MID/speedometer. Then, they were asked questions about it and their preference when using the MID. Furthermore, for testing the prototype, 7 participants were trying to run the new MID interface using a simulator while giving questions or feedback using Feedback Capture Grid. Next, the participant gave an assessment related to MID through a google form that had been prepared.

4. RESULTS

4.1 User Convenience Parameter

In order to get the perspective of user convenience, In-Depth Interviews were conducted to determine the parameters that make users feel convenience when reading the MID. The results of the In-Depth Interviews were processed using affinity diagram. Affinity diagram is a tool used to organize ideas or data into diagrams in order to group ideas or data according to their relationships. The data then grouped into three, there are male fossil-fuel motorcycle user, female fossil-fuel motorcycle user, and e-scooter user. From the three groups of data were then analyzed to obtain the conclusion that the user convenience parameters that will be used in the design of the Multi-Information Display E-Scooter are: 1) accuracy, to show measurement values that are clearer, more detailed, and provide certainty to the user, 2) safety, to provide a sense of security in driving, and 3) reminder, to assist users in remembering under certain conditions. These three parameter points then become the key for designing the MID interface using the Design Thinking method which is carried out according to the existing stages.

4.2 Empathize

The first stage in design thinking is to empathize with user to be able to design a Multi-Information Display (MID) according to the user's needs. At this stage what is done is to observe what people do and how they interact with MID, provide clues about what they think and feel, learn about what they need. All of these things are then stated in the empathy map for e-scooter user and general user. Overall, they say that the speed indicator is used as a control function while driving and the energy usage indicator is the most important features. For general users, the pain when using the MID are a number of inaccurate indicators that cause energy to suddenly run out also the turn signal indicator shape and position confusing the rider. The gain is being contacted by customer service for free warranty service when the vehicle is new. As for e-scooter users, it's a hassle to read the MID because it's too complicated, there's a lot of information about the MID that users don't know how to do, runs out of battery power unexpectedly, and the MID looks old school. While the gain obtained is without reading the speed indicator, it is limited by the choice of driving mode. There's a quiet voice reminder when a turn signal is used so you can focus on driving.

Processing the results of interviews into the form of a user journey map which in this study is used to help determine the focal point of user needs in the design of the Multi-Information Display (MID) on e-scooter. The user journey map in this study is divided into two categories,

namely the user journey map for conventional motorcycle users and the user journey map for e-scooter users. The description of the two user journey maps are as follows.

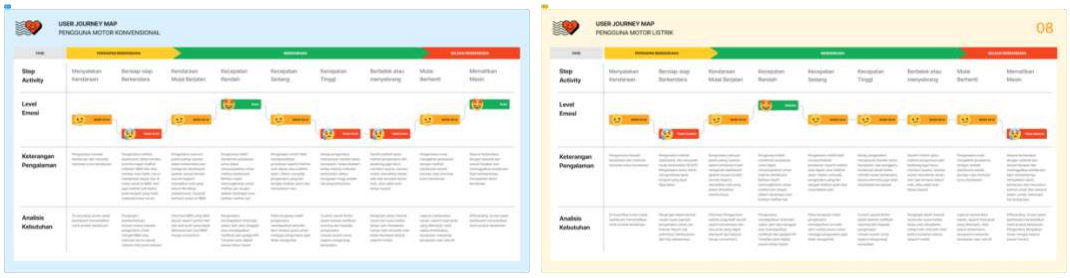


Figure 1. User Journey Map for: a) Conventional Motorcycle Users; b) E-Scooter Users

As seen in Figure 1, it can be concluded that there will be different experiences between conventional motorcycle users and e-scooter users in each stage of driving activity. The difference in experience tends to appear at the level of emotion felt by each user in each stage of driving activity. The results of this description of the user journey map are in the form of a needs analysis tailored to each description of the experience experienced by the user.

4.3 Define

The problem definition process is done by defining the problem based on the Point of View (PoV) Analysis obtained from the synthesis of the empathy map from each category of users. Based on PoV Analysis from users of conventional motorcycle and e-scooter, nine needs and insights are generally almost the same, such as the driver's need to know when to refill energy (fossil-fuel/Battery), get time information, the amount of remaining energy accurately, additional information (mobile phone notifications and maps), high speed limit reminders and turn signal lights, as well as detailed driving reports for further evaluation. For e-scooter users, there is a need for a reminder to recharge the battery after use. This PoV Analysis was then converted into a problem statement as outlined in the PoV Madlib and How Might We (HMW) Question which was then concluded as the problems faced by e-scooter users as follows:

1. How might we create information and time reminders to recharge the battery?
2. How might we make accurate battery percentage information with the remaining range?
3. How might we make time information, cellphone notifications, and maps more accessible?
4. How might we create a speed limit reminder/alarm?
5. How might we make the user to turn off the turn signal when not needed?
6. How might we make a driving information report?

4.4 Ideate

The ideas of the ideate stage are taken from the previous empathize and define stages. In the ideate stage, a brainstorming process is carried out which then the results of the brainstorming are described in the form of a post-it board. The results of the brainstorming of researchers obtained from answering the conclusions of the HMW Question in the define stage were 38 ideas. In addition, 21 ideas were also obtained from respondents during interviews. Of all the ideas that come in, not all can be implemented in the MID, some can be used as additional features in supporting applications.

After being curated, there are 14 main ideas that will be included in the MID as additional features and improvements. Some of them are the reminder feature and information about the estimated battery recharge time via voice on the MID dashboard; Converts battery percentage to

remaining distance as a number, progress bar, timer, or sound on the MID; Display date, day, and time on the MID; Pop-up notifications for calls and WhatsApp from Smartphones in the MID; MID can be used for the map feature with the settings of the smartphone; Speed limit reminder in the form of sound, vibrate coming out of the MID; as well as a turn signal reminder through the sound coming out of the vehicle/MID. Ideas that cannot be accommodated in the MID are proposed to be applied to mobile applications which are a support for more specific information and features.

The collected ideas are then adapted to the existing Multi-Information Display (MID) features and displays. Most of the main features will be retained. Some of the ideas collected earlier will be selected and become new features or improvements of existing features on the current Multi-Information Display (MID).

Table 1. New Features of Multi-Information Display

No	New Feature	Function
1	Charge Reminder	Provide reminders in the form of sound and notifications to recharge the battery
2	Speed limiter	Provide speed limit information according to the needs of the driver (customize) in each driving mode
3	Maps Direction	View mirroring maps from the Mobile application
4	Phone Notification	Incoming notifications from the driver's smartphone
5	Cycle Count	The number of battery charge cycles
6	Battery Health	Battery health information

4.5 Prototype

A prototype was subsequently designed so that an application design would be more interactive when tested and used to users later. Furthermore, the MID will be grouped into three types of modes based on the level of information complexity and the needs of the user. The three modes are Default, Intermediate, and Advance modes. To support this, a switcher button (physical button) is needed to change the type of information display on the MID.

The design style used in this MID design is Neumorphism which is Costa (2020) stated as a new approach to the Skeumorphism design style combined with the Flat Design concept. This interface concept was chosen because it has a modern and functional impression. At the prototype stage, after creating the user flow, a rough design in the form of a wireframe is also needed to see a more detailed user flow scenario, which will then be used as a bridge in exploring the form of the MID interface that will be generated as seen in Figure 2. The prototype generated from the wireframe shown in Figure 3 is ready for testing.

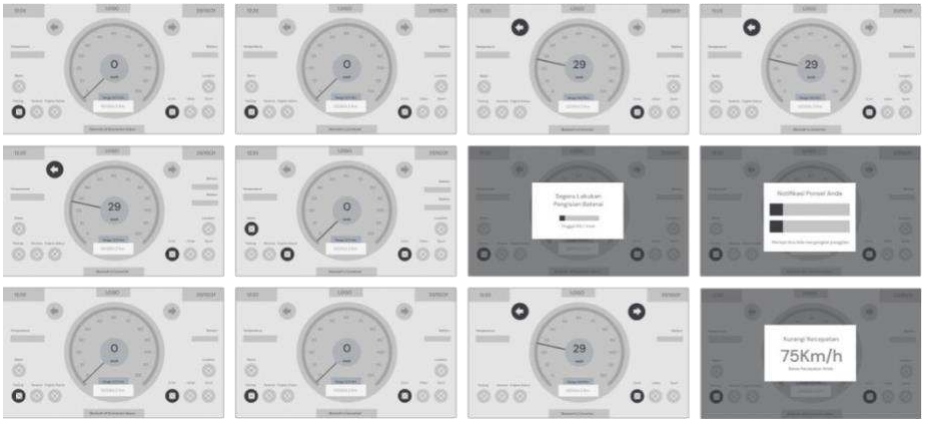


Figure 2. Wireframe Interface Multi-Information Display



Figure 3. Prototype Interface Multi-Information Display

4.6 Test

This research uses two different methods according to the group of participants who take part in the test, those are cognitive walkthrough for experts and usability testing for users. Salazar (2022) said that a cognitive walkthrough is a technique used to evaluate the learnability of a system from the perspective of a user. It relies on the expert who walk through a task and assess the interface from a user's point of view. In the other hand, usability testing is a method used to evaluating a product or service by testing it with representative users. This method is used for 5 participants, this number refers to Knapp (2017) which stated that 85% of the problems were observed after five interviews. More than that the pattern of answers tends to repeat itself. One thing that needs to be considered from the Usability Testing assessment is that the value measurement is carried out cumulatively for all users/respondents. Therefore, the results of testing with this method are in the form of accumulated numbers from the assessment of each user/respondent.

The feedback obtained from the expert are then processed using a feedback capture grid which shows that the two experts liked the results of the MID interface design. According to first expert, Battery Health and Cycle Count are very important features to see the health of the vehicle/battery so that having these features becomes a preferred point. Meanwhile, according to second expert, time information is not the main feature so it is necessary to check how large the display size can be (large, medium, small). As from user perspective, it can be concluded that all of them consider the MID interface to be very good, easy to understand and better than the previous interface. They also shared their favourite features, such as Range, Map Directions, and others. In addition, the five users also submitted several criticisms, questions, and ideas that can be used as the development of the MID interface such as safety when notification popups but other information are closed and MID interface design themes that can be changed.

Furthermore, the results of the Feature Score, Convenience Parameter Score, and System Usability Scale of each group of participants are shown in Table 2~4.

Table 2. Feature Score Test results

Feature Score (1-10)		Expert		User (avg)
		1st Expert	2nd Expert	
1	Speedometer	9	9	9.8
2	Energy Usage	10	9	8.6
3	Odometer	10	9	9.4
4	Range	10	4	10
5	Engine/Battery Temperature	10	8	9.4

6	Indicator (Turn Sign, Beam, Bluetooth, etc)	9	9	9.8
7	Additional Information (Cycle Count, Battery health)	9	9	9.6
8	Date & Time Information	10	6	10
9	Speed Limiter	9	8	8.4
10	Sound on Turn Sign	9	8	10
11	Hazard Light	8	9	10
12	Low Battery/Charge Reminder	9	9	9.6
13	Map Direction	8	7	9
14	Smartphone Notification	9	9	9.2
Final Score (avg)		**9.2**	**8.1**	**9.5**

Table 3. Convenience Parameter Score Test results

Convenience Parameter Score (1-10)		**Expert**		**User (avg)**
		1st Expert	**2nd Expert**	
1	Accuracy	10	9	8.8
2	Safety	9	9	9
3	Reminder	9	8	9
Final Score (avg)		**9.3**	**8.7**	**8.9**

Table 4. System Usability Scale test results

System Usability Scale (1-5)		**Expert**		**User (avg)**
		1st Expert	**2nd Expert**	
1	I think that I would like to use this MID frequently	4	3	3.6
2	I found this MID unnecessarily complex.	2	4	3.2
3	I thought this MID was easy to use.	4	3	3.6
4	I think that I would need the support of a technical person to be able to use MID.	3	3	3.4
5	I found the various functions in MID were well integrated.	4	3	3.6
6	I thought there was too much inconsistency in this MID.	3	4	3
7	I would imagine that most people would learn to use this MID very quickly.	4	1	3.8
8	I found this MID very cumbersome to use.	4	4	3.8
9	I felt very confident using this MID.	4	3	3.8
10	I needed to learn a lot of things before I could get going with this MID.	3	2	3.4
Final Score		**87.5**	**75**	**88**

Through the results of feature score test, it is found that the highest average score obtained from user that is 9.5, followed by 1st expert and 2nd expert, 9.2 and 8.1 respectively. Compared with the user and 1st expert, 2nd expert has different opinion about feature number 4 who suggested creating a more representative icon for the range feature. Meanwhile, from the results of convenience parameter score test, it is found that all participants gave a good score with an average above 8.

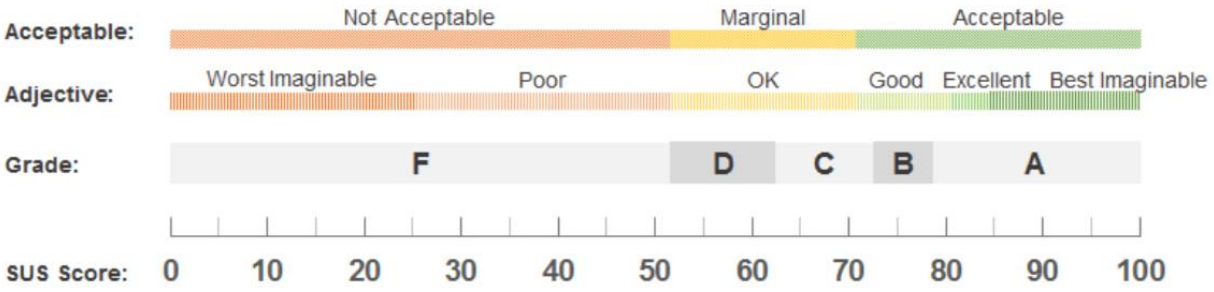


Figure 4. Grades, adjectives, acceptability associated with SUS scores

The results for System Usability Scale (SUS) test show that the final score obtained from 1st expert and user, which are close to each other, has a quite high score that is 87.5 and 88 out of 100 respectively. These scores then interpreted as seen in Figure 4, which based on the usability aspect, this prototype gets a grade A+, Best Imaginable category, and the level of acceptability is in the Acceptable category, which means this prototype is generally very accepted by users. In the other hand, lowest final score obtained from 2nd expert that is 75 out of 100, which is then interpreted based on the usability aspect, this prototype gets a grade B, Good category, and the level of acceptance is in the Acceptable category, which means this prototype is generally very accepted by users.

In general, the SUS score by both groups of participants (experts and user), gave a score above 68. The SUS score of 68 (grade C) has the percentile ranking at 50% which is the standard score for the interpretation of the SUS score. For this reason, a score above 68 if interpreted by the level of acceptability is in the marginally acceptable category which is above the average. This means that the final score is in the safe category (usability.gov), because if the score is below 68, it means that there are problems that affect the level of usability system. This System Usability Scale (SUS) can help determine if the system can be used properly or not, although it does not help determine problematic factors or features, while the determination of feature scores is interpreted through Feature Scores.

5. CONCLUSIONS

This research found that parameters regarding user convenience on a e-scooter Multi-Information Display include Accuracy, Safety, and Reminder. This parameter is a factor that becomes the main concern of the user in reading the Multi-Information Display. The development of the e-scooter Multi-Information Display feature is made based on convenience parameters according to the needs of the user, including Charge reminder, Speed limiter, Maps Direction, Phone Notification, Cycle Count, and Battery Health. The modified Multi-Information Display interface design is considered to be able to answer user problems from the current Multi-Information Display interface design with the results for System Usability Scale test gets a grade A+, Best Imaginable category, and the level of acceptability is in the Acceptable category, which means this prototype is generally very accepted by users.

In future work, the proposed interface design of MID can be visually adaptable to aspects of screen technology, type, and vehicle model. To answer the whole solution from the user's pain point, it is necessary to integrate the entire medium which includes not only the MID but such as innovation in the electric vehicle, IoT, or using additional devices such as supporting applications. Further research and development is needed for the mobile application medium as a supporting instrument in optimizing features on the E-Scooter. From the manufacturer's point of view, in

developing the MID on the E-Scooter, apart from considering the technological sophistication aspect, it also takes into account the aspect of the user's needs, in this case including three aspects of user convenience in the MID, namely Accuracy, Safety, and Reminder.

REFERENCES

Aprilia, I. (2015). Pengujian Usability Website Menggunakan System Usability Scale. IPTEK-KOM, 17(1), 31-38.

Aziz, M. A. (2016). Perancangan Sistem Antarmuka Berbasis Hmi (Human Machine Interface) pada Model Plant Auto Cowfeeder Machine. TRANSMISI, 18(3), 122-129.

Bahlawan, H. (2018). Kajian Psikologi Desain, Desain Interface Speedometer Sepeda Motor Metik, Tentang Pengaruh Cara Orang Berkendara. Jurnal IPTEK, 22(2), 77-86.

Costa, R. (2020). Neumorphism: Why It's All The Hype in UI Design. Retrieved June 2022, from https://www.justinmind.com/ui-design/neumorphism

François, M., Osiurak, F., Fort, A., Crave, P. & Navarro, J. (2017) Automotive HMI design and participatory user involvement: review and perspectives, Ergonomics, 60:4, 541-552

Hasso, P. (2010). An Introduction to Design Thinking: Process Guide. Hasso Plattner Institute of Design at Stanford University.

Honda. (2018). Multi-Information Display. Retrieved Oktober 15, 2021, from Techinfo Honda: http://techinfo.honda.com/rjanisis/pubs/om/ja0505/JA0505O00069A.pdf

Knapp, J. (2017). SPRINT: Pecahkan Masalah-Masalah Besar dan Uji Ide-Ide Baru Hanya dalam 5 Hari. Yogyakarta: Bentang Pustaka.

Razi, A. A. (2018, September). Penerapan Metode Design Thinking pada Model Perancangan UI/UX Aplikasi Penanganan Laporan Kehilangan dan Temuan Barang Tercecer. Demandia - Jurnal Desain Komunikasi Visual, Manajemen Desain dan Periklanan, 3(2), 219-237.

Salazar, Kim. (2022). Evaluate Interface Learnability with Cognitive Walkthroughs. Retrieved June 2022, from https://www.nngroup.com/articles/cognitive-walkthroughs/

Sauro, J. (2018). 5 Ways to Interpret a SUS Score. Retrieved June 2022, from https://measuringu.com/interpret-sus-score/

Spiteri, L. F. (2012). Social discovery tools: Extending the principle of user convenience. Journal of Documentation, 68(2), 206-217.

Susanto, B. (2019). Mengenal MID. Retrieved Oktober 15, 2021, from Otomotifinfo: https://www.otomotifinfo.com/mengenal-MID.html

Tambunan, G. R. (2021). Perbandingan Metode Heuristic Evaluation Dengan Cognitive Walkthrough Dalam Melakukan Evaluasi Usability Terhadap Sistem Informasi Rumah Sakit Del Egov Centre Berbasis Mobile. SEMINASTIKA, 3, 99-106.

Usability.gov. (2020). Usability Testing. Retrieved from Usability.gov Improving the User Experience: https://www.usability.gov/how-to-and- tools/methods/usability-testing.html

ANALYSIS OF SERVICE QUALITY ON NEW PLN MOBILE USING INTEGRATION OF E-S-QUAL, KANO, AND QFD METHODS

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ABSTRACT

The existence of New PLN Mobile as a synergy of PLN services is not only for the benefit of customers in terms of electricity, but there is also a need for PLN to develop businesses outside of PLN's core business that can increase company revenue. The importance of New PLN Mobile for PLN's business continuity makes the service quality of New PLN Mobile need to be continuously improved. Improving the quality of New PLN Mobile services will improve user satisfaction and increase the number of New PLN Mobile users. The increasing number of New PLN Mobile users will significantly impact PLN's business development. This research proposes an integrated approach involving the E-S-QUAL, Kano, and Quality Function Deployment (QFD) methods to improve the quality of New PLN Mobile services. This study obtained 15 technical responses to improve the New PLN Mobile services. Five technical responses with the highest priority, namely improvement of coordination among divisions; Yantek refreshment and upskilling; implementation of the compensation feature for customers; setting the proper target for recovery time; and repeated checking for information to be input into the application.

Keywords: E-S-QUAL, Kano, New PLN Mobile, QFD, service quality

1. INTRODUCTION

In 2020, PLN launched the New PLN Mobile application, which is claimed to improve the shortcomings of the previous PLN Mobile. Its development has referred to the best practice of mobile applications focused on improving user experience and user interfaces (PLN, 2020). Furthermore, the New PLN Mobile is part of PLN's transformation program. Apart from having electricity features, the New PLN Mobile is also a supporting application for the Beyond kWh PLN program (PLN, 2021, October 14). The PLN Beyond kWh program is a business activity carried out by the PLN Group outside of the sale of PLN kWh, which aims to increase company revenue (Sukma & Pamungkas, 2020). Examples of PLN's Beyond kWh programs are ICONNET and Listriqu, whose features exist in New PLN Mobile. Thus, the existence of New PLN Mobile is not only for the benefit of customers, but there is also a need for PLN to develop businesses outside of PLN's core business (PLN, 2020).

The importance of New PLN Mobile for PLN's business continuity makes New PLN Mobile needs special attention and needs to be evaluated regularly to increase the number of users. If the number of New PLN Mobile users increases, it will make PLN easier to introduce and develop its business. The increase in the number of New PLN Mobile users is indirectly related to the satisfaction of users who have installed New PLN Mobile. User satisfaction with an

application can be seen from the rating given to the application (Zaenudin, 2019). Users dissatisfied with the New PLN Mobile service tend to give the New PLN Mobile application a bad rating. The worse the rating of an application, the fewer people will be interested in using the application, and vice versa (Landry, 2020). In addition, we are currently entering a digital era where many people use the internet and have social media such as Facebook, Instagram, Whatsapp, and Twitter. According to Mola (2019), social media through the internet network has facilitated people in conveying an intention to others. The internet has been instrumental in creating a high-speed and effective communication medium. The dissatisfied users of New PLN Mobile can share their dissatisfaction experiences through social media so that it can cause people who initially intended to download New PLN Mobile to cancel their intention.

Currently, the New PLN Mobile rating on the Google Play Store and App Store is high, above 4 (PLN, 2021, October 14). However, many users still give a low rating or below 3 with various complaint comments. The researcher also interviewed several active users of New PLN Mobile directly. Some were satisfied with many features of New PLN Mobile, the speed of technicians who came to the location to perform the service, and the promo price provided. On the other hand, others expressed their complaints about the incomplete handling of complaints and difficulty logging in to the application. The poor rating of the application and the complaints given by some customers against the New PLN Mobile application describe that the New PLN Mobile service is considered bad by some users and indicates that the New PLN Mobile needs improvement. If PLN is satisfied with the current New PLN Mobile rating without making any improvements, customers may leave the New PLN Mobile application, which will cause PLN to be unable to reach the target number of New PLN Mobile users. Thus, the goal of expanding PLN's business to non-electricity businesses to increase the company's revenue may not be achieved.

2. LITERATURE REVIEW

2.1 New PLN Mobile

PLN first launched the PLN Mobile application in 2016. The PLN Mobile application received many complaints from customers and received a low rating on both the Google Play Store and the App Store, with an average of 2.6 out of 5 (PLN, 2021, October 14). In order to improve service to customers, PLN announced an update of the PLN Mobile application in 2020. Then this application is called the New PLN Mobile (PLN, 2021, October 14). New PLN Mobile is part of PLN's transformation program. With the number of PLN customers increasing from time to time, reaching more than 79 million customers in 2021, coupled with technological advances, PLN sees the potential to generate new revenue streams through the New PLN Mobile application (Divisi Manajemen Perubahan, 2021). Therefore, besides having electricity features, the New PLN Mobile has also been developed into a supporting application for the Beyond kWh PLN program. The New PLN Mobile's features include electricity token purchase feature, electricity bill payment, submission of new connection/upgrade capacity, SwaCAM, ListriQu (a customer-owned electricity installation service provider that provides fast and reliable), ICONNET (internet service), and Charge.IN ("Siaran Pers", 2021).

2.2 E-S-QUAL

In measuring electronic service quality, Parasuraman, Zeithaml, & Malhotra (2005) developed an electronic service quality measurement scale called E-S-QUAL which consists of seven dimensions, namely:

1. Efficiency: Users can easily and quickly access and use the site/application.

2. Fulfilllment: The extent to which the site can fulfill promises regarding the delivery of orders and availability of goods/services.
3. System availability: The ability to provide operational functions that users use to access the service
4. Privacy: The ability of the service to protect personal information and secure services from crime or damage.
5. Responsiveness: The ability of the service to solve problems via the site effectively.
6. Compensation: The extent to which the service can compensate the customer for the problems that the customer faces regarding the site's services.
7. Contact: The service provides assistance features by telephone or online.

2.3 Delphi Method

Dalkey and Helmer developed the Delphi method at the RAND Corporation in the 1950s (Linstone & Turoff, 2002). Furthermore, Linstone and Turoff explain that this method is based on the fact that one's opinion sometimes creates bias, while a small number of group members often dominate group meetings. In order to overcome this issue, the Delphi method was developed, which in principle recognizes the assessment of each expert as a valid and valuable input for decision-making. The Delphi method is based on a structured process of gathering and screening knowledge from a group of experts through a series of questionnaires interspersed with controlled opinion feedback (Adler and Ziglio in Gunaydin, 2016). The Delphi method has been widely used to generate forecasts in technology, education, and other fields (Cornish in Gunaydin, 2016).

2.4 Kano Method

The Kano method was first developed by Noriaki Kano (Kano in Siswanto, 2018). The Kano method can classify and prioritize product or service attributes based on how these attributes affect customer satisfaction (Kano in Xu, Jiao, Yang, Helander, Khalid, & Opperud, 2009). Xu et al. (2009) explained that there is a nonlinear relationship between product or service performance and customer satisfaction. Sauerwein, Bailom, Matzler, & Hinterhuber (1996) state that in the Kano method, product or service attributes are categorized into three types based on their effect on customer satisfaction, as follows:

1. Must-be: If this attribute is not met or missing, the customer will be very dissatisfied, so this attribute needs to be met first rather than other attributes.
2. One-dimensional: The higher the fulfillment of this attribute, the higher the customer satisfaction, or vice versa.
3. Attractive: The fulfillment of this attribute will lead to a high increase in customer satisfaction, but will not cause a decrease in customer satisfaction if this attribute is not met

Sauerwein et al. (1996) explain that basically, there are three categories of product or service attributes according to the Kano method as described above, but in practice, customer responses always appear in other categories, namely:

1. Indifferent: The customer does not care about this attribute
2. Reverse: The fulfillment of this attribute tends to disappoint customers
3. Questionable: If there is an attribute in this category in a customer satisfaction survey result, it indicates that the survey question contains ambiguity/bias, or the respondent misunderstood it.

The Kano method was constructed through a customer survey, in which the customer questionnaire contains a pair of questions for each product attribute (Xu et al., 2009). The pair of questions includes functional form questions, which capture customer responses if a product has a certain attribute, and dysfunctional form questions, which capture customer responses if the product does not have that attribute. Each pair of answers was evaluated with Kano's evaluation

table (Berger et al. in Xu et al., 2009). The final classification of an attribute can be determined by adding up each category based on results from the evaluation of each respondent (Walden, 1993). If (M+O+A)>(R+I+Q), then the category is the highest value of (M, O, A), and if (M+O+A)<(R+I+Q), then the category is the highest value of (R, I, Q).

Table 1. Kano Evaluation Table

Customer Requirements		**Dysfunctional**				
		1. Like	**2. Must-be**	**3. Neutral**	**4. Live with**	**5. Dislike**
Functional	**1. Like**	Q	A	A	A	O
	2. Must-be	R	I	I	I	M
	3. Neutral	R	I	I	I	M
	4. Live with	R	I	I	I	M
	5. Dislike	R	R	R	R	Q

Note: A=Attractive, M=Must-be, R=Reverse, O=One-dimensional, Q=Questionable, I=Indifferent; like=I like it when it happens, must-be: it is a must, neutral= neutral, live with: I can tolerate this happening, dislike: I do not like it happening

2.5 Quality Function Deployment (QFD)

According to Akao (cited in Chien & Su, 2003), the basic idea of QFD is to translate the voice of the customer into the final product/service quality to ensure good service to customers. Therefore, QFD is often used to develop new products or improve services (Chien & Su, 2003). QFD utilizes the House of Quality (HOQ) matrix in its process. The HOQ matrix has several elements: the Customer Requirements Matrix, Planning Matrix, Technical Requirements Matrix, Inter-Relationship Matrix, Roof Matrix, and Priorities to Design Matrix.

2.6 Integration of E-S-QUAL, Kano, and QFD

E-S-QUAL's conciseness in defining customer service and the ease of use of the E-S-QUAL format has made this method widely used in various industries. However, for service excellence development, some things need to be evaluated from this method (Tan & Pawitra, 2001). E-S-QUAL assumes a linear relationship between customer satisfaction and service attribute performance. The implication is that low customer satisfaction results from low attribute performance, which becomes a focus for organizational improvement, even though this assumption is not necessarily valid (Tan & Pawitra, 2001).

Tan and Pawitra (2001) state that paying more attention to specific low-performing service attributes may not necessarily lead to higher customer satisfaction. Furthermore, Tan and Pawitra (2001) explain that customer satisfaction can sometimes be significantly improved with a slight increase in pleasant and unexpected service attributes. For example, customers may perceive ease of navigation as an attribute of the services provided when shopping in an online store, but the ease of navigation in this context may not lead to high customer satisfaction. On the other hand, applying cashback promos on purchases of goods can lead to high customer satisfaction. Therefore, using the E-S-QUAL linear scale to set priorities to improve service attributes is inappropriate in some instances.

In this study, the Kano method is proposed to be integrated with E-S-QUAL to eliminate the assumption of linearity. As explained in the previous sub-chapter, Kano's method categorizes product or service attributes based on how well these attributes can meet customer needs (Kano in Xu et al., 2009). Therefore, the Kano method can support E-S-QUAL in prioritizing product/service attributes based on customer needs to lead to the highest customer satisfaction. In addition, the Kano method can enable E-S-QUAL to focus on the most preferred attractive attributes in the product/service innovation process.

The information generated from using the E-S-QUAL and Kano methods will help improve service attributes' quality. However, the combination of the E-S-QUAL method and the Kano method cannot improve the quality of service attributes systematically and operationally. Therefore, integrating E-S-QUAL and the Kano method into QFD will cover these weaknesses (Kesuma, Meyliana, Hidayanto, Phusavat, & Cahyati, 2016). Furthermore, with the HOQ of QFD, there will be a relationship between the attributes of customer requirements and the technical response of the company. Therefore, integrating the E-S-QUAL and Kano methods into the QFD will provide systematic and operational steps to improve the quality of service attributes.

3. METHODS

This study begins with determining the attributes of the New PLN Mobile service based on the E-S-QUAL dimension using the Delphi method with respondents from customer service experts at PLN UP3 Bogor. The Delphi method in this study was carried out by distributing questionnaires, namely a questionnaire to determine E-S-QUAL dimensions that are proper with the New PLN Mobile (Questionnaire I) and a questionnaire to determine the service attributes of the New PLN Mobile that affect customer satisfaction based on the predetermined E-S-QUAL dimensions (Questionnaire II). The results of each questionnaire were evaluated to reach an agreement among all respondents.

After obtaining the attributes of the New PLN Mobile service through the Delphi method, the E-S-QUAL questionnaire and the Kano questionnaire were distributed. Respondents to this questionnaire were 100 active users of the New PLN Mobile application in the work area of PLN UP3 Bogor. In the E-S-QUAL questionnaire, respondents were asked to assess the perception, expectation, and importance of each New PLN Mobile service attribute. This questionnaire uses a Likert scale of 1 to 5, where the smaller the scale, the more dissatisfied/unimportant, and the larger the scale, the more satisfied/important. In the Kano questionnaire, respondents were asked to assess the statements given. The statements given were in the form of functional and dysfunctional statements related to service attributes.

Furthermore, the gap value for each service attribute was determined from the E-S-QUAL questionnaire data processing, and the category of each attribute was determined using the Kano evaluation table. Attributes with Must-Be, One-Dimensional, and Attractive categories that had a negative gap value were included in the Customer Requirements matrix in the HOQ. Then, the technical responses were determined to respond to the Customer Requirements matrix, and the priority of the technical response was determined through the HOQ process.

4. RESULTS

Based on the Delphi method, we obtained seven dimensions of E-S-QUAL and 30 attributes of the New PLN Mobile service that affect customer satisfaction. These service attributes became the question item on the E-S-QUAL and Kano questionnaires. The result of the E-S-QUAL and Kano questionnaires is shown in Table 2.

4.1 Determining Matrix of Customer Requirements (Voice of Customer)

Based on the questionnaire data processing, 19 service attributes had a negative gap and were included in the Must Be, One Dimensional, or Attractive category. These service attributes were input into the Customer Requirements matrix, as shown in Table 3.

Table 2. Service Attributes of New PLN Mobile

No	Service Attribute	P	E	I	Gap (P-E)	Kano Category
Efficiency Dimension						
1	Easy to use app	4,49	4,49	4,66	0,00	M
2	Applications can be opened quickly	4,54	4,53	4,64	0,01	M
3	Loading each menu quickly	4,28	4,62	4,65	-0,34	M
4	Easily find the menu that customers need	3,89	4,64	4,47	-0,75	M
5	The information contained in the application is well organized	4,14	4,64	4,68	-0,50	O
System Availability Dimension						
6	Application is always easy to open	4,42	4,41	4,60	0,01	M
7	No/rarely found errors in the application	4,18	4,61	4,70	-0,43	M
8	Customers can view the history of service usage	4,55	4,53	4,73	0,02	O
Fulfillment Dimension						
9	Submission of service requests/complaints is confirmed correctly	4,47	4,46	4,64	0,01	M
10	The total cost that appears in the application is the same as the total cost paid	4,57	4,47	4,70	0,10	M
11	Provide the latest information/promotions (up to date)	3,48	4,68	4,40	-1,20	O
12	The information contained in the application is accurate	4,38	4,66	4,70	-0,28	M
13	PLN provides an estimated time for completion of service requests/complaint	3,26	4,48	4,47	-1,22	O
14	Notification related to the service request/complaint process on New PLN Mobile according to the actual condition (example: when the application gives a notification "completed", the actual condition has also been completed)	3,40	4,75	4,73	-1,35	O
15	The process of handling service requests and complaints is not complicated	3,64	4,67	4,67	-1,03	O
16	Ease of making payments through app	4,30	4,70	4,70	-0,40	M
17	New PLN Mobile has many payment methods for paying the service requests	4,30	4,66	4,59	-0,36	O
18	PLN officers who come are polite and friendly	4,25	4,64	4,64	-0,39	O
19	PLN officers who come are able to solve problems and provide solutions	3,65	4,72	4,76	-1,07	O
Privacy Dimension						
20	The app protects information related to customer transactions	4,53	4,51	4,75	0,02	M
21	The app protects customer's personal data	4,60	4,57	4,70	0,03	M
22	The app does not share customer personal information with other sites	4,59	4,58	4,76	0,01	M
Responsiveness Dimension						
23	Service requests/complaints submitted by customers are quickly confirmed	4,03	4,67	4,68	-0,64	O
24	Service requests/complaints submitted by customers are handled immediately	3,56	4,64	4,66	-1,08	O
25	The app asks how satisfied the customer is after the service request/complaint process has been followed up	4,08	4,48	4,48	-0,40	I
26	The app gives a clear notification if there is a delay in service	3,37	4,46	4,47	-1,09	O
Compensation Dimension						
27	The app provides compensation to customer when the customer's request is not completed properly	3,42	4,43	4,31	-1,01	A
28	The app provides compensation to customer when customer's request is slow to complete	3,38	4,41	4,30	-1,03	A
Contact Dimension						
29	The app provides a phone number to contact PLN	4,34	4,68	4,68	-0,34	I
30	There is a live chat feature that works well	4,10	4,64	4,62	-0,54	O

Note: P=Perception; E=Expectation; I=Importance

4.2 Developing Planning Matrix

1. Calculating the Adjusted Importance Value

The adjusted importance value of each attribute was obtained from the multiplication between the customer satisfaction score and the Kano category score for that attribute. Kano category score is 4 for the attractive category, 2 for the one-dimensional category, and 1 for the must-be category. The customer satisfaction score for an attribute was obtained from the

multiplication between the gap value and the average importance level of the attribute. Because the gap value is negative, the adjusted importance value will also be negative. Therefore, the adjusted importance value was converted to an absolute value.

Table 3. Customer Requirements and Planning Matrix

No	Customer Requirements	*AAI*	*IR*	*SP*	*RW*	*NRW*
1	Loading each menu quickly	1,58	1,09	1,00	1,72	0,01
2	Easily find the menu that customers need	3,35	1,19	1,20	4,8	0,02
3	The information contained in the application is well organized	4,68	1,13	1,20	6,35	0,02
4	No/rarely found errors in the application	2,02	1,12	1,00	2,27	0,01
5	Provide the latest information / promotions (up to date)	10,56	1,34	1,50	21,3	0,08
6	The information contained in the application is accurate	1,32	1,07	1,00	1,41	0,01
7	PLN provides an estimated time for completion of service requests/complaint	10,91	1,37	1,50	22,5	0,09
8	Notification related to the service request/complaint process on New PLN Mobile according to the actual condition (example: when the application gives a "completed" notification, the actual condition has also been completed)	12,77	1,40	1,50	26,8	0,10
9	The process of handling service requests and complaints is not complicated	9,62	1,28	1,50	18,5	0,07
10	Ease of making payments through app	1,88	1,09	1,00	2,05	0,01
11	New PLN Mobile has many payment methods for paying the service requests	3,30	1,08	1,00	3,58	0,01
12	PLN officers who come are polite and friendly	3,62	1,09	1,00	3,95	0,02
13	PLN officers who come are able to solve problems and provide solutions	10,19	1,30	1,50	19,9	0,08
14	Service requests/complaints submitted by customers are quickly confirmed	5,99	1,16	1,20	8,35	0,03
15	Service requests/complaints submitted by customers are handled immediately	10,07	1,31	1,50	19,8	0,08
16	The app gives a clear notification if there is a delay in service	9,74	1,33	1,50	19,4	0,08
17	The app provides compensation to customers when the customer's request is not completed properly	17,41	1,30	1,50	33,8	0,13
18	The app provides compensation to customers when customer's requests are slow to complete	17,73	1,30	1,50	34,7	0,13
19	There is a live chat feature that works well	4,99	1,13	1,20	6,78	0,03

Note: AAI = Absolute Adjusted Importance; IR = Importance Ratio; SP = Sales Point; RW = Raw Weight; NRW = Normalized Raw Weight

2. Determining the Value of Customer Satisfaction Performance (CSP)

The CSP value of an attribute is the average value of the respondent's perception of that attribute. The data was obtained from the E-S-QUAL questionnaire data processing.

3. Determining the Goal Value

The goal value was obtained from the maximum value of the average perception, expectation, or importance. For example, if an attribute has an average value of perception, expectation, and importance, each of 4.54; 4.53; and 4.64, then the goal value is the maximum value of the three elements, which is 4.64.

4. Calculating the Value of Improvement Ratio (IR)

The IR value of each attribute was calculated by dividing the goal value by the CSP value.

5. Determining the Value of Sales Point (SP)

The sales point value of each attribute was determined based on the value of the attribute gap, which was as follows:

• If the gap value is > -1, then the sales point value is 1.5 (high attribute selling power)

• If the gap value is between -0.50 to -0.99, then the sales point value is 1.2 (medium attribute selling power)

• If the gap value is between -0.01 to -0.49, then the sales point value is 1 (low/non-existent selling power of attributes)

6. Calculating Raw Weight (RW) and Normalized Raw Weight

The Raw Weight of the attribute was calculated from the multiplication of the attribute's Absolute Adjusted Importance, IR, and Sales Point values, while the Normalized Raw Weight was obtained from the division of the Raw Weight value with the Total Raw Weight value.

4.3 Designing Technical Requirement Matrix

In this matrix, the technical response was determined based on the analysis of customer requirements. Based on discussions with PLN, 15 technical responses were obtained as follows:

1. Server performance optimization
2. Bandwidth addition
3. Redesigned the menu layout in the app
4. Coding efficiency improvement
5. Repeated checking for information to be input into the application
6. Implementation of service time estimation feature
7. Yantek refreshment and upskilling
8. Improvement of coordination among divisions
9. Improvement of relationships and coordination with banks and digital wallets
10. Increase the number of collaborations with banks and digital wallets
11. Setting the proper target for response time
12. Setting the proper target for recovery time
13. Implementation of the service delay notification feature
14. Implementation of the compensation feature for customers
15. Optimization of the live chat function

4.4 Constructing Inter-Relationship Matrix

In this matrix, the relationship between customer requirements and technical requirements was determined by using this set of rules: if the relationship is weak, use the symbol ▲ (value=1); if the relationship is moderate, use the symbol ■ (value=3); if it has a strong relationship, use the symbol O (value = 9); if it has no relationship, do not use any symbol (value=0).

4.5 Compiling the Roof Matrix (Technical Correlation and Development Direction)

In this matrix, the relationship among technical responses was determined, and the development direction of each technical response was determined based on the results of discussions with PLN. Symbols used in the technical correlation matrix:

++ : Strong positive relationship; + : Positive relationship

Symbols used in the development direction matrix:

↑: Up; ◊ : Stagnant; ↓ : Down

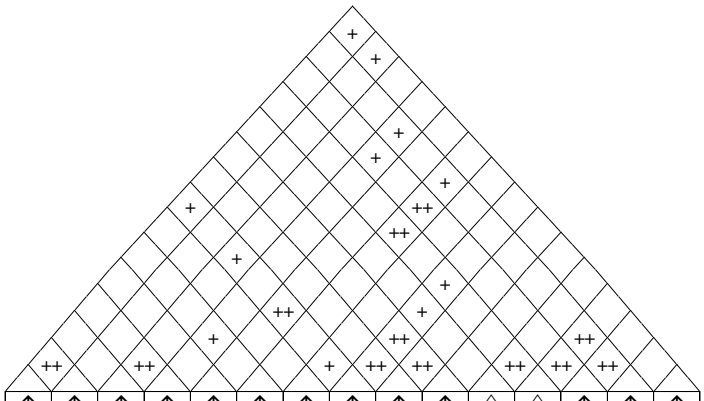
4.6 Calculating the Priorities to Design Matrix

This matrix determines the priority order of technical response (Technical Requirements) that has been designed to improve the New PLN Mobile application service. The calculation of the technical response priority is as follows:

a. Multiply the values in the Inter-Relationship matrix by the Normalized Raw Weight matrix.

b. The results of (a) are then added up per technical response so that the priority weight of the technical response is obtained.

c. Calculate the percentage of each technical response.



Tech. Req. / Cust. Req.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	AAI	Goal	CSP	IR	SP	RW	NRW
1	○	○		○				▲								1,58	4,65	4,28	1,09	1,00	1,72	0,01
2	▲	▲	○	▲				▲								3,35	4,64	3,89	1,19	1,20	4,80	0,02
3			○	▲				▲								4,68	4,68	4,14	1,13	1,20	6,35	0,02
4	■	■		○												2,02	4,70	4,18	1,12	1,00	2,27	0,01
5					○			○								10,56	4,68	3,48	1,34	1,50	21,30	0,08
6					○			○								1,32	4,70	4,38	1,07	1,00	1,41	0,01
7						○					■	■				10,91	4,48	3,26	1,37	1,50	22,48	0,09
8	▲	▲					○	○								12,77	4,75	3,40	1,40	1,50	26,76	0,10
9							○	○								9,62	4,67	3,64	1,28	1,50	18,51	0,07
10									○	○						1,88	4,70	4,30	1,09	1,00	2,05	0,01
11									○	○						3,30	4,66	4,30	1,08	1,00	3,58	0,01
12							○									3,62	4,64	4,25	1,09	1,00	3,95	0,02
13							○	▲								10,19	4,76	3,65	1,30	1,50	19,93	0,08
14	▲	▲					○				○	▲				5,99	4,68	4,03	1,16	1,20	8,35	0,03
15							○	○			▲	○				10,07	4,66	3,56	1,31	1,50	19,76	0,08
16											▲	▲	○			9,74	4,47	3,37	1,33	1,50	19,39	0,08
17														○		17,41	4,43	3,42	1,30	1,50	33,83	0,13
18														○		17,73	4,41	3,38	1,30	1,50	34,70	0,13
19	▲	▲	▲	▲				○							○	4,99	4,64	4,10	1,13	1,20	6,78	0,03
Total	0,27	0,27	0,42	0,21	0,79	0,78	3,39	3,43	0,2	0,2	0,7	1,06	0,68	2,39	0,24	Jumlah					257,93	1,00
Percentage (%)	1,78	1,78	2,77	1,39	5,28	5,22	22,6	22,8	1,31	1,31	4,69	7,05	4,51	15,9	1,57							
Priority	10	11	9	13	5	6	2	1	14	15	7	4	8	3	12							

Figure 1. House of Quality Matrix

5. CONCLUSIONS

There were seven dimensions of E-S-QUAL and 30 service attributes of the New PLN Mobile that affect customer satisfaction based on the Delphi method that has been carried out. Based on the questionnaire data processing, 19 service attributes had a negative gap and were included in the Must Be, One Dimensional, or Attractive category. Based on the results of the QFD analysis, a priority order of technical responses was obtained to improve the New PLN Mobile service. Five technical responses with the highest priority, namely improvement of coordination among divisions; Yantek refreshment and upskilling; implementation of the compensation feature for customers; setting the proper target for recovery time; and repeated checking for information to be input into the application. PLN UP3 Bogor can use the results of this study as a reference to determine the priority of improving the New PLN Mobile service.

This research is limited to the working area of PLN UP3 Bogor. However, given that the demographics of PLN customers may differ between regions, it is hoped that further research can be carried out with a broader area coverage to represent better the customers' need for New PLN Mobile services. In addition, to meet customer demands that are increasingly high and rapidly changing in this digital era, it is necessary to periodically analyze the quality of New PLN Mobile services so that the satisfaction level of New PLN Mobile users always increases.

REFERENCES

Chien, T., & Su, C. (2003). Using the QFD Concept to Resolve Customer Satisfaction Strategy Decisions. *International Journal of Quality & Reliability Management,* Vol. 20, No. 3, 345–359, DOI:10.1108/02656710310461332.

Divisi Manajemen Perubahan. (2021, Agustus), *Progress Breakthrough PLN Mobile Re-Launch,* Paper presented at the PLN Mobile Re-Launch Breakthrough Progress Meeting, Agustus 19, 2021. Jakarta.

Gunaydin, H. M. (2016). The Delphi Method. *ResearchGate.* Retrieved from https://www.researchgate.net/publication/308653253_The_Delphi_Method

Kesuma, D.P., Hidayanto, A.N., Meyliana, Phusavat, K., dan Chahyati, D. (2016). Integrating E-SERVQUAL and Kano Model into Quality Function Deployment to Improve Website Service Quality: An Application to University's Website. DOI:10.4018/978-1-4666-9764-5.ch003

Landry, Glen. (2020, Mei 18), Pentingnya Fungsi Review Aplikasi di Play Store Bagi Aplikasimu. *Kompasiana.* Retrieved from https://www.kompasiana.com/glenlandry/5e8b48fb097f3617ce6c9432/pentingnya-fungsi-review-aplikasi-pada-play-store-bagi-aplikasimu

Linstone, H. A., & Turoff, M. (2002), Introduction, in Linstone, H. A., & Turoff, M. (ed.), *The Delphi Method: Tecniques and Applications,* New Jersey Institute of Technology, Newark.

Mola, Ferdinandus Dominicus Ceme. (2019), *Peranan Media Sosial Sebagai Media Komunikasi dan Informasi pada Generasi Muda Di Pedesaan*, Skripsi Sarjana, Sekolah Tinggi Pembangunanan Masyarakat Desa, Yogyakarta.

Moradi, M. & Raissi, S. (2015), A Quality Function Deployment Based Approach in Service Quality Analysis to Improve Customer Satisfaction. *International Journal of Applied Operational Research,* Vol. 5, No. 1, 41-49.

Parasuraman, A. P., Zeithaml, V. A., & Malhotra, A. (2005). E-S-QUAL: A Multiple-Item Scale for Assessing Electronic Service Quality. *Journal of Service Research,* Vol. 7, No. X, 1-21

PLN. (2020). *Laporan Tahunan 2019: Memaknai Tantangan, Meningkatkan Layanan.* Jakarta: PT PLN (Persero).

PLN. (2021, Oktober, 14). Major Launch Fitur Baru PLN Mobile [File video]. Retrieved from https://www.youtube.com/watch?v=8vewf4mvWEI

Sauerwein, E., Bailom, F., Matzler, K., & Hinterhuber, H. H. (1996, February), The Kano model: How to Delight Your Customers, *International Working Seminar on Production Economics,* Vol. 1, No. 4, 313-327.

Siaran Pers: Beri Kemudahan Pengguna Kendaraan Listrik, PLN Luncurkan Aplikasi Charge.IN. (2021). Retrieved from https://web.pln.co.id/eng/news/press-release/2021/01/beri-kemudahan-pengguna-kendaraan-listrik-pln-luncurkan-aplikasi-chargein

Siswanto, Slamet. (2018), *Analisis Kualitas Layanan Perpustakaan di SMA Negeri 1 Gedangan dengan Metode SERVQUAL, Kano Model, dan QFD,* Tesis Magister, Institut Teknologi Sepuluh Nopember, Surabaya.

Tan, K. C. & Pawitra, T. A. (2001). Integrating SERVQUAL and Kano's Model into QFD for Service Excellence Development. *Managing Service Quality*, Vol. 11, No. 6, 418-430.

Walden. D. (1993), A Special Issue on Kano's Methods For Understanding Customer Defined Quality. *The Center for Quality of Management Journal*, Vol. 2. No. 4, 3-35.

Xu, Q., Jiao, R. J., Yang, X., Helander, M., Khalid, H. M., & Opperud, A. (2009). An Analytical Kano Model for Customer Need Analysis. *Design Studies*, Vol. *30, No.* 1, 87-110.

Zaenudin, Ahmad. (2019). Rating Satu Bintang: Ketika Aplikasi Tempo Tumbang karena Netizen. Retrieved from https://tirto.id/eiE6

Zeithaml, V., Parasuraman, A. P., & Malhotra, A. (2000). A Conceptual Framework for Understanding E-Service Quality: Implications for Future Research and Managerial Practice. *Marketing Science Institute Working Paper Report* No. 00-115.

CONTINUANCE INTENTION TO HEALTH CENTER DURING THE COVID-19 PANDEMIC

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ABSTRACT

The social distancing policy has forced hospitals to replace some of their physical care with telemedicine. Of course, there are different forms of service between the two. This new service in digital form is expected to influence public interest in returning to conventional health care facilities for treatment. The purpose of this study was to determine the factors that influence public interest in returning to the health center during the COVID-19 pandemic using the SEM-PLS method. The object of the research is the people of Ponorogo District who know or have done outpatient treatment during the COVID-19 pandemic at the health center and telemedicine. Service quality is an exogenous latent variable, while value, satisfaction, and continuance intention are endogenous latent variables. The results of the analysis show that the quality variable affects the value and satisfaction of the community. The satisfaction variable affects continuance intention. So it can be concluded that health centers need to always pay attention to the quality of their services to maintain value and provide satisfaction to patients so that they have an interest in returning to the health center for treatment.

Keywords: continuance intention, health center, SEM-PLS

1. INTRODUCTION

COVID-19 was identified as an acute respiratory disease that was first discovered in the city of Wuhan, Hubei, China (Ye et al., 2020). COVID-19 is characterized by fatigue, cough, anosmia (loss of sense of smell), sore throat, headache, fever, myalgia (muscle pain), arthralgia (joint pain), and diarrhea (Lechien et. al., 2020; Gilani et. al., 2020; Elibol, 2020). The World Health Organization (WHO) declared COVID-19 a global pandemic on March 11, 2020 (WHO, 2020). The emergence of the COVID-19 pandemic has brought many new challenges to the world of health in various countries. Health services are disrupted due to inadequate personal protective equipment, lockdown policies, and the risk of spreading an infection to patients and medical practitioners (Golinelli et. al., 2020).

To adjust government regulations to prevent the spread of COVID-19, healthcare facilities have replaced some physical care with digital technology through telemedicine (Neubeck et. al., 2020). Treatment through telemedicine protects patients and medical practitioners to reduce the risk of transmitting COVID-19 (Perrin et. al., 2020). Based on the explanation by the Secretary-General of the Ministry of Health, the role of telemedicine is important and is a solution to geographic challenges and the gap in the distribution of health facilities in Indonesia (Setiawan, 2020).

Therefore, the Indonesian Ministry of Health cooperates with eleven telemedicine platforms to expand the provision of doctor consulting services and drug delivery (Kominfo, 2021a).

There are differences in the business model between conventional health facilities such as health centers, hospitals, and clinics with all-digital telemedicine. This new service in digital form is expected to affect people's interest in returning to conventional health facilities for treatment, or vice versa, people are not interested in using telemedicine after the pandemic ends. Through this research, the factors that influence people's interest in returning to health centers for treatment during the COVID-19 pandemic will be obtained. The object of the research is the people of Ponorogo District who know or have done outpatient treatment during the COVID-19 pandemic at the health center and telemedicine. Structural Equation Modeling – Partial Least Square (SEM-PLS) is the method to be used because this method can be applied to all data scales, does not require assumptions, and does not have to use a large number of samples, considering that the data used is primary data from a questionnaire that distributed by purposive sampling technique.

2. LITERATURE REVIEW

The context of this study refers to someone who has used and will use it again (Hidayat, 2020) so he uses the continuance intention variable or interest to reuse. Purchase intention or reuse is part of buying behavior (Kotler & Keller, 2016). After buying a product or using a service, consumers will experience a level of satisfaction. Satisfaction with the product will influence subsequent consumer behavior namely, whether consumers will have the desire to continue using, have confidence that this is the right use, and desire to recommend it to others (Hermawan & Paramita, 2021). In general, satisfaction is a person's feelings of pleasure or disappointment resulting from comparing the perceived product or service quality performance with expectations (Kotler & Keller, 2016). Quality is the totality of features and characteristics of a product or service that depend on its ability to satisfy stated or implied needs (Kotler & Keller, 2016). Companies provide quality products or services to meet or exceed customer expectations. There are five dimensions in measuring service quality (Parasuraman et. al., 1988), namely: tangibles, reliability, responsiveness, assurance, and empathy. Service quality (service quality) can be known by comparing the perceptions of consumers on the services they receive with the services they expect on the service attributes of a company. Perceived value is a comprehensive assessment made by consumers of the usefulness of a product or service based on perceptions of what is received and what is perceived by consumers (Parasuraman et. al., 1988). The way organizations create, deliver, and derive value or benefits is the business model canvas (Osterwalder, 2010). In the business model canvas (BMC), the building blocks that have an impact on customers are the value proposition, channels, and customer relationships. A value proposition is a company's promise about the experience customers expect from their offerings and relationships with their suppliers (Kotler & Keller, 2016). Channels explain how the company communicates and reaches its customers to provide a value proposition. Customer relationship describes the type of relationship between the company and its customers.

Apart from theory, causality between latent variables is the result of previous studies. Research by Lestari et. al. (2017) about the effect of service quality on patient satisfaction and interest in repeat visits in the work area of the Mandai health center was carried out to determine the effect of service quality on patient satisfaction, the effect of service quality on patient return visit interest, and the effect of satisfaction on patient return visit interest. This research is a quantitative research using a cross-sectional design. Collecting data using a questionnaire with a sample of 94 outpatients at the Mandai Health Center. The results showed that service quality had a direct and significant positive effect on patient satisfaction at the Mandai Health Center, the service quality had a significant positive direct effect on the interest in repeat visits at the Mandai Health Center,

and patient satisfaction did not have a direct positive effect on the interest in repeat visits at the Mandai Health Center. This shows that there is a significant positive effect of service quality on satisfaction and service quality on the interest of patient repeat visits.

Research Faaghna et. al. (2019) regarding the analysis of factors affecting patient revisit interests to the specialist polyclinic at RSI Ibnu Sina Padang with SEM analysis using latent variables, including consumer attitudes, brand image, perceived value, perceived quality, and interest in revisiting. The data used are primary data from the distribution of questionnaires to respondents, namely 348 specialist polyclinic patients who use BPJS health insurance. The results showed that the variables of patient attitude, brand image, perceived value, and perceived quality had a significant effect on the patient's interest in revisiting the specialist polyclinic of RSI Ibnu Sina Padang.

Farasannia (2020) conducted a study about the effect of service quality on customer value and its impact on BPJS patient satisfaction at the Nagrak Health Center. This study was conducted to determine the effect of service quality on customer value and its impact on patient satisfaction at the Nagrak Health Center. This study involved 100 BPJS patients at the Nagrak Health Center who were analyzed using multiple regression analysis techniques. The results showed that service quality had a significant effect on customer value by 40.4%, and customer quality together with customer value had a significant effect on patient satisfaction by 70.7%. In addition, the direct effect of service quality on patient satisfaction is smaller than its effect on patient satisfaction through customer value.

Octodiva's research (2018), namely the effect of service quality and customer perceived value on inpatient patient satisfaction BPJS Kesehatan (government health insurance) participants RSUP M. Djamil Padang aims to analyze the effect of service quality on customer perceived value, the effect of service quality on patient satisfaction, the influence of customer perceived value on patient satisfaction, and the effect of service quality on inpatient satisfaction of BPJS Kesehatan participants at RSUP M. Djamil Padang through customer perceived value. The samples used were 100 inpatients participating in BPJS Kesehatan RSUP M. Djamil Padang, which were taken using a non-probability sampling technique with the type of convenience sampling. The results show that service quality has a positive and significant effect on customer perceived value, service quality has a positive and significant effect on patient satisfaction, customer perceived value has a positive and significant effect on patient satisfaction, and service quality has a positive and significant effect on patient satisfaction. BPJS Kesehatan at RSUP M. Djamil Padang through customer perceived value.

These studies became a reference for this study using a different research object, namely the people of Ponorogo District who used the health center for treatment during the COVID-19 pandemic. Based on theoretical explanations and references from several studies, the relationship between exogenous and endogenous latent variables can be described in a conceptual framework as shown in Figure 1.

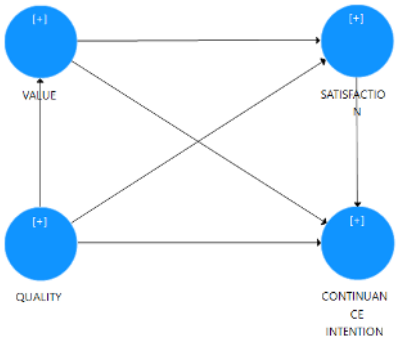


Figure 1 . Conceptual Framework

From the conceptual framework formed, six research hypotheses were obtained as follows.
H_1 : The quality variable affects the value variable
H_2 : The quality variable affects the satisfaction variable
H_3 : The quality variable affects the continuance intention variable
H_4 : The value variable affects the satisfaction variable
H_5 : The value variable affects the continuance intention variable
H_6 : The satisfaction variable affects the continuance intention variable

3. METHODS

The data used in this study is primary data obtained through a survey. This research survey was conducted by distributing questionnaires in February 2022 by way of offline and online. Respondents can assess all statements in the questionnaire by choosing one answer score. There are answer choices according to a Likert scale of 1 to 7, namely 1 strongly disagree, 2 disagree, 3 less agree, 4 is neutral, 5 moderately agree, 6 is agreed, and 7 strongly agree. Respondents are research samples whose determination uses a purposive sampling technique, namely taking samples with certain considerations (Sugiyono, 2009). The criteria used in this study were the people of Ponorogo District who knew or had done outpatient treatment by utilizing the health center and telemedicine available in Ponorogo District during the COVID-19 pandemic.

After being collected, the data were analyzed by the Structural Equation Modeling-Partial Least Square (SEM-PLS) method. PLS is one of the analytical methods in SEM that can be applied to all data scales, does not require assumptions, and does not have to use large samples. PLS can analyze as well as constructs formed with reflective indicators and formative indicators. However, there is a weakness in the PLS method, namely the distribution of the data is unknown so statistical significance cannot be assessed. Weaknesses in the PLS method can be overcome by using resampling or bootstrap methods (Ghozali, 2011). The latent variables in this study are quality variables as exogenous latent variables (giving effect), while value, satisfaction, and continuance intention variables as endogenous latent variables (receiving effect). The indicators of each latent variable are described in Table 1.

Table 1. Variable Indicator

Latent Variable	Indicator
Quality	Tangible - The environment is beautiful - The building is clean - The examination room is neat - The equipment is adequate - The staff is neat*
	Reliability - The health worker understands the patient's condition - The health worker gives the right diagnosis* - The health worker examines carefully - The medicine according to the complaint
	Responsiveness - The registration is not complicated* - The information on the treatment procedure is clear - The staffs are quick to serve*

Table 1. Variable Indicator (Continuation)

Latent Variable	Indicator
	Assurance - The parking area is safe* - The staffs are friendly and polite* - The staff can communicate effectively and maintain data confidentiality* - The knowledge and skills of the staff are adequate* - Feels safe while undergoing the treatment process
	Empathy - The staffs provide adequate psychological support and attention*
Value	Value proposition - The health center is the best health care facilities - The health center implements health protocols strictly - The health center is very useful for the community - The health center provides the best treatment experience
	Channel - The health center is easy to access - The cost of treatment at the health center is very affordable
	Customer relationship - The health center provides a place for complaints and suggestions - The health center serves treatment with health insurance
Satisfaction	Feel comfortable while undergoing the treatment process
	Cost according to treatment
	Satisfied with the health center service*
Continuance intention	I will go back to the health center for treatment*
	Do not want to move to another healthcare facility

*Reference: Halimah (2017)

In SEM, there are two models, namely the measurement model or the outer model and the structural model or the inner model (Wijanto, 2008). The outer model shows the relationship between latent variables and indicator variables directly, while the inner model shows the relationship between latent variables based on substantive theory (Chin, 1998). Evaluation of the outer model is carried out to ensure that the measurements made are feasible to be used as measurements (valid and reliable) which can be seen from several indicators consisting of convergent validity and composite reliability. The value of convergent validity is the value of the loading factor (λ) on the latent variable with its indicators that have gone through the standardized process. A loading factor value of more than 0.7 can be said to be ideal, which means that the indicator is significant as an indicator that measures the latent variable. If the standardized loading factor value is less than 0.5, it must be removed from the model (Chin, 1998). Reliability testing is done by using the composite reliability value. The composite reliability value above 0.6 indicates the consistency of internal reliability (Hair et. al., 2019). The evaluation of the inner model can be seen from the coefficient of determination (R^2) and predictive relevance (Q^2). The value of R^2 is the same as in linear regression, namely the amount of variability in endogenous variables that can be explained by exogenous variables. The value of R^2 can be classified into 3 parts, namely if the value of R^2 is less than 0.3 then it can be said to be low, if the value of R^2 is between 0.3 to 0.6 then it can be said to be sufficient, and if the value of R^2 above 0.6 is said to be high (Sanchez, 2013). The value of Q^2 is used to validate the model's ability to predict. If the value of Q^2 is greater than 0 and is getting closer to the value of 1, it can be said that the structural model fits the data (Ghozali, 2011).

4. RESULTS

From the data collection process, 100 respondents obtained data, which is according to the recommendation, namely the minimum sample size used in the SEM model is 100 samples (Zuhdi et. al., 2016). Table 2 shows evaluation of outer model by convergent validity. All loading factor values are more than 0.5, so these indicators are valid in measuring each variable.

Table 2. Loading Factor Value

Variable	λ	Variable	λ	Variable	λ	Variable	λ	Variable	λ
$X_{.1.1}$	0,714	$X_{.2.3}$	0,585	$X_{.4.3}$	0,888	$Y_{1.1.1}$	0,599	$Y_{1.3.4}$	0,882
$X_{.1.2}$	0,573	$X_{.2.4}$	0,629	$X_{.4.4}$	0,717	$Y_{1.1.2}$	0,593	$Y_{1.3.5}$	0,522
$X_{.1.10}$	0,524	$X_{.3.2}$	0,842	$X_{.4.5}$	0,521	$Y_{1.1.5}$	0,762	$Y_{2.1}$	0,778
$X_{.1.11}$	0,543	$X_{.3.3}$	0,699	$X_{.4.6}$	0,702	$Y_{1.1.6}$	0,838	$Y_{2.3}$	0,807
$X_{.1.12}$	0,820	$X_{.3.4}$	0,703	$X_{.4.7}$	0,922	$Y_{1.1.7}$	0,578	$Y_{2.4}$	0,627
$X_{.2.1}$	0,773	$X_{.4.1}$	0,552	$X_{.5.2}$	0,564	$Y_{1.2.1}$	0,894	$Y_{3.3}$	0,900
$X_{.2.2}$	0,563	$X_{.4.2}$	0,719	$X_{.5.3}$	0,793	$Y_{1.2.2}$	0,684	$Y_{3.4}$	0,876

While Table 3 shows evaluation of outer model by composite reliability. The value of composite reliability is more than 0.6, so this shows that the data is reliable or there is consistency of internal reliability. According to the evaluation results of outer model, it can be said that all variables are valid and reliable.

Table 3. Composite Reliability

Variable	Composite Reliability
Quality (X)	0,950
Value (Y_1)	0,903
Satisfaction (Y_2)	0,784
Continuance Intention (Y_3)	0,882

Next, evaluate the inner model as shown in Table 4. The R^2 value in modeling the value variable is high, namely 0.845, which means that the quality variable can explain the variability in the variable value of 84.5%, while the remaining 15.5% is explained by variations in other variables not included in the model. The R^2 value in modeling the satisfaction variable is high, namely 0.745, which means that the value and quality variables can explain the variability in the satisfaction variable by 74.5%, while the remaining 25.5% is explained by variations in other variables not included in the model. The value of R^2 of the variable modeling of continuance intention is low because it is less than 0.3, namely 0.289, which means that the value, quality, and satisfaction variables are only able to explain the variability in the continuance intention variable of 28.9%, while 71.1% is explained by variations in other variables not included in the model. Overall, the value of Q^2 is close to 1, it can be said that the continuance intention modeling has fit with the data.

Table 4. Evaluation of Inner Model

Variable	R^2	Q^2
Value	0.845	0.971
Satisfaction	0.741	
Continuance intention	0.289	

Next, test the hypothesis on the inner model using a significance level (α) of 0.05 as shown in Table 5. The p-value of the quality variable on the value variable is less than α, so the decision is to reject H_0 which means that the quality significantly affects the value. The positive T-statistic value means that the quality will have a positive or unidirectional effect on value. So, if the score on the quality variable increases by 1 level, the score on the value variable will also increase by 0.919 levels, and vice versa. The p-value of the quality variable on the satisfaction variable is less

than α, so the decision is to reject H_0 which means that quality significantly affects satisfaction. The positive T-statistic value means that the quality variable will have a positive or direct influence on satisfaction. So, if the score on the quality variable increases by 1 level, the score on the satisfaction variable will also increase by 0.455 level, and vice versa. However, the p-value of the quality variable on the continuance intention variable is more than α which causes the decision to fail to reject H_0 or the quality does not significantly affect continuance intention.

The p-value of the value variable on the satisfaction and continuance intention variables is more than α, thus giving a decision to fail to reject H_0 which means the value does not significantly affect satisfaction or continuance intention. The p-value of the satisfaction variable on continuance intention is less than α which gives the decision to reject H_0, namely, satisfaction significantly affects continuance intention. T-statistic has a positive value which means that satisfaction has a positive or direct influence on continuance intention. So, if the satisfaction variable score increases by 1 level, the continuance intention variable score will also increase by 0.413 level, and vice versa.

Table 5. Hypothesis Testing Result

Variable	Original Sample	T-statistic	P-value	Decision
Quality → Value	0.919	23.970	0.000	Reject H_0
Quality → Satisfaction	0.455	2.305	0.022	Reject H_0
Quality → Continuance intention	-0.078	0.226	0.821	Fail to reject H_0
Value → Satisfaction	0.424	1.879	0.061	Fail to reject H_0
Value → Continuance intention	0.216	0.909	0.364	Fail to reject H_0
Satisfaction → Continuance intention	0.413	2.492	0.013	Reject H_0

By the results of hypothesis testing, it can be seen that there is a relationship between the variables of value, quality, satisfaction, and continuance intention. The results showed that the value or benefits felt by the community towards health center services were not a factor that influenced people's behavior to return to health centers for treatment. The health center has proven its value or benefits (value proposition) to the community through easy access (channels) and maintaining relationships with the community (customer relationship), but the community already has insight regarding the quality standards or minimum service quality of the health center, so that the community can understand the lack of services that the health center provides. This was also conveyed by several respondents during the survey. In addition, the community follows health service procedures with BPJS/KIS cards which require users to come to the health center.

The quality of health center services affects the community's perceived value of the health center. Quality services are part of the value offering (Jimmy, 2013), so the quality of health center services, such as the appearance and attitude of officers and good treatment and support services, must be considered and ensured. The value of the health center that has been embedded in the community strongly agrees that the health center is very useful for the community, easy to access, and serves BPJS/KIS which of course reduces the cost of treatment. With this health center value standard, quality can be established and implemented. Quality is one of the important factors that affect community satisfaction with health center services. The better the quality of health center services, the more satisfied the community will be. People who feel satisfied tend to return for treatment to the health center and will create a close relationship with the health center. This is to the results of the study that satisfaction is one of the factors that shape people's behavior to return to health centers for treatment. One important indicator that causes people to be satisfied is related to costs. Based on the survey results, the majority of respondents are very satisfied with going to the health center because the cost is very affordable, especially if you use the BPJS/KIS card which can reduce or even eliminate medical expenses. This is to the condition of the people of Ponorogo District who generally have lower-middle economic conditions. This condition is one of the reasons

why people prefer health centers to telemedicine. In addition, it is also due to inadequate and uneven technological facilities, especially in the Ponorogo District area.

5. CONCLUSIONS

The results of hypothesis testing are that the quality variable affects the value variable and the satisfaction variable, and the satisfaction variable affects the continuance intention variable. For people to return to the health center for treatment, managers need to maintain values by paying attention to the quality of officers and services so that they can provide satisfaction to the community. Quality that needs to be considered is the appearance and attitude of officers in providing services, as well as reliable treatment and support services. In addition, appropriate costs are important to pay attention to satisfy patients. The health centers can maintain their value by paying attention to service quality that can provide a sense of satisfaction for the community so that people have an interest in returning to the health center for treatment.

REFERENCES

Chin, W. W. (1998). The Partial Least Squares Approach to Structural Equation Modeling. *Modeling Methods for Bussiness Research* 295(2), 295-336.

Elibol, E. (2020). Otolaryngological Symptoms in COVID-19. *European Archives of Oto-Rhino-Laryngology* (2021) 278, 1233–1236.

Faaghna, L., Lita, R. P., & Semiarty, R. (2019). Analisis Faktor yang Mempengaruhi Minat Berkunjung Ulang Pasien ke Poliklinik Spesialis di RSI Ibnu Sina Padang (BPJS Kesehatan). *Jurnal Kesehatan Andalas* 8(2), 295-304.

Farasannia, M. (2020). *Pengaruh Kualitas Pelayanan Terhadap Nilai Pelanggan dan Dampaknya Terhadap Kepuasan Pasien BPJS di Puskesmas Nagrak*. Universitas Pasundan Bandung, Bandung.

Ghozali, I. (2011). *Model Persamaan Struktual Konsep dan Aplikasi dengan Program Amos 22 Update Bayesian SEM*. Universitas Diponegoro, Semarang.

Gilani, S., Roditi, R., Naraghi, M. (2020). COVID-19 and Anosmia in Tehran Iran. *Med Hypotheses* 141:109757.

Golinelli, D., Boetto, E., Carullo, G., Nuzzolese, A. G., Landini, M. P., & Fantini, M. P. (2020). Adoption of Digital Technologies in Health Care During the COVID-19 Pandemic: Systematic Review of Early Scientific Literature. *Journal of Medical Internet Research* 22(11), e22280.

Hair, J. F., Black, W. C., Babin, B. J., & Anderson, R. E. (2019). *Multivariate Data Analysis, Eighth Edition.* Prentice-Hall: New York.

Halimah, S. N. (2017). *Analisis Pengaruh Kualitas Layanan dan Kepuasan Terhadap Loyalitas Pasien di Medical Center ITS dengan Metode Structural Equation Modeling – Partial Least Square* (SEM-PLS). Institut Teknologi Sepuluh Nopember, Surabaya.

Hermawan, V. K. & Paramita, E. L. (2021). Faktor Yang Mempengaruhi Keberlanjutan Minat Pengguna Dalam Menggunakan Aplikasi mHealth Melalui Variabel Satisfaction. *Jurnal Bisnis dan Manajemen* 8(1), 150-166.

Hidayat, R. (2020). New Trend in New Normal, Factors Influencing Continuance Intention to Use Video Conferencing. *Jurnal Ilmiah PoliBisnis*, 12.

Kominfo. (2021a). Gandeng 11 *Telemedicine*, Pemerintah Sediakan Layanan bagi Pasien Isoman. Available: https://www.kominfo.go.id/content/detail/35472/gandeng-11-*telemedicine*-pemerintah-sediakan-layanan-bagi-pasien-isoman/0/berita. Accessed on 4 October 2021.

Kotler, P. & Keller, K.L. (2016). *Marketing Management*, 15th Edition. Pearson Education, United States.

Lechien, J.R., Chiesa-Estomba, C.M., Place, S., Van Laethem, Y., Cabaraux, P. et al. (2020). Clinical and Epidemiological Characteristics Of 1,420 European Patients With Mild-To-Moderate Coronavirus Disease. *J Intern Med* 1(2), 120-157.

Lestari, E. D., Samsualam, S., Ahri, R. A. (2017). Pengaruh Kualitas Layanan Terhadap Kepuasan dan Minat Kunjungan Ulang Pasien di Wilayah Kerja Puskesmas Mandai Kabupaten Maros Tahun 2017. *Jurnal Ilmiah Kesehatan Diagnosis* 11(4), 423-428.

Neubeck, L., Hansen, T., Jaarsma, T., Klompstra, L., & Gallagher, R. (2020). Delivering Healthcare Remotely To Cardiovascular Patients During COVID-19: A Rapid Review Of The Evidence. *European Journal of Cardiovascular Nursing* 19(6), 486-494.

Octodiva, V. R. (2018). Pengaruh Kualitas Pelayanan dan Customer Perceived Value Terhadap Kepuasan Pasien Rawat Inap Peserta BPJS Kesehatan RSUP M. Djamil Padang. Universitas Negeri Padang, Padang.

Osterwalder, A. & Pigneur, Y. (2010). *Business Model Generation*. John Wiley & Sons Inc, New Jersey.

Parasuraman, A., Zeithaml, V. A., & Berry, L.L. (1988). SERVQUAL: A Multiple-Item Scale for Measuring Consumer Perceptions of Service Quality. *Journal of Retailing* 64 (1), 12- 37.

Perrin, P. B., Pierce, B. S., & Elliott, T. R. (2020). COVID-19 and Telemedicine: A Revolution in Healthcare Delivery is at Hand. *Health Science Reports* 3(2), e166.

Sanchez, G. (2013). *PLS Path Modeling with R.* Trowchez Editions, Berkeley.

Setiawan, V. N. (2020), Pandemi Virus Corona Pacu Pemerintah Kembangkan Telemedisin. Available: https://katadata.co.id/muhammadridhoi/berita/5f40b2ef614e2/pandemi-virus-corona-pacu-pemerintah-kembangkan-telemedisin. Accessed on 5 October 2021.

Sugiyono. (2009). *Metode Penelitian Pendidikan Pendekatan Kuantitatif, Kualitatif, dan R&D*. Alfabeta, Bandung.

WHO. (2020). Critical preparedness, readiness and response actions for COVID-19: Interim guidance-24 June 2020. Available: https://reliefweb.int/report/world/critical-preparedness-readiness-and-response-actions-covid-19-interim-guidance-24-june.

Wijanto, S. H. (2008). *Structural Equation Modeling dengan LISREL 8.8: Konsep dan Tutorial.* Graha Ilmu, Yogyakarta.

Ye, Z., Zhang, Y., Wang, Y., Huang, Z. dan Song, B. (2020). Chest CT Manifestations Of New Coronavirus Disease 2019 (COVID-19): A Pictorial Review. *European Radiology* (2020) 30, 4381–4389.

Zuhdi, Suharjo, B., Sumarno, H. (2016). Perbandingan Pendugaan Parameter Koefisien Struktural Model Melalui SEM dan PLS-SEM. *Jurnal Matematika dan Aplikasinya* 15(2), 11-22.

LEAN CONSTRUCTION IMPLEMENTATION TO REDUCE WASTE IN THE ROKAN AREA OIL REPLACEMENT PROJECT (Case Study: Oil Replacement and Installation of PT. Pertamina Gas – Rokan Region)

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ABSTRACT

The oil pipeline replacement and installation project in the Rokan area is a strategic project belonging to the oil company PT. Pertamina The upstream sub-holding manages because it is related to energy needs, energy budget efficiency, and government policies to reduce oil imports. However, in the pipe installation construction work, there is still waste such as delays in meeting project deadlines, the progress of construction project work is still not as expected by the customer due to many non-value-added activities, such as: waiting for the arrival of materials, defects in welding work, deficiencies in pillars, waiting for work instructions, permits, area sterilization, and so on. Related to this problem, it is necessary to do Lean Construction as an improvement effort by eliminating waste and increasing project value. This research was conducted by identifying the overall construction project flow of oil pipeline installation from the planning stage to construction through the visualization of Big Picture Mapping. Using WAM and VALSAT, the most dominant waste waiting is obtained with an NNVA lead time of 288 days.

Furthermore, through Process Activity Mapping from Process Activity Mapping, it is known that the total time Value Added Activity is 405 days with a time saving of 190 days, Non-Value Added Activity is 527 days, time savings is 117 days, and Necessary But Non-Value Added Activity is 216 days, time savings is Rp. 63 days. Based on the FMEA analysis, three problems in the oil pipe replacement and installation project in the Rokan area are the length of licensing from the local government, the equipment maintenance process is not carried out properly, and the project work is complex. From 817 days to 588 days, inspection reduced from 296 days to 249 days, delay reduced from 299 days to 233 days, and transportation decreased from 96 days to 71 days. In addition, there are savings in using a workforce of 98 people.

Keywords: *waste*, *mapping, value, stream, lean*

1. INTRODUCTION

The construction industry in Indonesia has problems related to the inefficient and effective construction implementation process. Activities associated with using resources are more likely not to add value or high-value activities as expected but a lot of waste (Kim & Park, 2006). Due to these inefficiencies, the results of construction work, quantity, and quality are also low. Therefore, industry players must conduct a more in-depth evaluation of various aspects to eliminate or reduce waste as much as possible. Lean construction adopts the poor manufacturing concept by reducing waste—types of debris- from TPS's perspective (Toyota Production System). From the identification carried out by Kim & Park (2006), there are several wastes in construction projects so that construction projects are not optimal, for example, at the engineering design stage, which takes a relatively long time because they have to wait for a team of design and engineering experts, especially for piping and plumbing work. Other wastes related to waiting can be in the form of approval from parties with

authority over design decisions (Saygili et al., 2019). So before the project work process is carried out, a verification process for corrections and validation of the revisions made must be carried out so that design approval can be given.

The project waste observed in the research object, namely the replacement and installation of oil pipelines in the Rokan area, often experiences project cost overruns. Based on the observations of researchers in the field, waste in the previous Rokan pipe installation project occurred due to several things such as poor and professional project management, contractors who did not understand the problems of project efficiency and effectiveness, environmental and natural aspects, aspects of planning and forecasting errors on the project, aspects of workers who did not possess the competence and other elements that have the potential to harm project implementers. The project was carried out by the KPP contractor (Konsortium PGASOL-PDC) with an initial estimated investment value of USD 450 million. However, there have been successful efficiency efforts to reduce the project investment value by USD 150 million. As a result, the investment value is USD 300.62 million and is planned to be completed by early 2022.

The progress of construction project work is still not as expected by the customer due to many non-value-added activities, such as: waiting for material arrivals, defects in welding work, permits, area sterilization, and so on (Salem et al., 2006). Therefore, it is necessary to take appropriate steps to identify and eliminate existing waste to avoid delays and losses in construction project work.

2. LITERATURE REVIEW

2.1 Construction Project

A construction project is a series of interrelated activities between one activity and another to achieve specific goals but has limitations on costs, time, and specific quality standards (Gunduz & Naser, 2017). Some of the resources related to construction project activities include project workers (workforce), project equipment, materials, capital or money, and the project period as a limit from the end of the project. Therefore, construction projects have essential aspects for assessment by users, namely time, cost, and quality.

2.2 *Lean Construction*

Lean construction is an effort by company management to improve and optimize value and efficiency and reduce waste in the construction industry (Ahmed & Wong, 2018). Lean construction includes (Abdelhamid & Salem 2005): (a) eliminating waste; (b) determining the exact product according to the customer's wishes; (c) identifying processes that show how the material delivery system and provide information to consumers by reducing unnecessary value-added; (d) make products when needed very quickly; and (e) making perfect products by continuous improvement.

2.2.1 VALSAT (*Value Stream Mapping Analysis Tools*)

VALSAT is a method used to generate waste weighting using the scale on the VALSAT table according to theory (Singh & Kumar, 2020). VALSAT data includes production activities, production time, the relationship between 7 (seven) types of waste, the weighting of the Waste Assessment Questionnaire, the calculation of the Waste Assessment Questionnaire, and the analysis of PAM. PAM identifies lead times for physical, and information product flows. The basic concept is to map each stage of existing activities, starting from the operation, transportation, inspection, delay, and storage. After that, grouping is then carried out into the categories of Value Added (VA), Necessary Non-Value Added (NNVA), and Non-Value Added (NVA).

2.2.2 *Big Picture Mapping* (BPM)

Big picture mapping is a tool or method adopted by the Toyota Production System in describing the production system as a whole by adding a value stream to find out inefficient process flows for both material flow and information flow (Thakkar & Shah, 2021).

2.2.3 Waste Analysis

To improve project efficiency, efforts are needed to eliminate and eliminate activities in the form of non-value-added (not providing added value). Zanotti et al. (2017) categorize the types of project activities into 3 (three), namely: (1) Value Added Activity (VA), which is an activity that can provide added value to the implementation of project activities, either through the flow of information or through the flow of information. For example, physical project activities; (2) Non-Value Added Activity (NVA), which is an activity that does not add value to all project activities. This activity includes the type of waste that can result in the process not running efficiently; (3) Non-Value Added but Necessary Activity (NNVA), an action that does not provide added value to the project but is still required to carry out all series of activities on the project. Non-value Added but Necessary activities cannot be eliminated but can be minimized.

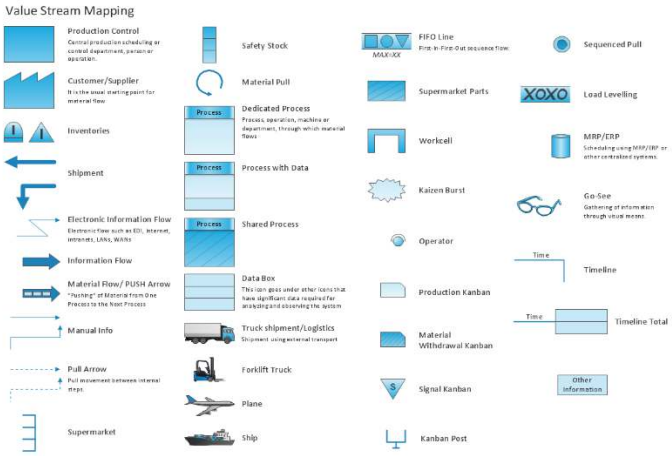


Figure 1. Symbol of VALSAT (Dinesh *et al*., 2017)

3. RESEARCH METHODS

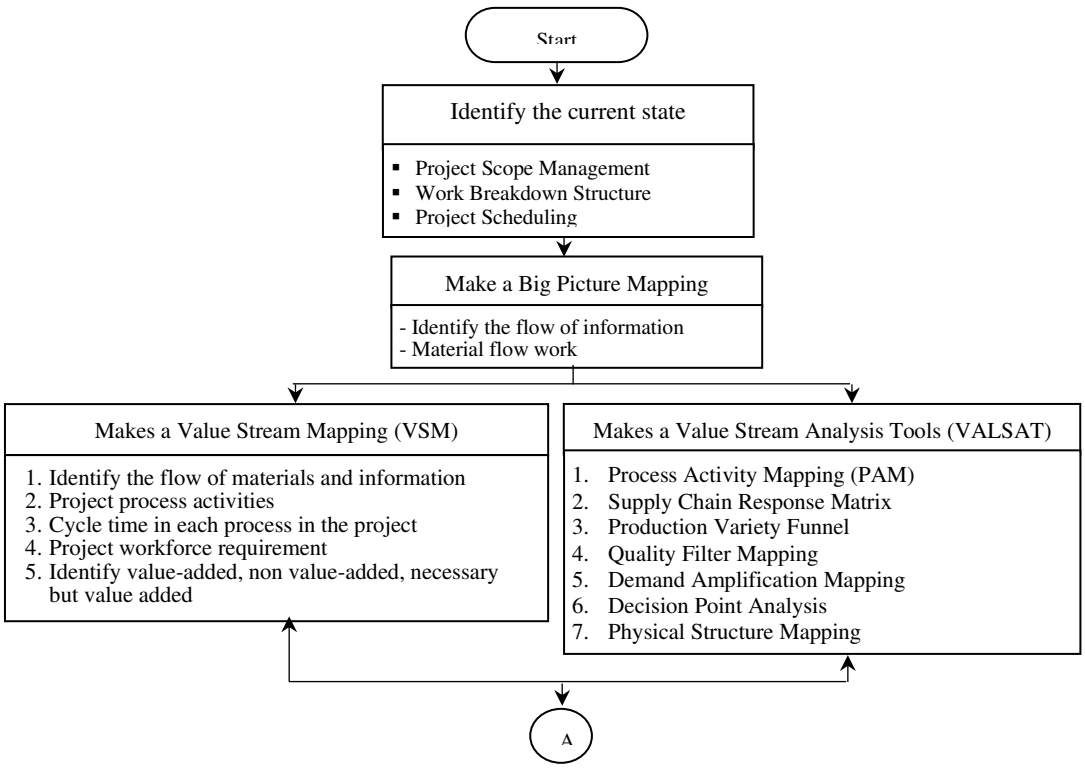


Figure 1. Research Methodology

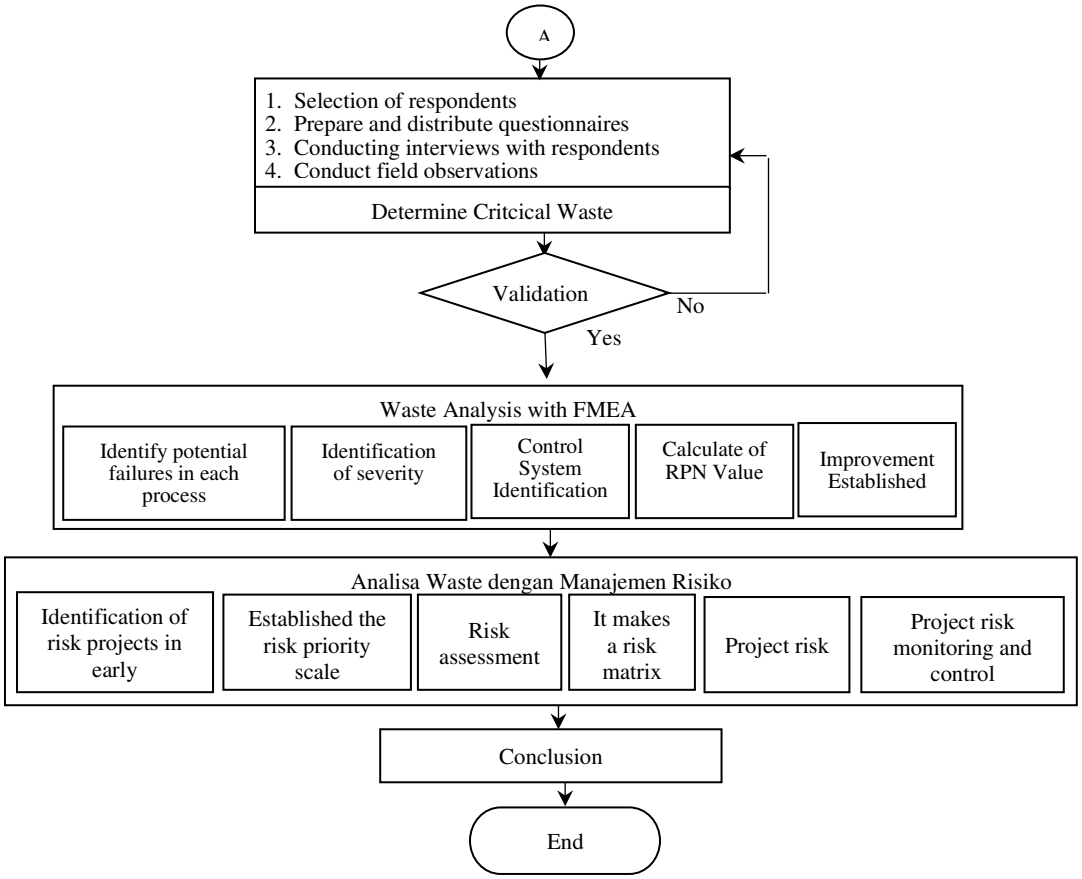


Figure 1. Research Methodology (contiunous)

4. RESULT AND DISCUSSION

4.1 Information Flow of Oil Pipeline Replacement and Installation Process

Table 1. Information Flow of Oil Pipeline Replacement and Installation Process

Process	Activity	Target Time (days)	Time Realized (days)	Time Delay (days)
Engineering	Preliminary survey	18	22	4
	Calculation	45	61	16
	Analysis of survey results	36	52	16
	Detail Engineering Design	65	84	19
Sub Total Time Duration for Engineering Stage		164	219	55
Procurement	Needs analysis and planning	85	138	53
	Assessment of vendors or suppliers	32	57	25
	Lowest price offer	45	48	3
	Choosing the right vendor or supplier	18	14	-4
	Order mailing	6	10	4
	Development of sourcing/outsourcing strategy	52	66	14
	Purchase finalization	22	26	4
	Supervision	14	14	0
	Goods receipt	25	39	14
	Repayment	14	12	-2
Sub Total Time Duration for Procurement Stage		313	424	111
Construction	Mobilization and Survey	15	23	8
	Site clearing and grading	11	13	2
	Pipeline hauling: - Load and unload pipes - Load and unload joints - Load and unload hot bend pipe	 3 1 6	 8 7 12	 5 6 6
	Pipeline stringing	18	30	12
	Line-up welding	10	19	9
	Non Destructive Test	3	5	2
	Field joint coating	7	9	2
	Holiday test	4	6	2

	Trenching	109	230	121
	Pipe lowering	10	15	5
	Tie-in: - Pipe Installation - Reaming - Pipe connection	 36 13 43	 64 20 55	 28 7 12
	NDT	10	13	3
	Backfilling	42	51	9
	Cleaning	59	61	2
	Pigging	21	30	9
	Chatodic Protection Installation	30	37	7
	Re-instatement	23	35	12
	Aerial marker, warning sign, marker sign	30	39	9
	Pre – Commissioning	78	83	5
	Commissioning	5	7	2
Sub Total Time Duration for Construction Stage		587	872	285
Total		1064	1515	451

Source: Rokan Area Oil Pipe Replacement and Installation Project Data (2018 – 2021) – Processed data

4.2 *Current State Value Stream Mapping*

Current state mapping illustrates the current state of the oil pipeline replacement and installation in the Rokan area. With this current state mapping, it will be known about the flow of the pipe replacement and installation process along with the time required during the work process.

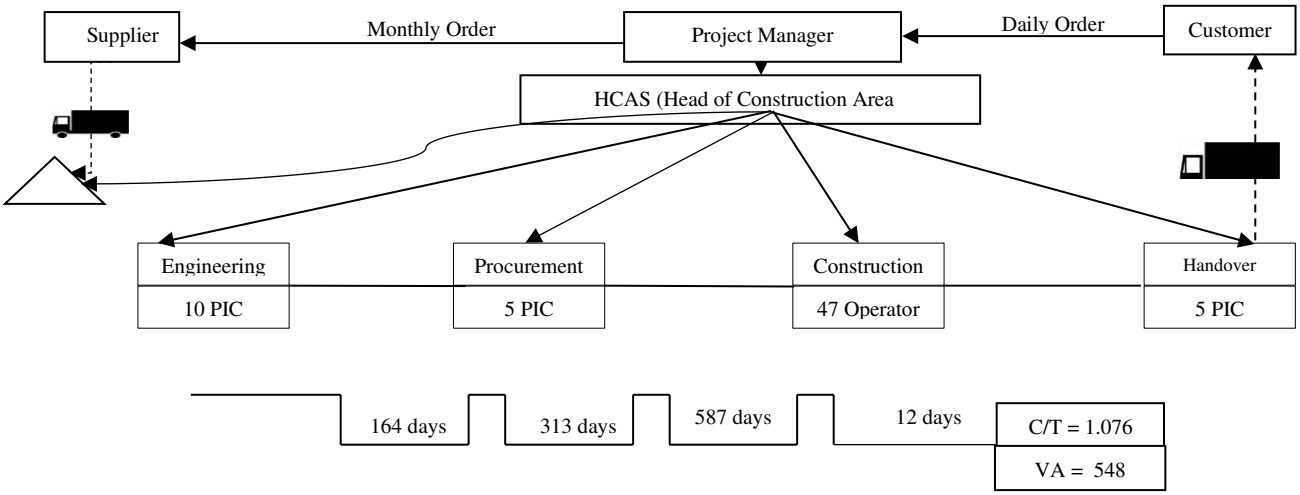


Figure 2. Current State Value Stream Mapping on Oil Pipeline Installation in Rokan Region

4.3 Seven Waste Relationship

At this stage is an activity to identify waste linkages using weighting on company needs. The following are the weighting criteria with variables X and Y filled using 7 (seven) types of waste, namely:

Table 2. Seven Waste Relationship Scale

No.	Question	Answer Options	Skor
1.	Does Waste X result in or produce Waste	a. Often	4
		b. Not Often	2
		c. Seldom	0
2.	What is the relationship between Waste X and Waste Y	a? The increase in waste X is followed by Y	2
		b. The increase in waste X is not followed by Y	1
		c. The increase occurs according to the situation and conditions	0

After knowing the questions and the measurement scale, the following is the total score of the questionnaire results on the relationship between waste in the replacement and installation of oil pipes in the Rokan area.

Table 3. Types of Waste

Waste	
O	Overproduction
I	Inventory
D	Defect
M	Motion
T	Transportation
W	Waiting
P	Processing

Table 3 shows the answers in the form of assessment scores given by respondents to the Seven Waste Relationship Scale with the types of waste.

Table 4. Calculation of Waste Relationship

Question Relationship	P1	P2	P3	P4	Total Score
O-I	4	0	2	2	8
O-D	4	1	4	2	11
O-T	4	2	2	4	12
O-P	2	1	2	2	8
O-W	2	2	4	4	12
I-O	4	1	2	2	9
I-D	4	0	2	2	8
I-M	2	2	4	2	10
I-T	4	2	2	4	12
I-P	2	1	2	2	7
I-W	4	2	4	2	12
D-O	4	2	4	2	12
D-I	4	2	2	4	12
D-M	4	2	4	2	12
D-W	4	1	4	4	13
M-O	2	1	4	2	9
M-I	2	2	4	4	12

Question Relationship	P1	P2	P3	P4	Total Score
M-D	2	1	2	2	7
M-T	4	1	4	4	13
M-W	4	1	4	2	11
M-P	2	0	4	2	8
T-O	2	1	2	2	7
T-I	2	2	4	4	12
T-D	2	0	2	2	6
T-M	2	1	2	2	7
T-P	2	2	2	2	8
P-O	2	0	4	2	8
P-I	2	0	2	2	6
P-D	4	2	4	2	12
P-M	4	1	4	2	11
W-M	4	2	4	2	12
W-O	2	1	4	4	11
W-I	4	1	4	2	11
W-D	4	2	4	2	12

After getting the score above, the next step will be to convert the score with the conversion reference as follows:

Table 5. Conversion of Waste Relationship Values

Range	Relationship Type	Symbol
12 – 14	Necessary	A
9 – 11	Especially Important	E
6 – 8	Important	I
3 – 5	Ordinary Closeness	O
1 – 2	Unimportant	U
0	No relation	X

(Balabuch, 2017)

Table 6. Relationship between Waste

Question Relationship	Total Score	Linkage Level		Question Relationship	Total Score	Linkage Level
O-I	8	I		M-D	7	I
O-D	11	E		M-T	13	A
O-T	12	A		M-W	11	E
O-P	8	I		M-P	8	I
O-W	12	A		T-O	7	I
I-O	9	E		T-I	12	A
I-D	8	I		T-D	6	I
I-M	10	E		T-M	7	I
I-T	12	A		T-P	8	I
I-P	7	I		P-O	8	I

I-W	12	A		P-I	6	O
D-O	12	A		P-D	12	A
D-I	12	A		P-M	11	E
D-M	12	A		W-M	12	A
D-W	13	E		W-O	11	A
M-O	9	E		W-I	11	E
M-I	12	A		W-D	12	A

Tabel 7. Matrix of Waste

F/T	**O**	**I**	**D**	**M**	**T**	**P**	**W**
O	A	I	E	X	A	I	A
I	E	A	I	E	A	I	A
D	A	A	A	A	X	X	E
M	E	A	I	A	A	I	E
T	I	A	I	I	A	I	X
P	I	O	A	E	X	A	X
W	A	E	A	A	A	X	A

Based on the matrix that has been compiled, a value for each matrix will be given with the following values:

Table 8. Matrix Score Conditions

Symbol	Score
A	10
E	8
I	6
O	4
U	2
X	0

After knowing the provisions of the matrix score then, the score will be calculated as follows:

Table 8. Matrix Score Conditions

F/T	O	I	D	M	T	P	W	Score	%
O	10	6	8	0	10	6	10	50	14.045
I	8	10	6	8	10	6	10	58	16.292
D	10	10	10	10	0	0	8	48	13.483
M	8	10	8	10	10	6	8	60	16.854
T	6	10	6	6	10	6	0	44	12.360
P	6	4	10	8	0	10	0	38	10.674
W	10	8	10	10	10	0	10	58	16.292
Score	58	58	58	52	50	34	46	356	100.000
%	16.292	16.292	16.292	14.607	14.045	9.551	12.921	100.000	

Source: Data Processing (2022)

Based on the results of the matrix assessment, it is found that the most significant waste is from Waiting at 16.3%, motion at 16.8%, and from Inventory at 16.3%. So these results indicate that waiting, motion, and inventory waste is the most influential and occur the most. This can suggest that Waiting, Motion, and Inventory waste are caused mainly by other wastes.

4.4 Waste Assessment Questionnaire

The waste value obtained from WRM is then used for the initial WAQ assessment based on the type of question. Each question from the questionnaire represents an activity, condition, or behavior in all project activities or activities that may cause waste. Some of the questions are grouped

in the "From" type, meaning that the question refers to any waste that can trigger or generate different types of waste. In comparison, the other questions represent the type of "To," which means all kinds of waste generated by other wastes.

The Waste Assessment Questionnaire in this study consisted of 20 questions according to the identification of the waste that occurred. Each waste in this study has a relationship with other waste, so the assessment of the questionnaire score will be determined as follows:

1. In the first classification, namely A, if the answer is "YES," then it gets a score of 1; if "Medium," then 0.5, and if "No," then the score is 0.
2. In the second classification, namely B, if the answer is "YES," the score is 0. If "Medium," the score is 0.5, and if "No," the score is 1.

Table 10. Waste Assessment Questionnaire

No.	Question Type	Question Category	Wasteful Relationship	Question
1.	To Motion	*Man*	B	Does the management often transfer operators for all work related to changing and installing oil pipes, especially for handling machinery and equipment, so that all operators can do one type of work?
2.	From Waiting	*Man*	B	Does the company provide a schedule for operators to carry out activities by changing and installing oil pipelines in the Rokan area?
3.	From Process	*Man*	B	Has work safety protection (PPE use) been used in the work area when changing and installing oil pipes in the Rokan area?
4.	From Transportation	*Man*	B	Do operators find it challenging to move project materials, machinery, and equipment from one work station to another in the oil pipe replacement and installation project in the Rokan area?
5.	From Motion	*Material*	B	Are identical materials stored in one location to reduce search time in inventory handling related to oil pipeline replacement and installation projects in the Rokan area?
6.	From Inventory	*Material*	A	Is there any unimportant or residual material around the pile of materials or after the oil pipe replacement and installation project in the Rokan area is completed?
7.	From Defect	*Material*	A	Is there an excessive accumulation of material (remaining in the project implementation process) due to errors or failures during the replacement and installation of oil pipeline projects in the Rokan area?
8.	To Transportation	*Material*	A	Is there a buildup of material in the work area that can block the road or the implementation of project mobilization so that the oil pipe replacement and installation activities in the Rokan area are spent too much on transportation?
9.	From Transportation	*Material*	B	Is the material for a sub-project of oil pipe replacement and installation received in one shipment?
10.	From Process	*Machine*	B	Has testing of the efficiency of machines and equipment and standard specifications for work results and installations been carried out periodically?
11.	From Overproduction	*Machine*	A	Is there a project leadership policy to carry out excessive sub-project work to achieve engine utilization in the oil pipeline replacement and installation project in the Rokan area?
12.	From Waiting	*Machine*	A	Does the sub-work process for replacing and installing oil pipes take a long time to set up, causing delays in the following work process?
13.	From Transportation	*Machine*	B	Is the capacity of material handling equipment sufficient to lift the heaviest loads in large quantities for implementing the oil pipeline replacement and installation project in the Rokan area?
14.	To Transportation	*Method*	B	Is the project work area sufficient for free movement of project materials, machinery, and equipment to replace and install oil pipelines in the Rokan area?
15.	To Waiting	*Method*	B	Is the reordering schedule related to the addition of materials, machines, or equipment adjusted to the number of needs and user requests?
16.	From Defect	*Method*	B	Is there any implementation of Quality Control in the work process of the oil pipe replacement and installation project in the Rokan area?
17.	To Waiting	*Method*	B	If a delay in sub-project work on replacement and installation is determined, is the delay communicated to all parts of the project?
18.	To Defect	*Method*	B	Is there a procedure for inspection in each sub-project work produced at the Rokan area oil pipeline replacement and installation project?
19.	From Process	*Method*	B	Is there a schedule arrangement for the needs of each type of sub-work so that there is no need to repeat machine or equipment settings in the oil pipe replacement and installation project in the Rokan area?

20.	From Waiting	*Method*	B	Is the storage space used effectively for the storage of project materials and spare parts of machines or equipment so that there is no need to make repeated orders for oil pipe replacement and installation projects in the Rokan area?

After the assessment classification is carried out, the waste ranking will be measured with the following steps:

1. Counting questions From and To

Table 11. Number of Types of Questions To and From

No.	Jenis Pertanyaan	Total (Ni)
1.	From Overproduction	1
2.	From Inventory	1
3.	From Defects	2
4.	From Motion	1
5.	From Transportation	3
6.	From Process	3
7.	From Waiting	3
8.	To Defects	1
9.	To Motion	1
10.	To Transportation	2
11.	To Waiting	2
Total		20

2. Make a mapping activity for the replacement and installation of oil pipelines

Table 12. Mapping Activities for Oil Pipe Replacement and Installation in the Rokan Region

No.	Activity	Number of Activity	Time (Day)	Percentage (%)
1.	Delay (D)	5	299	19,7
2.	Operation (O)	18	817	53,9
3.	Transportation (T)	5	96	6,3
4.	Storage (S)	1	7	0,5
5.	Inspection (I)	9	296	19,5
Total		38	1515	100

Source: Data Processing (2022)

Table 13 Recapitulation of Oil Pipe Replacement and Installation Activities in the Rokan Region

Rekapitulasi Hasil VA, NVA, dan NNVA			
Activity	Number of Activity	Time (Day)	Percentage
VA (Value Added)	10	592	39,07 %
NVA (Non-Value Added)	17	644	42,51 %
NNVA (Necessary but Non-Value Added)	11	279	18,42 %
Total	38	1.515	100,00%

Source: Data Processing (2022)

4.5 Waste Analysis Based on Value Stream Analysis Tools (VALSAT)

Following the results of the identification of waste related to one another, the subsequent analysis is carried out using the VALSAT model to determine the appropriate tools for the research. Based on the identification results, it can be concluded that the number of production processes that have no value can be calculated. Based on the PAM (Processing Activity Mapping) method, the results of the analysis of waste in the work process of the oil pipe replacement and installation project in the Rokan area can be explained in Table 14 below according to the NNVA categorization during the production process.

Table 14. RPN Value in Replacement and Installation Projects Oil Pipeline in Rokan Wilayah Region

No.	Potential Failure	Severity	Occurancy	Detection	RPN	Rank
1.	Initial survey data is lacking or inaccurate.	4.75	3	4	57	15
2.	RAB calculation is not accurate	6	5.5	4.25	140.3	10
3.	An error occurred in the project analysis	7	6	6	252	4
4.	Inaccuracy in Engineering Design Details	4	4	5.5	88	13
5.	The duration of the permit from the local government	8.25	8.25	5.5	374.3	1
6.	The duration of permission from the Board of Directors	7	7.25	3.75	190.3	6
7.	The selection of vendors or suppliers is too long	5.25	5.25	3.25	89.6	12

Table 14. RPN Value in Replacement and Installation Projects Oil Pipeline in Rokan Wilayah Region (continuous)

No.	Potential Failure	Severity	Occurancy	Detection	RPN	Rank
8.	The supplier or vendor cannot fulfill the project leader's request	3.5	4.25	3	44.6	17
9.	Demands of land owners and affected people	4.25	6.75	6.25	179.3	7
10.	Material damage when received	2.75	2.5	4.75	32.7	18
11.	Lack of project support equipment	7.25	6.75	4.75	232.5	5
12.	Complex project work	5.5	8.75	6.25	300.8	3
13.	Cleaning process failure	2	3	5	30	19
14.	Re-work occurred due to the failure of sub-project work	6	6.25	4.75	178.1	8
15.	The equipment maintenance process is not carried out properly.	6.75	7.5	7	354.4	2
16.	Bad weather conditions	2.75	2.25	4.25	26.3	20
17.	Connection failure	5	2.75	3.75	51.6	16
18.	Test failure	7.5	2.75	3.75	77.3	14
19.	Workers do not understand project work	7	6.75	3.75	177.2	9
20.	Incompetent project leader	5.75	4.5	4.5	116.4	11

Table 15. Project Activities for Replacement and Installation of Pipes in the Rokan Area that can be reduced in time

No.	Activity Description	Time (day)	Activity					Type of Activity		
			O	T	I	S	D	VA	NVA	NNVA
Engineering										
1.	Preliminary survey	8								
2.	Calculation	11								
3.	Analysis of survey results	5								
4.	Detail Engineering Design	15								
Procurement										
5.	Needs analysis and planning	40								
6.	Assessment of vendors or suppliers	14								
7.	Lowest price offer	15								
8.	Choosing the right vendor or supplier	7								
9.	Order mailing	5								
10.	Development of sourcing/outsourcing strategy	0								
11.	Purchase finalization	5								
12.	Supervision	0								
13.	Goods receipt	0								
14.	Repayment	7								
Construction										
15.	Mobilization and Survey	13								
16.	Site clearing and grading	6								
17.	Load and unload pipe	7								
18.	Load and unload joint	6								
19.	Load and unload hot bend pipe	9								
20.	Pipeline stringing	7								
21.	Line-up welding	0								
22.	Non Destructive Test	2								
23.	Field joint coating	0								
24.	Holiday test	3								
25.	Trenching	130								

Table 15. Project Activities for Replacement and Installation of Pipes in the Rokan Area that can be reduced in time (continuous)

No.	Activity Description	Time (day)	Activity					Type of Activity		
			O	T	I	S	D	VA	NVA	NNVA
26.	Pipe lowering	4								
27.	Pipe Installation	0								
28.	Reaming	0								
29.	Pipe connection	0								
30.	NDT (*Non-Destructive Tests*)	3								
31.	Backfilling	11								
32.	Cleaning	6								
33.	Pigging	0								
34.	Chatodic Protection Installation	16								
35.	Re-instatement	0								
36.	Aerial marker, warning sign, marker sign	9								
37.	Pre – Commissioning	0								
38.	Commissioning	0								

Source: Data Processing (2022)

Based on Table 15, several activities can be reduced in time, especially at the engineering stage, which can be minimized to 180 days from the initial 219 days, so that project work is more effective because there is a reduction in time of 39 days. Likewise, in the procurement stage, it can be minimized to 331 days from the initial 424 days, so project work is more effective because there is a reduction in time of 93 days. Meanwhile, at the construction stage, it can be minimized to 630 days from the initial 872 days, so that project work is more effective because there is a reduction in time of 242 days.

4.6 Future State Value Stream Mapping

Following the PAM description in the previous explanation, the future state value stream mapping can be illustrated as shown in Figure 2 below:

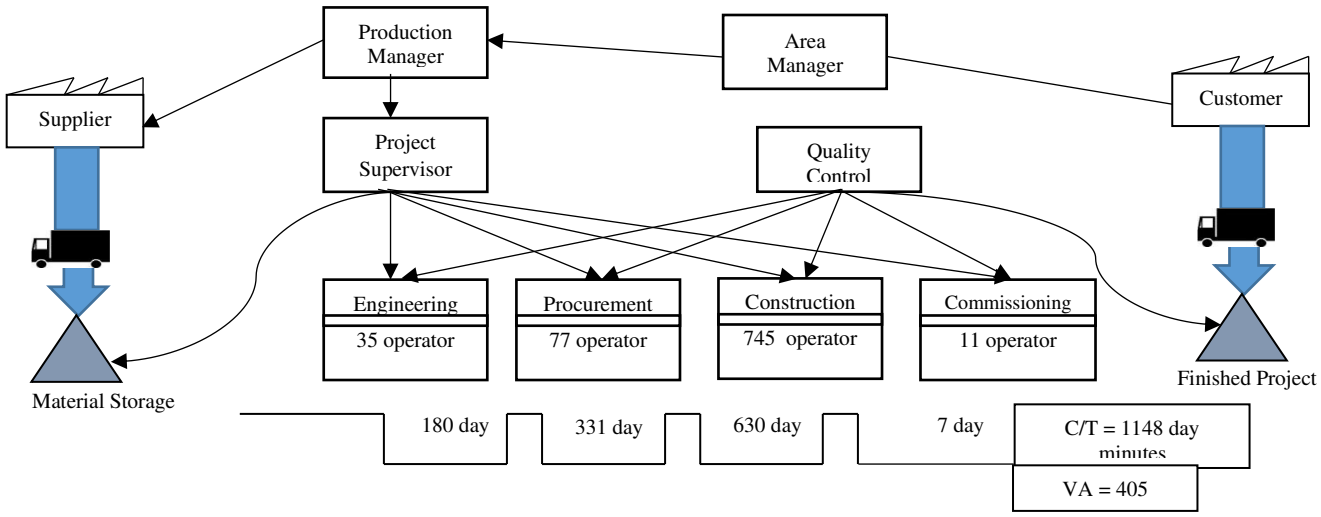


Figure 2. Future State Value Stream Mapping on Project

5. Conclusion

The following are conclusions that can be drawn from the results and discussion of this thesis research, namely as follows:

1. In this study, the project process for replacing and installing oil pipelines in the Rokan area went through several stages, namely engineering, engineering, and construction. In

comparison, the way to identify waste in this research is using WAM and VALSAT to obtain waste waiting as the most dominant in the form of NNVA with a lead time of 288 days.

2. Analysis of the selected VALSAT tools is Process Activity Mapping from Process Activity Mapping. It is known that the total time Value Added Activity is 405 days with a time saving of 190 days, Non-Value Added Activity is 527 days, time savings is 117 days, and Necessary But Non-Value Added Activity by 216 days saving time by 63 days.
3. Based on the FMEA analysis, three problems in the oil pipe replacement and installation project in the Rokan area are the length of licensing from the local government, the equipment maintenance process is not carried out properly, and the project work is complex.
4. Meanwhile, based on PAM's recommendation, project activity time reductions were obtained, including operations reduced from 817 days to 588 days, inspection reduced from 296 days to 249 days, delays were reduced from 299 days to 233 days, and transportation was reduced from 96 days to 71 days. In addition, there are savings in using a workforce of 98 people.

6. Reference

Abdelhamid, T., & Salem, S. (2005). Lean construction: A new paradigm for managing construction projects. In *Proceedings of the International Workshop on Innovations in Materials and Design of Civil Infrastructure*, pp. 28-37.

Ahmed, M. E. A. M., & Wong, L. S. (2018). Assessment of lean construction practice at selected construction sites in Klang Valley. *International Journal of Engineering and Technology*, vol. 7, no. 2, pp. 125-130.

Dinesh, S., Sethuraman, R., & Sivaprakasam, S. (2017). The review on lean construction as a practical approach in the construction industry. *International Journal of Engineering Research and Modern Education, Special Issue*, pp. 119-123.

Ghosh, S., & Burghart, J. (2021). Lean Construction: Experience of US Contractors. *International Journal of Construction Education and Research*, vol. 17, no. 2, pp. 133-153.

Gunduz, M., & Fahmi Naser, A. (2017). Cost-based value stream mapping as a sustainable construction tool for underground pipeline construction projects. *Sustainability*, vol. 9, no. 12, pp. 2184-2198.

Hakas Prayuda, F. M., Cahyati, M. D., Hermansyah, B., & Afriandini, D. B. (2021). Critical Review on Development of Lean Construction in Indonesia. *Journal of Reliability System*, vol. 12, no. 3, pp. 671-688.

Kim, D., & Park, H. S. (2006). Innovative construction management method: Assessment of lean construction implementation. *KSCE Journal of Civil Engineering*, vol. 10, no. 6, pp. 381-388.

Li, S., Fang, Y., & Wu, X. (2020). A systematic review of lean construction in Mainland China. *Journal of Cleaner Production*, vol. 2, no. 57, pp. 125-136.

Nowotarski, P., Paslawski, J., & Skwarek, J. (2019). Waste Reduction by Lean Construction-Office Building Case Study. *IOP Conference Series: Materials Science and Engineering* (Vol. 603, No. 4, p. 042061). IOP Publishing.

Salem, O., Solomon, J., Genaidy, A., & Minkarah, I. (2006). Lean construction: From theory to implementation. *Journal of management in engineering*, vol. 22, no. 4, 168-175.

Sarhan, J. G., Xia, B., Fawzia, S., & Karim, A. (2017). Lean construction implementation in the Saudi Arabian construction industry. *Construction Economics and Building*, vol. 17, no. 1, pp. 46-69.

Singh, S., & Kumar, K. (2020). Review of literature on lean construction and lean tools using systematic literature review technique (2008–2018). *Ain Shams Engineering Journal*, vol. 11, no. 2, 465-471.

Saygili, M., Erdekli, Y. K., & Tokdemir, O. B. (2019). Research development of Lean Construction Journal: a bibliometric analysis. *Lean Construction Journal*.

Thakkar, H., & Shah, V. A. (2021). Barriers to Implementation of Lean Construction Techniques in Gujarat Construction Industry. *International Journal of Engineering Technologies and Management Research*, vol. 8, no. 4, pp. 17-24.

Wen, Y. (2014). Research on cost control of construction project based on the theory of lean construction and BIM: case study. *The Open Construction and Building Technology Journal*, vol. 8, no. 1, pp. 261-279.

Zanotti, N. L., Maranhao, F. L., & Aly, V. L. C. (2017). Bottom-up strategy for lean construction on-site implementation. *25th Annual Conference of the International Group for Lean Construction (IGLC)*, 9-12 July 2017. Heraklion. Greece.

ANALYSIS OF INTEREST OF USING EV CHARGING PLATFORM CHARGE.IN BY USING MODIFIED TAM

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ABSTRACT

PT PLN (Persero) has launched Charge.IN, an aggregator platform for electric vehicle charging operating systems and payment transactions at Electric Vehicle Charging Station (EVCS) based on Open Charge Point Protocol (OCPP) 1.6. The benefits and conveniences offered by Charge.IN can affect the increasing interest of electric vehicle users to use Charge.IN. So it is necessary to do a study to measure the acceptance of Charge.IN technology. This study identifies the factors that influence the success of technology acceptance especially it is mobile application by using the Technology Acceptance Model (TAM). The survey only addressed to Charge.IN users. The questions in the survey use a modified TAM approach. Testing Outer Model and Inner Model to test and analyze data from research instruments using the SMART PLS 3.2.9 application. From the results of the test and analysis, it can be seen that of the 14 research hypotheses, it was found that 8 were fails to be rejected and 6 were rejected. It is known that Behavioral Intention has a positive and significant effect on Actual Use, then Perceived Usefulness and Brand Image has a positive and significant effect on Behavioral Intention. System/ Software Quality has a positive and significant effect on Perceived Usefulness, Perceived Ease of Use, Perceived Security, Perceived Risk, and Trust. Meanwhile Perceived Ease of Use, Perceived Security, Perceived Risk, Self Efficacy, Perceived Cost, and Trust have no effect on Behavioral Intention. The results of this study can be a recommendation to PLN to increase the existence of Charge.IN as a charging platform and PLN as pioneers of provider electric vehicle infrastructure in Indonesia.

Keywords: interest of use, Charge.IN, Mobile Application, Electric Vehicle Charging Station, Technology Acceptance Model (TAM), SmartPLS.

1. INTRODUCTION

With the issuance of Presidential Regulation number 55 of 2019 concerning the Acceleration of the Battery Electric Vehicle Program for Road Transportation and Minister of Energy and Mineral Resources Regulation number 13 of 2020 concerning Provision of Electric Charging Infrastructure for Battery-Based Electric Motor Vehicles, PLN has built as many as 96 Electric Vehicle Charging Stations (SPKLU) with 148 chargers until April 2022. PLN also developes Charge.IN, an electric vehicle aggregator platform in Indonesia that works as an operating system for charging electric vehicles on Electric Vehicle (EV) Chargers, payment transactions, and media to improve the user experience of electric vehicles. This platform is a mobile application on smart phones and webdesk using the Open Charge Point Protocol (OCPP).

As a provider of 31.3% of the total 307 SPKLU in Indonesia, this is the basis for conducting this research on Charge.IN (PLN).

The benefits and conveniences offered by Charge.IN can affect the increase in users. When a product has benefits and conveniences in dailylife, it is likely that the product will be used by the wider community. Moreover with Charge.IN, which is considered very helpful for the purpose of charging electric vehicles, it is possible that people will be interested in switching to electric vehicle users. Research using the TAM approach for mobile-based applications has been carried out previously by several researchers, including Wonderful Indonesia (Natalia, Binca, & Pradipta, 2019), mobile banking (Kurniawati, Winarnol, & Arif, 2017), and PLN Mobile (Fahresi, 2021). However, no one has researched the interest in using electric vehicle charging applications in Indonesia. In addition the functions of these applications are still not as complex as the electric vehicle charging application at SPKLU. The Charge.IN which has features that are not only virtual but also interact directly with other objects, such as finding a location, viewing the status of the charger device, operating using QRcode scanning, payment transactions using e-wallet, charging operation processes, into variety car brands can have an influence on interest in use. Therefore, research on the electric vehicle charging platform at SPKLU needs to be carried out.

This study will analyze the factors that influence user acceptance of Charge.IN application technology in Indonesia. In this study, the TAM model was developed by adding variables of perceived security, perceived risk, self-efficacy, perceived cost, system/software quality, trust, and brand image. With the addition of this construct, it is hoped that it will help to better understand user acceptance of the Charge.IN application technology. So that the research objectives are to identify variables that influence the interest of electric vehicle users using Charge.IN and provide recommendations to increase the interest of users of the Charge.IN platform.

2. LITERATURE REVIEW

Electric Vehicle Charging Station (EVCS)

EVCS is an element in the electric vehicle infrastructure that supplies electrical energy to recharge electric vehicles. These stations provide one or more Electric Vehicle Supply Equipment (EVSE) or also called chargers with special connectors that conform to various electrical charging connector standards. Fees for using EVSE is vary, ranging from flat monthly/yearly rates, per-kWh rates, or per hour. For the most part, EVSE is divided into Slow Charger (<22 kW), Medium Charger (>22kW - <50 kW), Fast Charging (> 50 kW - <100 kW), and Ultra Fast Charging (>100 kW). The types of connectors recognized in Indonesia include AC type 2, DC CCS2, DC CHAdeMO. The SPKLU operated by PLN uses the Open Charge Point Protocol (OCPP) as a communication protocol between the EVSE and the Charging Station Management System (CSMS). OCPP is an application protocol for communication between electric vehicle charging stations and a central management system, also known as a charging station network, similar to cell phones and cell phone networks (Alcaraz, Lopez, & Wolthusen, 2017). The original version was written by Joury de Reuver and Franc Buve in 2013.

Charge.IN

To provide benefits and convenience for electric vehicle users, on January 29, 2021, PLN launched Charge.IN, an operating system aggregator platform for PLN's EVCS, payment for SPKLU transactions, and information related to SPKLU using a communication protocol based on Open Charge Point Protocol 1.6. Currently, there are six features in the Charge.IN application for mobile applications:

1. SPKLU Location Search, which is useful for providing information on directions to the SPKLU location, SPKLU location address, distance to SPKLU location, number of EVSE/chargers, connector type, and charging power capacity
2. SPKLU status, provides a utility to identify the availability status of connectors on SPKLU with statuses including “available”, “used”, and “maintenance”
3. Starting and stopping the charging process online, which provides benefits for users to control and monitor the vehicle charging process on the EVSE
4. Payments using e-wallet, which makes digital payments easier because they work with leading fintechs in Indonesia.
5. Energy Consumption, displays the amount of electrical energy used when charging at SPKLU
6. Information on activity and transaction history using SPKLU, which provides benefits for users to monitor transactions and energy that has been used so far at SPKLU, so that it can help report cashflow of electric vehicle users.

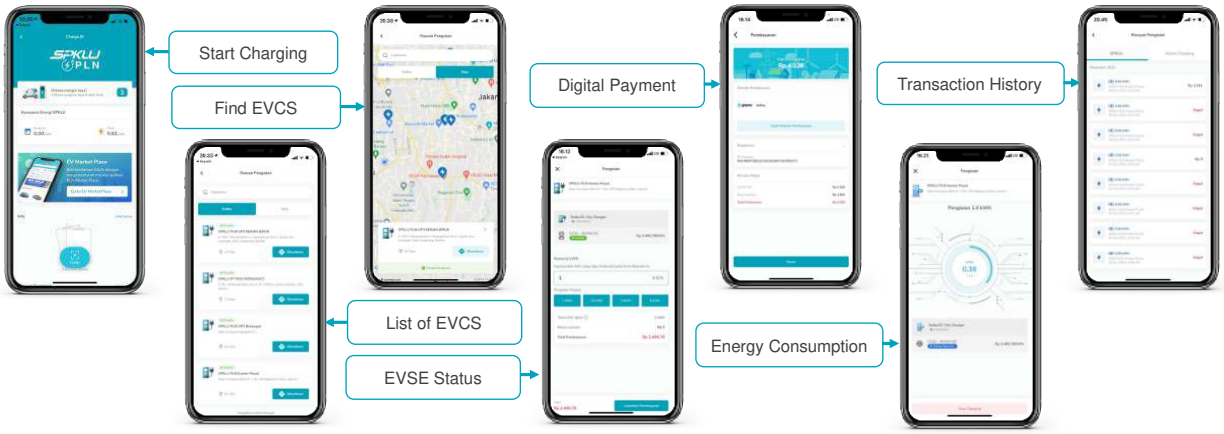


Figure 1. Charge.IN Features

***Technology Acceptance Model* (TAM)**

According to (Davis, 1989), the main purpose of TAM is to provide a basis for exploring the influence of external factors on user beliefs, attitudes, and goals. TAM considers that two individual beliefs, which are perceived usefulness and perceived ease of use, are the main influences on information technology acceptance behavior.

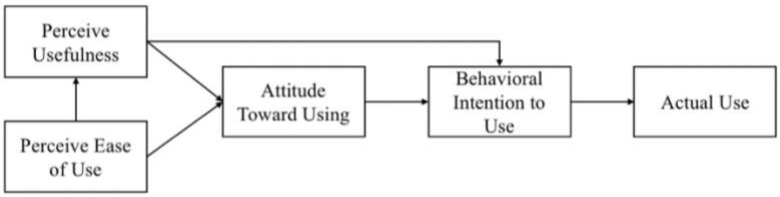


Figure 2. Technology Acceptance Model (Davis, 1989)

In the TAM system, Davis proposes two theoretical constructs that affect individual acceptance technology/systems of information technology, there are:

1. Perceived Usefulness (PU), “The degree to which a person believes that using a particular (information) system would enhance his or her job performance”. The extent to which a person believes that using a technology will improve his or her job performance.
2. Perceived Ease of Use (PEOU), "The degree to which a person believes that using a particular (information) system would be free of effort". The degree to which a person believes that using

a technology will be effort-free. The point is that if a person believes that an information system is easy to use, he will use it.

The first unmodified TAM uses the following five main constructs:

1. *perceived usefulness*
2. *perceived ease of use*
3. *attitude towards behaviour* or *attitude towards using technology*
4. *behavioral intention* or *behavioral intention to use*
5. *behavioral* or *actual technology use*

Structural Equation Model (SEM)

Research models that use several exogenous latent variables, endogenous latent variables, moderating variables, and intervening, must use as more comprehensive analysis technique, namely the structural equation modeling (Ghozali I., 2011a). There are two types of variables used in SEM:

a. latent variables or unobserved variables are variables that cannot be measured directly. Latent variables can be divided into two different variables, exogenous latent variables and endogenous latent variables. Endogenous latent variables are independent or independent variables in the equation, while exogenous latent variables are dependent variables or variables that are not independent.

b. the observed variable (manifest) is a variable that can be measured empirically through survey or census activities (Hair, Risher, Sarstedt, & Ringle, 2019). Manifest variables can be divided into two, exogenous manifest variables that are independent and endogenous manifest variables that are dependent.

The construction model is also known as the inner model, all variables are behind each other based on the substance of the theory. Latent variables has two types, exogenous and endogenous. Exogenous latent variables are causative variables or variables without being preceded by other variables with arrows leading to other variables, also called endogenous latent variables (Sarwono, 2018).

Path analysis is a statistical technique that aims to analyze the causal relationship that occurs in the multiple regression model, if the independent variable / affects the independent variable not only directly but also indirectly. Path analysis is used to find out whether the data used are theoretical, which was previously hypothesized by researchers regarding the structural relationship between variables. The main subjects in path analysis are correlated variables. Three kinds of activities that can be carried out simultaneously by SEM are checking the validity and reliability of instruments (related to confirmatory factor analysis), analysis of testing the relationship model between variables (related to path analysis), and activities to obtain a suitable model for prediction (related to predictions). path analysis), and activities to obtain a suitable model for structural model prediction) (Ghozali, 2011b).

3. METHODS

The Conceptual Framework

The following is the Modified TAM Model that the researcher proposes and hypothesizes in analyzing the interest in using Charge.IN.

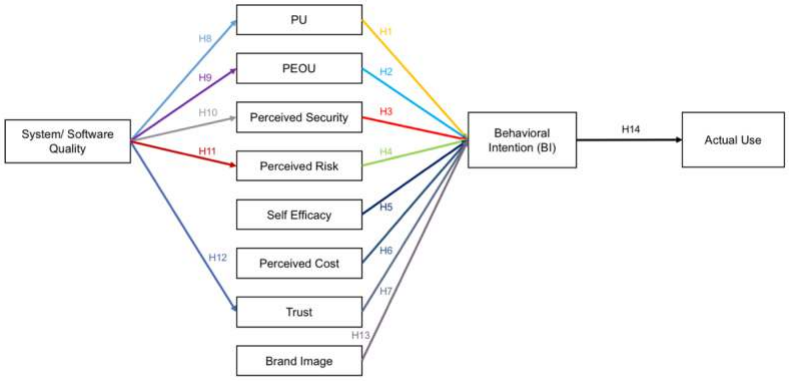


Figure 3. Modified TAM Charge.IN User Adoption

a. Perceived Usefulness (PU) → H1
PU has a positive effect on the use of Charge.IN, in other words whether this platform is useful for user activities.
b. Perceived Ease of Use (PEOU) → H2
PEOU has a positive effect on Behavioral Intention (BI). Ease of using Charge.IN is very necessary.
c. Perceived Security → H3
Perceived Security has a positive effect on Behavioral Intention (BI).
d. Perceived Risk → H4
Perceived Risk has a negative effect on Behavioral Intention (BI).
e. Self Efficacy → H5
Self efficacy has a significant influence on Behavioral Intention (BI).
f. Perceived Cost → H6
Perceived Cost has a significant influence on Behavioral Intention (BI).
g. Trust → H7
Trust has a positive effect on Behavioral Intention (BI).
h. System/ Software Quality (SQ) → H8, H9,H10,H11,H12
System/Software Quality has a positive effect on PU, PEOU, Perceived Security, Perceived Risk, and Trust.
i. Brand Image → H13
Brand Image has a positive effect on Behavioral Intention (BI).
j. Behavioral Intention → H14
Behavioral Intention has a positive effect on Actual Use.

Population and Research Sample

Charge.IN users total 462,499 users in Indonesia (data as of April 2022). Using the slovin formula, the sample value of 100 respondents was obtained.

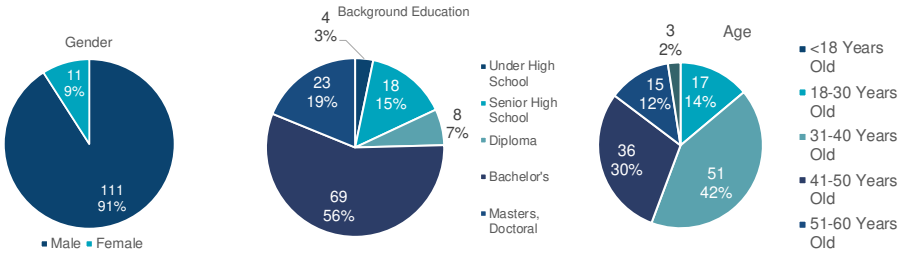
Questionnaire Creation and Distribution

In this study, a questionnaire will be used to collect and analyze data. The type of question structure used is Multiple Choice Questions (used to determine the respondent's profile), 43 closed questions using a 4-point Likert scale method (Strongly Agree, Agree, Disagree, Strongly Disagree). Open-ended questions are also included in the questionnaire, but they are not used to

analyze the data but rather to ensure that the questionnaire is filled out consistently by the respondents and is a forum for making suggestions to the application owner.

4. RESULTS

In testing the model and processing the data, this research uses the SmartPLS 3.2.9 software. Data collection was carried out for 23 days and received answers from 122 respondents. The characteristics of the respondents are known as follows:



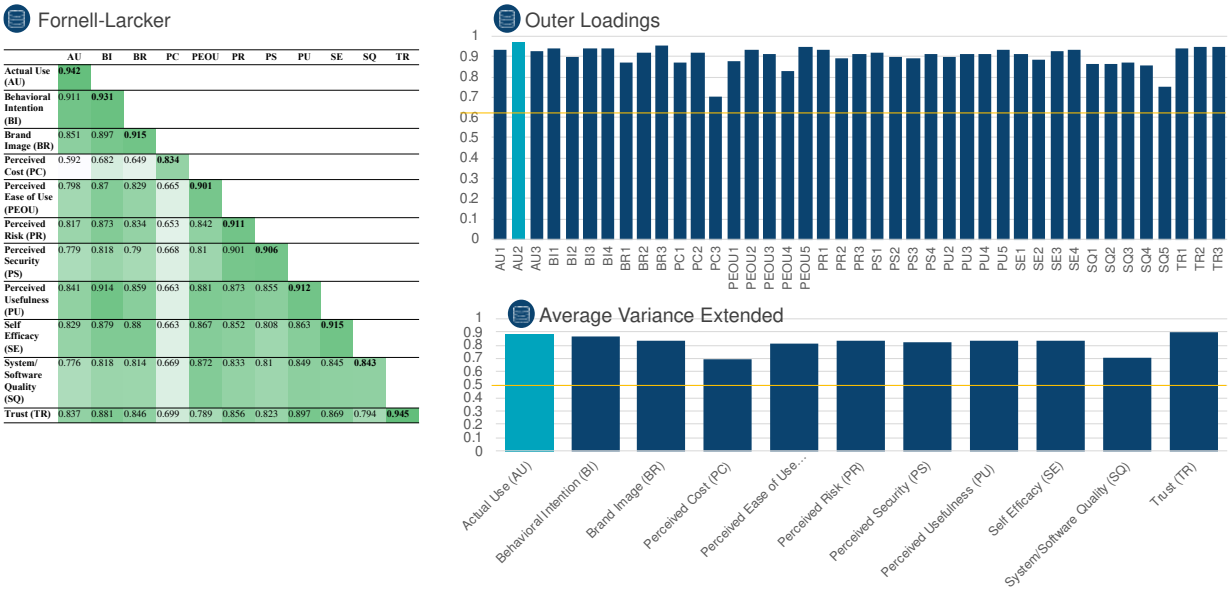
Brand of EV while Using Charge.IN			
	Hyundai Ioniq	61	50.00%
	Hyundai Kona EV	37	30.33%
	Nissan Leaf EV	8	6.56%
	Tesla Model 3	4	3.28%
	Tesla Model X	1	0.82%
	BYD E6	4	3.28%
	Mitsubishi MIEV	1	0.82%
	Lexus UX300e	1	0.82%
	Porsche Taycan EV	4	3.28%
	DFSK	1	0.82%
	Total	**122**	**100.00%**

Figure 4. Respondent Description

Figure 4 shows that out of 122 respondents, 111 people are dominated by the "Male" gender (90.98%). The majority of respondents are aged "31-40 years old", which is 51 people (41.80%). Then it is known that the background education of respondents is dominated by "Bachelor's Degree" as many as 69 people (56.56%). Furthermore, the majority of respondents answered "Hyundai Ioniq" for "Brand of EV while using Charge.IN" with a total of 61 respondents (50%).



Figure 5 Discriminant Validity Test Result



	AU	BI	BR	PC	PEOU	PR	PS	PU	SE	SQ	TR
Actual Use (AU)	**0.942**										
Behavioral Intention (BI)	0.911	**0.931**									
Brand Image (BR)	0.851	0.897	**0.915**								
Perceived Cost (PC)	0.592	0.682	0.649	**0.834**							
Perceived Ease of Use (PEOU)	0.798	0.87	0.829	0.665	**0.901**						
Perceived Risk (PR)	0.817	0.873	0.834	0.653	0.842	**0.911**					
Perceived Security (PS)	0.779	0.818	0.79	0.668	0.81	0.901	**0.906**				
Perceived Usefulness (PU)	0.841	0.914	0.859	0.663	0.881	0.873	0.855	**0.912**			
Self Efficacy (SE)	0.829	0.879	0.88	0.663	0.867	0.852	0.808	0.863	**0.915**		
System/ Software Quality (SQ)	0.776	0.818	0.814	0.669	0.872	0.833	0.81	0.849	0.845	**0.843**	
Trust (TR)	0.837	0.881	0.846	0.699	0.789	0.856	0.823	0.897	0.869	0.794	**0.945**

Figure 6 Discriminant Validity Test Result

Convergent Validity and Discriminant Validity test results meet the test requirements, all measuring items are valid and can be used to measure each latent variable.

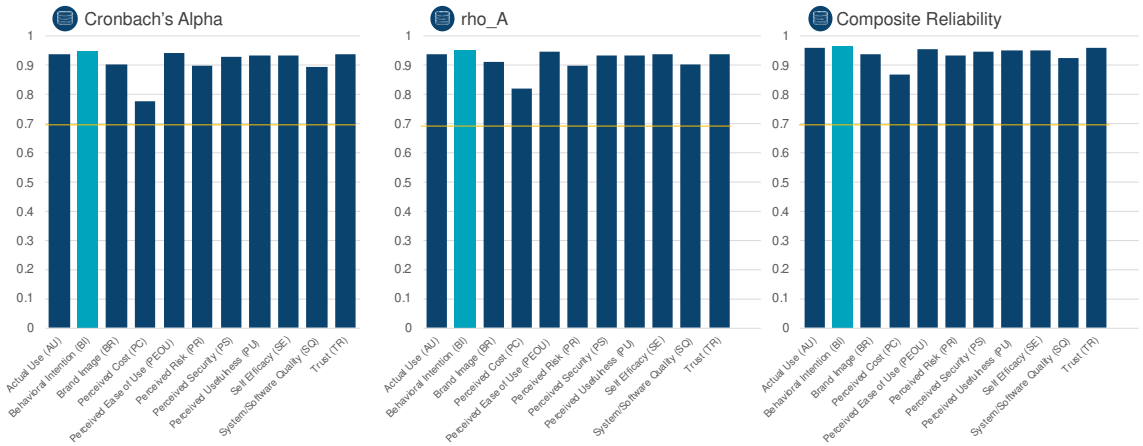


Figure 7. Construct Reliability Evaluation

Based on Figure 6, it is known that all constructs are acceptable for reliability, behavioral intention has the best reliable construct, and although it is still declared reliable, the Perceived Cost (PC) has the lowest value.

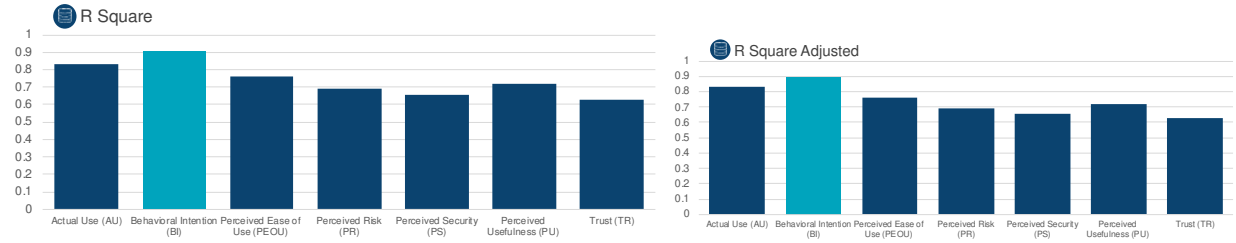


Figure 8. Coefficient Determination

Coefficient Determination test results, interest in using the Charge.IN application is influenced 90% by System/Software Quality, Self Efficacy, Perceived Cost, and Brand Image.

Table 1. Cohen Effect Test

Relationship	f²	*Effect Size*
BI --> AU	4.878	big
BR --> BI	0.148	small
PC --> BI	0.007	-
PEOU --> BI	0.028	small
PR --> BI	0.037	small
PS --> BI	0.017	-
PU --> BI	0.097	small
SE --> BI	0.002	-
SQ --> PEOU	3.172	big
SQ --> PR	2.259	big
SQ --> PS	1.902	big
SQ --> PU	2.573	big
SQ --> TR	1.703	big
TR --> BI	0.021	small

Based on the test results in table 1, it can be found that there are seven relationships that have a large effect, four relationships have a small effect and the other three have no effect.

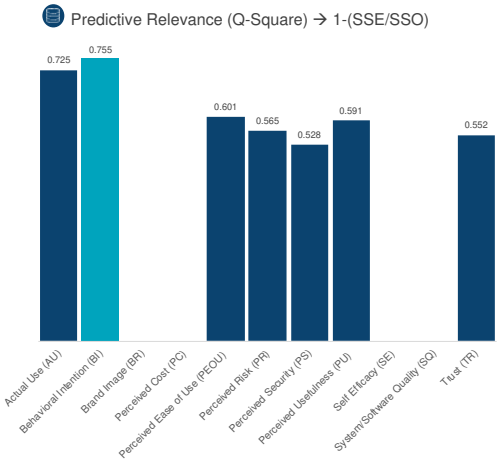


Figure 9. Predictive Relevance Test

From Figure 8, it is known that Behavioral Intention has the Highest Prediction Relevance Level.

Table 2. Hypothesis Testing

Hipotheses	Direct Relationship	Original Sample (O)	T Statistics (|O/STDEV|)	P Values	Decision	
H1	PU -> BI	0.3050	2.4380	**0.0150**	Supported	Positive and Significant
H2	PEOU -> BI	0.1360	1.3170	**0.1880**	Unsupported	No. Effect
H3	PS -> BI	-0.1030	1.2110	**0.2260**	Unsupported	No. Effect
H4	PR -> BI	0.1720	1.8070	**0.0710**	Unsupported	No. Effect
H5	SE -> BI	0.0430	0.3620	**0.7170**	Unsupported	No. Effect
H6	PC -> BI	0.0400	0.6170	**0.5370**	Unsupported	No. Effect
H7	TR -> BI	0.1290	0.8970	**0.3700**	Unsupported	No. Effect
H8	SQ -> PU	0.8490	20.2260	**0.0000**	Supported	Positive and Significant
H9	SQ -> PEOU	0.8720	23.6120	**0.0000**	Supported	Positive and Significant
H10	SQ -> PS	0.8100	17.9470	**0.0000**	Supported	Positive and Significant
H11	SQ -> PR	0.8330	18.6040	**0.0000**	Supported	Positive and Significant
H12	SQ -> TR	0.7940	12.9930	**0.0000**	Supported	Positive and Significant
H13	BR -> BI	0.2880	2.3540	**0.0190**	Supported	Positive and Significant
H14	BI -> AU	0.9110	30.3730	**0.0000**	Supported	Positive and Significant

Based on the test results in Table 2 above, it can be concluded that of the 14 hypotheses, 8 are supported and 6 are unsupported. Based on the test results, it was found that Perceived Usefulness (PU) had a positive and significant effect on Behavioral Intention (BI). This is indicated by the path coefficients value of 0.305 which is close to the value of +1, the T-Statistic value of 2.438 (> 1.96) and the p-value of 0.015 (<0.05), thus H1 fails to be rejected, the higher the Perceived Usefulness (PU) the more Behavioral Intention (BI) is also high. Meanwhile, based on the test results it was found that Perceived Ease of Use (PEOU), Perceived Security (PS), Perceived Risk (PR), Self Efficacy (SE), Perceived Cost (PC), and Trust (TR) had no effect on Behavioral Intention. (BI). This is indicated by the successive p-values of 0.188, 0.226, 0.071, 0.717, 0.537, and 0.370 (>0.05), thus H2, H3, H4, H5, H6, and H7 are rejected, so that the high or low Perceived Ease of Use (PEOU), Perceived Security (PS), Perceived Risk (PR), Self Efficacy (SE), Perceived Cost (PC), and Trust (TR), the level of Behavioral Intention (BI) will remain the same. Based on the test results, it was found that System/Software Quality (SQ) had a positive and significant effect on Perceived Usefulness (PU), Perceived Ease of Use (PEOU), Perceived Security (PS), Perceived Risk (PR), and Trust (TR). This is indicated by the path coefficients of 0.849, 0.872, 0.810, 0.833, and 0.794 which are close to the value of +1, the T-Statistic values are 20,226, 23,612, 17,947, 18,604, and 12,993 (>1.96). and the fifth p-value is 0.000 (<0.05), thus H8, H9, H10, H11, and H12 fail to be rejected.

6. CONCLUSIONS

From the results of hypothesis testing and the discussion that has been described previously, several conclusions can be drawn, including the identification of 14 research hypotheses, 8 supported research hypotheses and 6 unsupported research hypotheses were found. PU→BI, SQ→PU PEOU PS PR TR BR→BI, BI→AU, positive and significant effect. PT PLN (Persero) as the owner of the Charge.IN application can focus on increasing Perceived Usefulness (PU), System/Software Quality (SQ), and Brand Image (BR) in order to increase the interest of Charge.IN users. The increase in the use of Charge.IN is more significant and has a major impact by improving and maintaining the quality of the system/software, user self efficacy, exemption

from fees, and Charge.IN compatibility for charging various brands of electric vehicles, so PT PLN (Persero) needs to pay attention to this.

REFERENCES

Alcaraz, C., Lopez, J., & Wolthusen, S. (2017, September). OCPP Protocol: Security Threats and Challenges. *IEEE TRANSACTIONS ON SMART GRID, 8*(5), 2452-2459.

Chuttur, M. (2009). Overview of the Technology Acceptance Model: Origins, Developments and Future Directions. *Working Papers on Information Systems*.

Davis, F. D. (1989). Perceived Usefulness, Perceived Ease of Use, and User Acceptance of Information Technology. *MIS Quarterly, 13*, 319-340.

Fahresi, F. (2021). *Analisis Minat Penggunaan Aplikasi PLN Mobile Dengan Menggunakan Modifikasi Model TAM.* Surabaya: ITS Repository.

Fornell, C., & Larcker, D. F. (1981). Evaluating Structural Equation Models with Unobservable Variables and Measurements Errors. Journal of Marketing Research, Vol.18 No.1, 39¬50. *Journal of Marketing Research*, 39-50.

Ghozali. (2011b). *Structural Equation Modelling Metode Alternatif dengan Partial Least Square (PLS) 3rd ed.* Semarang: Badan Penerbit Universitas Diponegoro.

Ghozali, I. (2011a). *Aplikasi Analisis Multivariate dengan Program IBM SPSS 19* (5 ed.). Semarang: Badan Penerbit Universitas Diponegoro.

Hair, J. F., Risher, J. J., Sarstedt, M., & Ringle, C. M. (2019, 01 14). When to use and how to report the results of PLS-SEM. *European Business Review, 31*(1).

Kasiram, M. (2010). *Metodologi penelitian: Kualitatif–Kuantitatif.* Malang: UIN-Maliki Press.

Keller, K. L. (2013). *Strategic brand management; Building, measuring, and managing brand equity, 4th Edition.* Pittsburgh: Pearson Education Limited.

Kurniawati, H. A., Winarnol, W. A., & Arif, A. (2017). Analisis Minat Penggunaan Mobile Banking dengan Pendekatan Technology Acceptance Model (TAM) yang Telah Dimodifikasi. *e-Journal Ekonomi Bisnis dan Akuntansi, 4*, 24-29.

Natalia, Binca, S., & Pradipta, I. A. (2019). Analysis User Acceptance Of Wonderful Indonesia Application Using Technology Acceptance Model (case study: Indonesian Ministry Of Tourism). *2019 International Conference on Information Management and Technology (ICIMTech)*.

Sarwono, J. (2018). *Structural Equation Modeling: Theory and Application.* Independently Published.

Sitkin, S. B., & Pablo, A. L. (1992, Jan 19). Reconceptualizing the Determinants of Risk Behavior. *Academy of Management Review, 17*.

Suh, B., & Han, I. (2003). The Impact of Customer Trust and Perception of Security Control on the Acceptance of Electronic Commerce. *International Journal of Electronic Commerce, 7*, 135-161.

Yuliana, K. (2016). Model Kesuksesan Sistem Informasi DeLone dan McLean untuk Evaluasi Sistem Informasi Pos Pada PT. Pos Indonesia (Persero) Divisi Regional VI Semarang. *INFOKOM, 12*.

RISK MANAGEMENT ON CLOUD KITCHEN: CASE STUDY OF A CLOUD KITCHEN IN SURABAYA

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ABSTRACT

Cloud kitchen is a new delivery business model. Despite many advantages offered, there must be some risks in running the cloud kitchen business model. However, there is no research conducted to assess risks and design the appropriate mitigation strategies for eliminating the risks that may occur in cloud kitchens. Due to the absence of risk assessment research on cloud kitchens, the study identifies the risks of using cloud kitchens as a business model and provides a risk management analysis using the house of risk multistakeholder model. The type of cloud kitchen chosen is a cloud kitchen aggregator. The stakeholders mapping results indicate that five main stakeholders are involved in the supply chain risk assessment, and eight respondents are involved, including cloud kitchen management, cloud kitchen staff, merchant management, merchant staff, online food delivery application management, online food delivery application driver, customer, and supplier. Based on risk identification results, 34 risk events and 36 risk agents might occur within the supply chain, with 16 risk agents of priority risk. The selected risks were analyzed and produced 31 preventive actions, which are the responsibility of each stakeholder, with 12 priority preventive actions whose influence on the supply chain reaches 80.24%.

Keywords: Cloud Kitchen, Online Food Delivery Service, House of Risk, Multistakeholder

1. INTRODUCTION

Based on the data from Statista (2022), the online food delivery services itself already has been a breakthrough trend since 2019 and strengthened by the revenue forecast in the online food delivery segment is projected to reach USD 1.136 million in 2022. Let alone given that in 2020, 73% of Indonesians are internet users, with 44% of them using the internet for online food delivery services, 56% for e-commerce shopping, and the rest for grocery shopping. The number and opportunities are still going to be massive and multiplying. Padjar (2021) mentioned that since the pandemic outbreaks, Indonesians tend to choose online food delivery services through aggregated online food delivery apps rather than dine-in, take-home, or takeaway. In 2021, the most considerable amount of transactions from online food delivery applications in South-East Asia (SEA) was created by Grab with a value of USD 7 billion, followed by Food Panda with a value of USD 3.4 billion, and Gojek with a value of USD 2 billion (Yudhistira, 2022).

The significant opportunities ahead are now emerging with the demand of people who want to spend less time eating in restaurants because of COVID, with fewer waiting periods but still want to enjoy excellent food – in the privacy of their own homes, and it is a right time to implement new technology and an operational system called cloud kitchens. Thanks to the well-developed and convenience of one-click order placement, reliable delivery, and integrated digital payments, online food delivery service is a significant disruption in traditional restaurant models.

Cloud kitchen is disrupting the food industry by bringing in cost-efficient shared spaces riding on the back of the revolution brought by online food ordering apps. This model creates value for both end-consumer by expanding their selection and convenience of ordering from home and for the cooked meal providers by significantly reducing their real estate and operational costs. Cloud kitchen can enhance process efficiency, minimizes operating costs, and reduces risk (Beniwal, 2021).

Besides the benefits of the cloud kitchen business model, there must be some risks that may occur in running the cloud kitchen business model. However, there is no research conducted to analyze the risks and design the appropriate mitigation strategies for minimizing or eliminating the risks that may occur in the cloud kitchen business model. This research uses the house of risk method because it can prioritize which risk source is selected first for the most effective action to be taken to reduce the potential risk from the risk agents. The disadvantage of this method is that its implementation requires considerable effort to describe the current business process and define the desired process (Ulfah, 2016).

As a solution due to the absence of risks assessment research on cloud kitchen, the study shall identify the risks of using cloud kitchen as a business model and also as a risk management analysis using the house of risk (HOR) multistakeholder model to give the best suggestions to handle the risks overcoming in the running of cloud kitchen aggregator business model.

2. LITERATURE REVIEW

2.1. Supply Chain Risk Management

Supply chain management is the definition of how organizations manage the flow process of their products, involving the transformation of raw materials within the organization or services the organization delivers. It includes the process of sourcing, procurement, and logistics functions. Supply chain risk management (SCRM) is the process of identifying, assessing, and mitigating the risks that may occur in an organization's supply chain. Implementing global supply chain risk management strategies can help an enterprise operate more efficiently, reduce costs, and enhance customer service (Bailey, 2019).

2.2. House of Risk Multistakeholder

The house of risk concept is founded on the idea that proactive supply chain risk management should try to focus on preventive efforts, primarily in lowering the likelihood of risk agents arising (Pujawan, 2009). The supply chain risk management model that considers stakeholders' interests integrated with the risk assessment, analysis, and evaluation process is still limited in number. Parenreng (2016) developed a risk management model by considering the interests of stakeholders to be involved in risk management or risk assessment process. The house of risk (HOR) model is modified by adding stakeholder functions. In the multistakeholder HOR1 model, the probability of risk occurrence and risk severity is determined, such as in the single stakeholder HOR1 model. If O_j is the probability value of the cause of risk j, SV_{is} is the value of the impact of stakeholder s on risk event i, and R_{ij} is the value of the relationship between risk occurrence j and risk event i, then ARP_{js} (aggregate of potential risks from risk occurrence j and

risk events i). Later on, the HOR multistakeholder has its formulation. The formulation is as follows.

$$ARP_{js} = O_j \sum_i SV_{is} R_{ij}$$

Assuming that each risk occurrence has an ARP value associated with each stakeholder, then the ARP value ranking is determined by accumulating ARP values for all s, formulated as follows.

$$CARP_j = O_j \sum_s \sum_i SV_{is} R_{ij}$$

The HOR2 multistakeholder model developed by Parenreng (2016) is used to determine the priority of mitigation actions. In the HOR2 multistakeholder model, modifications were made to obtain the total effectiveness value of the mitigation actions with the formulation that is as follows.

$$TE_k = \sum_j \sum_s ARP_{js} E_{jk}$$

3. METHODS

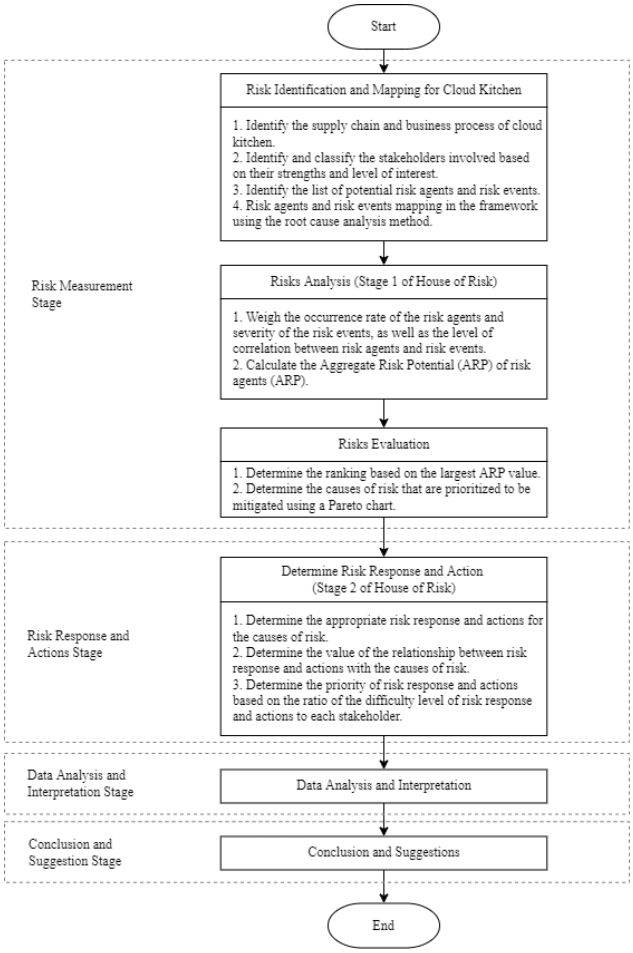


Figure 1. Research Methodology Flowchart

Figure 1 mentions the method used for the research, which is quantitative risk assessment using the house of risk multistakeholder as a risk analysis tool. In HOR stage 1, the level of risk

agents is determined based on the value of the Aggregate Risk Potential (ARP). In HOR stage 2, preventive actions are identified and prioritized to minimize the occurrence of risks. Research data gathering was done by doing focus group discussions with the stakeholders and doing questionnaires distributed on several criteria, namely the severity, occurrence, and correlation between risk events and risk agents.

The object of the research is a cloud kitchen aggregator in Surabaya called Cloud Kitchen Aggregator X. Cloud Kitchen Aggregator X was established in August 2020 to answer the problems of culinary business entrepreneurs, which includes MSMEs, established brands, and local restaurants/shops that felt the impact of pandemic outbreaks.

4. RESULTS

4.1. Risk Identification

Before doing risk identification, the stakeholders of the cloud kitchen aggregator are identified and analyzed. Based on table 1, there are two types of stakeholders: primary stakeholders and secondary stakeholders. The primary stakeholders are stakeholders who are directly in contact with the supply chain activities of the cloud kitchen aggregator. After the respondents are known, the risk identification stage starts by identifying the supply chain activities of the cloud kitchen based on SCOR (supply chain operations reference), and the result is validated by focus group discussion with respondents. The result of the supply chain activities is shown in table 2.

Table 1. Stakeholders and Respondents of The Research

No	Stakeholders	Respondents	Type	Int/Ext
1	Cloud Kitchen Aggregator	Cloud Kitchen Aggregator CEO	Primary	Internal
2	Cloud Kitchen Aggregator	Cloud Kitchen Staff	Primary	Internal
3	Merchants	Merchant Owner	Primary	Internal
4	Merchants	Merchant Staff	Primary	Internal
5	Online Food Delivery Application	Online Food Delivery Application	Primary	External
6	Drivers	Drivers	Primary	External
7	Customers	Cloud Kitchen Customers	Primary	External
8	Suppliers	Cloud Kitchen Suppliers	Primary	External
9	Competitors	-	Secondary	External
10	Department of Cooperatives and SMEs	-	Secondary	External

Table 2. Supply Chain Activities of Cloud Kitchen

Process	Activity
Plan	Demand forecasting
	Price negotiation
	Inbound schedule
	Inventory control
Source	Procurement process
	Quality control and material handling
	Order creation process through online food application
	Supplier evaluation

Table 2. Supply Chain Activities of Cloud Kitchen (Cont.)

Process	Activity
Make	Order processing and control
	Product pricing and promotion decision
Deliver	The delivery process through an online food application
	The delivery process to the customer
Return	Handling customer complaints
	Returning rejected items to the supplier
	Receiving cooking oil waste processed from the third party
Enable	Sales data analysis

4.2. Risk Analysis (HOR Stage 1)

Based on the results of the observation and the literature review, 34 potential risk events and 36 potential risk agents are identified. Each risk agent can cause one or more risk events to occur. Risk events identified are shown in table 3, and risk agents identified are shown in table 4.

Table 3. Potential Risk Events in The Supply Chain of Cloud Kitchen Aggregator

Code	Risk Events	Code	Risk Events
E1	Miscalculation between demand forecasting and actual demand	E18	Occupational accidents
E2	Received higher price of the raw materials	E19	Gas leakage
E3	Late inbound schedule	E20	Lower demand
E4	Out of stock	E21	Wrong pricing input
E5	Incorrect quantity compared to the quotation	E22	Low margin
E6	Incorrect item delivered compared to the quotation	E23	Incorrect address input by customers
E7	Low quality of the item delivered	E24	Slower order giving to the driver
E8	Bad material handling in the receiving process	E25	The wrong order was given to the driver
E9	Application crash	E26	The delivery process does not meet SLA
E10	Incorrect quantity input by customers	E27	The customer cannot receive the order
E11	Incorrect item input by customers	E28	Fictitious address/order
E12	The sudden canceled order	E29	Giving free vouchers for the next purchase
E13	Low performance of supplier	E30	Exchange goods as requested by the customer
E14	The wrong item processed	E31	Buyer accepts bad quality of items
E15	Slow order processing	E32	New cooking oil not received
E16	Unhygienic order processing	E33	Bad processed cooking oil received
E17	The order processed does not match the picture/specification in the apps	E34	Inefficient use of sales data analysis

Table 4. Potential Risk Agents in The Supply Chain of Cloud Kitchen Aggregator

Code	Risk Agents	Code	Risk Agents
A1	Manual demand forecasting	A19	Database migration
A2	Doing forecasting without checking the inventory	A20	Human error from the customers
A3	Asking quotations without market research	A21	Human error from the merchant staffs

Table 4. Potential Risk Agents in The Supply Chain of Cloud Kitchen Aggregator (Cont.)

Code	Risk Agents	Code	Risk Agents
A4	Sudden price changes	A22	Lack of human resources from the merchant
A5	Scarcity of raw materials	A23	Human error from the cloud kitchen staffs
A6	Have a limited list of suppliers	A24	The competitor has lower prices
A7	Miscommunication between buyer and supplier	A25	Human error from the merchant management
A8	Force majeure (i.e., accidents)	A26	Bad financial management from the merchant
A9	Sudden schedule changes from the buyer	A27	Inflation
A10	The location of the supplier is far from the buyer	A28	Lack of human resources from the cloud kitchen
A11	Miscalculation between the real stock and the record	A29	Driver having trouble reading the map
A12	Not carrying the daily stock control	A30	The phone battery runs out
A13	The supplier does not deliver the item	A31	Fraud by customers
A14	Late inbound schedule	A32	Customer complaints
A15	Bad material handling in the process	A33	The supplier does not accept the rejected item
A16	The supplier delivers near expired items	A34	Buying new cooking oil with a higher price
A17	The untrained staff of the cloud kitchen or the merchant	A35	Merchants throw away cooking oil carelessly
A18	Internet network disturbance	A36	Merchants do not understand data analysis

The risk analysis stage is carried out by assessing the impact of risk events (severity) for each stakeholder and the risk agents (occurrence) for each stage of the cloud kitchen supply chain. The assessment is obtained from the interviews with respondents and filling out the questionnaire. The rating scale for severity and occurrence uses a 1-10 scale with the interpretation that the higher scale is worse. The rating scale for correlation between risk events and risk agents is using [0, 1, 3, 9] scale with the interpretation that the higher scale has the highest correlation.

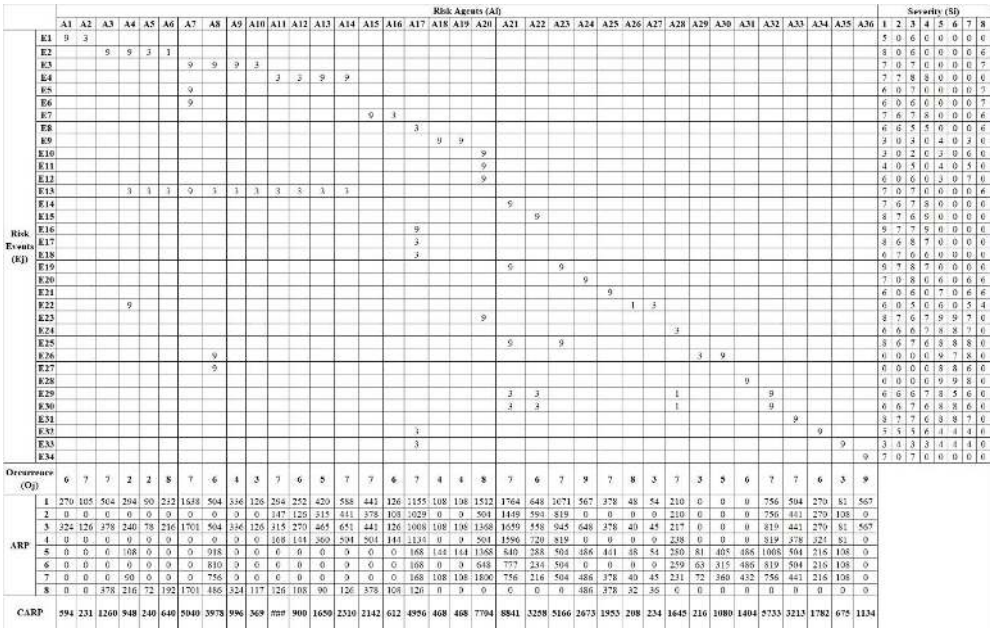


Figure 2. HOR 1 Multistakeholder of Cloud Kitchen Aggregator in Surabaya

After getting the results, each stakeholder's Aggregate Risk Potential (ARP) is going to be calculated, which then adds up to get the value of the Combined Aggregate Risk Potential (CARP). Referring to figure 2, the higher Aggregate Risk Potential (ARP) and Combined Aggregate Risk Potential (CARP) values indicate the higher the risk agents can give an impact on the supply chain of cloud kitchen aggregator. Number 1-8 is associated with table 1, which is based on the respondents' number.

4.3. Risk Evaluation

After getting the results of the Aggregate Risk Potential (ARP) and Combined Aggregate Risk Potential (CARP) values, the risk evaluation stage can be carried out that is going to be a reference for taking risk responses and actions. There are 36 risk agents that have been identified and mapped. The risk agents selected are prioritized for identifying the preventive actions. In determining the priority of risk agents, the Pareto diagram is used to maximize the further risk preventive actions that will be carried out in the future. The Pareto diagram is shown in figure 3, with the detail of the Combined Aggregate Risk Potential (CARP) result in table 5.

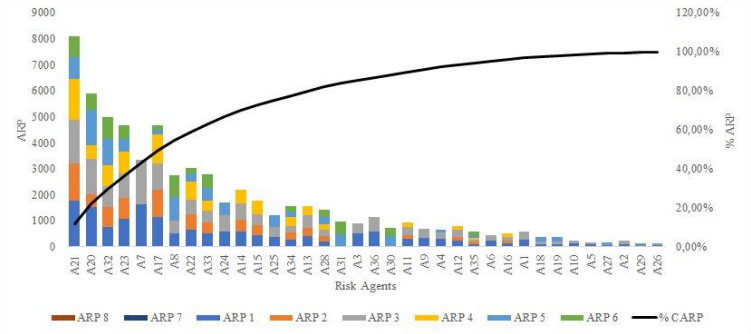


Figure 3. Pareto Diagram of ARP

Table 5. Combined Aggregate Risk Potential (CARP) Result

Risk Agent	CARP	% CARP	% CARP
A21	8841	11,67%	11,67%
A20	7704	10,17%	21,84%
A32	5733	7,57%	29,40%
A23	5166	6,82%	36,22%
A7	5040	6,65%	42,87%
A17	4956	6,54%	49,41%
A8	3978	5,25%	54,66%
A22	3258	4,30%	58,96%
A33	3213	4,24%	63,20%
A24	2673	3,53%	66,73%
A14	2310	3,05%	69,78%
A15	2142	2,83%	72,61%
A25	1953	2,58%	75,18%
A34	1782	2,35%	77,53%
A13	1650	2,18%	79,71%
A28	1645	2,17%	81,88%

Based on the results of the Pareto diagram for each stakeholder and all stakeholders, there are 16 risk agents out of 36 risk agents that will have a significant influence on the cloud kitchen aggregator supply chain. Referring to table 5, the 16 risk agents can affect up to 81.88% of the various risks that occur in the cloud kitchen aggregator supply chain. After conducting a risk evaluation by determining the priority risk agents, the next step is the preparation of risk response or preventive actions identification.

4.4. Determine Risk Response and Actions (HOR Stage 2)

Risk response and actions that are made based on various risk agents that have been selected based on Pareto affect up to approximately 80% of the entire cloud kitchen aggregator supply chain. Preventive actions are obtained through literature study, brainstorming, and field observations which are then confirmed by the stakeholders involved. The result is shown in table 6.

Table 6. Preventive Actions Identification

Code	Preventive Actions
PA1	Arrange a monthly meeting with critical supplier
PA2	Create a strict standard for all supplier
PA3	Create KPIs and performance appraisals every month for critical supplier
PA4	Create a long-term contract with a critical supplier
PA5	Register to insurance to avoid further loss
PA6	Create training for occupational health and safety for cloud kitchen staff
PA7	Provide safety tools, first aid kits, and alarm
PA8	Provide a standard operating procedure for receiving process
PA9	Hire quality assurance to check the raw material
PA10	Held initial training for all staff before doing the operations
PA11	Arrange training for merchant owners to standardize the input to the online food application
PA12	Create a standard for all products input by the merchants
PA13	Provide confirmation button
PA14	Provide gift button
PA15	The cancel button disappears after order on the process
PA16	Confirm customer of the order quantity and address
PA17	Avoid inputting too many products in the application
PA18	Build a program for the best merchant to increase merchant performance
PA19	Create a clear standard operating procedure for all staff
PA20	Create a manual book of SOP
PA21	Fulfill the standard for minimum staff in the merchant
PA22	Arrange monthly training for cloud kitchen staff
PA23	Arrange weekly operational evaluation to cloud kitchen staff
PA24	Create KPIs and performance appraisals to cloud kitchen staff every month and for three months
PA25	Do market research on competitor prices
PA26	Do voucher penetration
PA27	Hire an eventual KOL (key opinion leader) to boost the sales
PA28	Do weekly promotions and payday promotion
PA29	Hire more for critical process
PA30	Do daily service level agreement (SLA) control by the cloud kitchen staff
PA31	Create a service level agreement (SLA) for all merchants

The next stage is carried out by assessing the difficulty and the effectiveness of preventive actions. The assessment is obtained from the interviews with respondents and filling out the questionnaire. The rating scale for the difficulty is using the [1, 3, 5, 7, 9] scale with the interpretation that the higher scale is crucial. The rating scale for effectiveness is using the [0, 1, 3, 9] scale with the interpretation that the higher scale has the highest effectiveness.

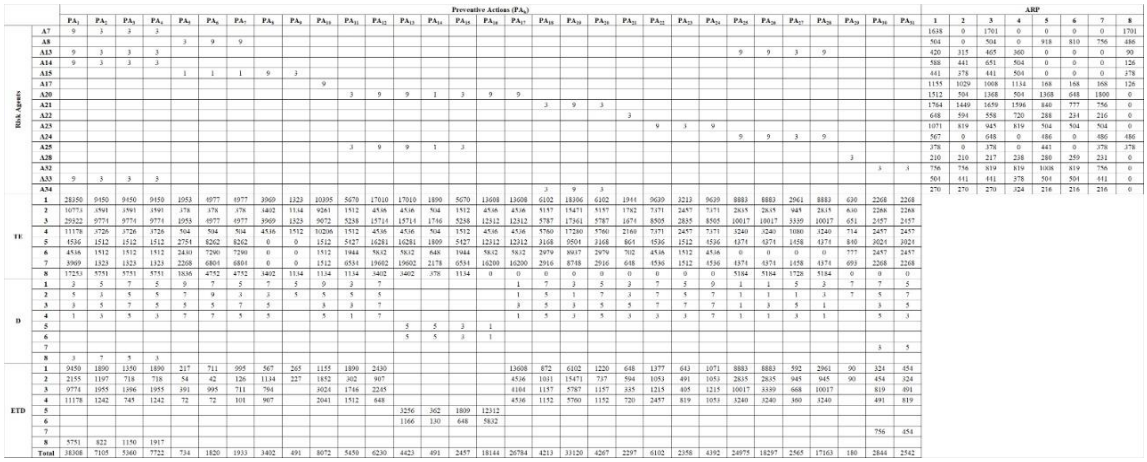


Figure 4. HOR 2 Multistakeholder of Cloud Kitchen Aggregator in Surabaya

The HOR 2 multistakeholder method, shown in figure 4, is used to design mitigation strategies and determine risk preventive action priorities. HOR 2 multistakeholder was conducted to calculate the total effectiveness (TE) of each proposed risk preventive action and to calculate the effectiveness to difficulties ratio (ETD). Figure 5 and Table 7 show the result of the HOR 2 multistakeholder – effectiveness to difficulty ratio – Pareto diagram to determine the priority preventive actions.

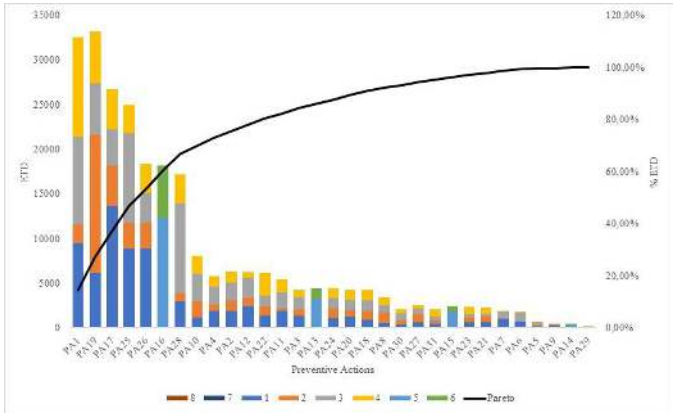


Figure 5. Pareto Diagram of ETD

Table 7. Effectiveness to Difficulty Ratio (ETD) Result

Code	ETD	% ETD	Pareto
PA1	38308	14,50%	14,50%
PA19	33120	12,53%	27,03%
PA17	26784	10,14%	37,17%
PA25	24975	9,45%	46,62%

Table 7. Effectiveness to Difficulty Ratio (ETD) Result (Cont.)

Code	ETD	% ETD	Pareto
PA26	18297	6,92%	53,54%
PA16	18144	6,87%	60,41%
PA28	17163	6,50%	66,91%
PA10	8072	3,05%	69,96%
PA4	7722	2,92%	72,88%
PA2	7105	2,69%	75,57%
PA12	6230	2,36%	77,93%
PA22	6102	2,31%	80,24%

6. CONCLUSIONS

The conclusions obtained from research on risk management of cloud kitchen aggregator supply chain in Surabaya are as follows.

1. Based on the result of the stakeholder's assessment, it is known that there are five primary stakeholders from the key players and context setters with eight respondents involved in the risk assessment of the cloud kitchen aggregator supply chain in Surabaya.
2. The potential risks in the cloud kitchen aggregator supply chain in Surabaya are divided into two groups, namely risk events and risk agents, where the results of risk identification show that there are 34 risk events and 36 risk agents obtained through a literature study and brainstorming with stakeholders involved in the cloud kitchen aggregator supply chain.
3. Based on the results of the HOR 1 multistakeholder calculation by considering the assessment of severity, occurrence, and the correlation between risk events and risk agents, it is known that there are 16 selected risk agents that are prioritized with a total accumulated combined aggregate risk potential (CARP) of 81.88%.
4. 31 preventive actions are obtained. Based on the calculation of the effectiveness to difficulties ratio (ETD) with the Pareto diagram on the HOR 2 multistakeholder, there are 12 proposed preventive actions that can affect up to 80.24% of the total proposed preventive actions.

REFERENCES

Beniwal, T., (2021). Multi-Brand Cloud Kitchens: The Efficient Route, *International Advanced Research Journal in Science, Engineering, and Technology vol 8,* 158-165.

Bailey, T. and Baribal, E, (2019). A Practical Approach to Supply-Chain Risk Management*, McKinsey & Company, United States.*

Padjar (2021). Survei KIC: Ada Tiga Layanan Digital yang Semakin Banyak Dipakai Gen Z, *Katadata Survey,* Indonesia*.*

Parenreng, S. M., (2016). Supply Chain Risk Management Model Considering Multistakeholder Interests in Tuna Commodities, *Institut Teknologi Sepuluh Nopember: Surabaya.*

Pujawan and Geraldine (2009). House of Risk: A Model for Proactive Supply Chain Risk Management, *Business Process Management Journal.*

Statista, (2022). eService Report – Online Food Delivery, *Statista Digital Market Outlook,* Statista, United States.

Ulfah, M., (2016). Analysis and Improvement of Supply Chain Risk Management of Refined Sugar Using House of Risk Approach, *Jurnal Teknologi Industri Pertanian,* 67-74.

Yudhistira, A. (2021). Persaingan Sengit Bisnis Pesan-Antar Makanan di ASEAN, Katadata Survey, Indonesia.

MODELING OF SURABAYA'S MUNICIPAL SOLID WASTE

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ABSTRACT

The waste problem has become a complex problem for cities in the world, not only causing environmental problems, but also has become a fairly heavy budget burden in financing waste management. Decision making about Municipal Solid Waste (MSW) management is often problematic with many variables and conflicting with stakeholder goals. For this reason, an ideal model of municipal solid waste generation is needed using a Structural Equation Modelling approach, so that from this model we can find out what factors have a correlation with municipal solid waste generation. The results of this study are expected to provide an overview of the key variables that have a significant effect on the municipal solid waste generation, so that efforts to control municipal solid waste generation can be carried out in a targeted manner. This research shows that the Number of TPS, the Number of Composting Houses, the Number of markets, the Number of Restaurants and the the Number of Supermarkets has a significant effect on the amount of municipal solid waste generation in Surabaya, so strategic plans are needed to handle the five variable so that the municipal solid waste generation can be reduced.

Keywords: Municipal Solid Waste, Model, Structural Equation Modelling, correlation.

1. INTRODUCTION

The problem of solid waste has become a complex problem for cities in the world and also happened in Surabaya City. The World Bank in a report entitled "What a Waste: A Global Review of Solid Waste Management", revealed that the amount of solid waste in the world's cities will continue to increase by 70% from 2012 to 2025, from 1.3 billion tons per year to 2.2 billion tonnes per year (Daniel Hoornweg, 2012). Currently, waste management in Indonesia is still using the old "collect-transit-disposal" paradigm or known as the end-of-pipe approach. Here waste is collected, transported and disposed of to the final waste processing site, even still referred to as a final disposal site. Currently, there are around 1,600 tons of waste entering the Benowo Landfill (TPA Benowo) every day and the trend of this waste generation continues to increase from year to year. This high waste generation, apart from causing environmental problems, is also a fairly heavy budget burden in financing waste management at TPA Benowo. In the study of Michal Struk and Martin Bod'a in 2022, they have identified a set consisting of 12 research variables and tested their effect on waste management performance in the South Moravian Region of the Czech Republic. This shows the importance of identifying factors that affect the performance of waste management for local governments.

According to a study by the Japan International Cooperation Agency (JICA), the increase in the average annual rate of waste volume in the Surabaya City is 5%. To reduce the high municipal solid waste generation, the Surabaya City Government has tried to manage municipal

solid waste which aims to reduce waste from the source. Currently, the Surabaya waste management system is supported by 190 TPS (Temporary Disposal Site), 9 TPS3R (Reduce Reuse Recycle Places), 1 TPST (Integrated Waste Management Sites), 25 composting houses, 336 waste banks and 190 environmental cadres. However, with the various waste management efforts that have been carried out by the Surabaya City Government, it does not simply reduce the high generation of waste in the City of Surabaya. This is because the improvement of solid waste services is often carried out without a policy and planning as a clear reference which is making it difficult to be implemented in the field. Weakness in solid waste modeling causes the planning system for the construction of waste management facilities to be ineffective and inefficient. Often a waste management infrastructure that has no significant effect on efforts to reduce waste generation, is built in massive quantities, while an effective and significant waste management infrastructure that has an influence on efforts to reduce waste generation has not been sufficiently developed.

The goal of this research is to find an ideal model of urban waste generation based on the key variables of waste infrastructure, public participation, the number of Economic place and socio-economic conditions of the community. The outcome to be achieved is to optimize the sources of APBD financing for building the best suitable and effective waste management infrastructure in reducing waste. This research is expected to provide an overview of the strategic direction of the City's policies in the preparation of development work programs and increasing public participation.

2. LITERATURE REVIEW

2.1. waste Definition

Waste is solid Garbage that is considered useless and must be managed so as not to harm the environment and protect development investments (leebai, 2022). Waste is all Garbage arising from human and animal activities which is usually solid and disposed of because it is useless or unwanted. (Pathak, 2018), (Enri Damanhuri Tri Padmi, 2010). Within the scope of the City scale, municipal solid waste is defined as waste generated, collected, transported and disposed of in municipal landfills by the city government which includes residential, industrial, institutional, commercial, municipal and construction and demolition waste. (Daniel Hoornweg and Perinaz Bhada-Tata, 2012; lo Storto, 2021; Zurbrugg, 2003). The Waste generation forecasts, both for now and in the future, are the basis for planning, designing and reviewing solid waste management systems. Waste management is a series starting from collecting waste in containers at the source (producing), collected to temporary shelters, then transported to processing and recycling sites, such as composting, incineration, landfilling, or other methods aimed at dealing with the negative impacts of waste on health, protect the environment from leachate pollution, environmental aesthetic disturbances from waste generation and air pollution from incomplete waste burning. According to (Surahma Asti Mulasari, 2014) and the Regulation of the Minister of Public Works of the Republic of Indonesia No. 03/PRT/M/2013 concerning the implementation of waste infrastructure and facilities in the handling of household waste and similar household waste, explains that waste management includes the following activities:

a. sorting;
b. collection;
c. transportation;
d. processing; and
e. waste final processing

Waste management, of course, cannot be carried out unilaterally by the government only, but also requires close cooperation with other stakeholders which include: central government, local government, community, non-government institutions, formal private sectors, informal private sectors and other supporting institutions. (Kusumawardhani, 2016; Leeabai, 2022; Peter Schübeler, 1996)

2.2. Waste Management in Surabaya City

The Surabaya City has an area of 334.51 km2 consisting of 31 sub-districts, 154 urban villages, 1,361 RW and 9,131 RT. The population of the Surabaya City in 2021 is 2,970,952 people. The Surabaya City has the northern boundary of the Java Sea and the Madura Strait, the eastern boundary of the Madura Strait, the southern boundary of the Sidoarjo Regency and the western boundary of the Gresik Regency.

Currently, Surabaya City has waste infrastructure facilities, including 190 Temporary Disposal Site (TPS), 9 Temporary Disposal Site with 3R treatment (reuse, reduce, recycle) TPS3R, 25 composting houses. Based on the data obtained from the Surabaya City Environment Agency, there are around 1,600 tons of waste that enters the Benowo Final Disposal Site (TPA) every day and the increasing of this waste generation is continues every year.

The Surabaya City Government also implements a community-based waste management program which implements waste management from the source using the 3R (Reduce, Reuse, Recycle) method. People segregate household waste between organic waste (food scraps, leaves) and inorganic waste (used bottles, used paper and so on). In managing inorganic waste, the community forms a waste bank in their respective areas. The waste bank is one solution to reduce the waste that is disposed of to the TPS/TPA. The number of waste banks in the Surabaya City is 338 units spread throughout the Surabaya City. In this city, there are also environmental cadres who assist the residents in managing their village environment, conducting door to door environmental check and also mobilizing village residents to care about their environment.

2.3. Factors Affecting Waste Generation

Based on a literature review that specifically discusses urban solid waste, we summarize some of the parameters that affect the generation of urban waste as presented in the following table:

Table 1. Synthesis Of Variables

RESEARCH VARIABLE	OPERATIONAL DEFINITION	REFERENCE JOURNAL	EXP
waste Generation of Each District	The amount of waste transported from all TPS in each District		
Number of TPS	Number of Temporary Waste Shelters in each District	(Azadi & Karimi-Jashni, 2016), (Struk & Boďa, 2022)	waste Infrastructure Factors
Number of Compost Houses	Number of organic waste processing sites in each district	(Struk & Boďa, 2022)	
Number of TPS3R	Number of Waste Processing Places - Reduce Reuse Recycle (TPS3R) in each District	(Struk & Boďa, 2022).	
Number of Faskel	Number of Environmental Facilitators (Faskel) and other Environmental Cadres who carry out community development in each District	(Struk & Boďa, 2022).	Public Participation Factors
Number of Waste Banks	Number of Waste Banks in each District	(Struk & Boďa, 2022).	

Number of community participation in cleaning competitions	The number of RT, RW in each sub-district participating in the cleaning competition	(Struk & Boďa, 2022).	
Number of Adiwiyata Schools	Number of schools participating in the adiwiyata award	(Díaz-Villavicencio et al., 2017)	
Number of Traditional Markets	The number of traditional markets in each district	(Díaz-Villavicencio et al., 2017)	Economic place factor
Number of Malls	The number of malls in each district	(Díaz-Villavicencio et al., 2017)	
Number of Restaurants	The number of restaurants in each district	(Díaz-Villavicencio et al., 2017)	
Number of Supermarkets	Number of supermarket houses in each district	(Díaz-Villavicencio et al., 2017)	
Total population	Number of Population in each District	(Azadi & Karimi-Jashni, 2016; Kannangara et al., 2018)	Socio-Economic Factors
Area of the district	Area of each District	(Díaz-Villavicencio et al., 2017),	
Area Altitude	The altitude of the area as measured from the height of the sea level. Shows the influence of climate and geography of the region	(Azadi & Karimi-Jashni, 2016)	
Human Development Index	a composite index that describes the basic human ability to expand opportunities for a better life	(Elyasa, 2020)	

3. METHODS

3.1. Measurement of Variables

Structural Equation Model (SEM) has a measurement model that establishes the rules of theoretical correspondence between the measured variable and the latent variable (Hair et al., 2019). Researchers identify specific indicator variables associated with each construct, usually based on a combination of previous similar studies and the situation at hand. When SEM is applied, researchers can assess the contribution of each indicator variable in representing the associated construct and measure how well the combined set of indicator variables represents the construct (reliability and validity). The assessment of Goodness of Fit on the outer PLS-SEM model uses convergent validity, discriminant validity and composite reliability. Convergent validity measures the extent to which the construct indicators meet so as to explain the variance of items assessed using average variance extracted (AVE). Discriminant validity evaluates the extent to which a construct is different from other constructs. The underlying principle is to assess how uniquely the indicators of a construct represent that construct versus how much the construct is correlated with all other constructs in the model. In designing the structural model, the researcher uses theory, previous experience and the opinion of several experts in the field of environmental governance to distinguish which independent variables explain each dependent variable. The structural model reveals this dependency relationship between the independent and dependent variables, even when the dependent variable becomes the independent variable in another

relationship. The inner model is measured using the coefficient of determination (R2), effect size (ƒ2), cross-validated redundancy (Q2) and the size of the significance of path coefficients.

3.2. **Conceptual Framework and Hypotheses**

Based on the literature review and the variables that have been determined with reference to previous research, a conceptual framework is made to show the flow of causal relationships between variables and then visualized into Figure 2.1 so that it is easier to understand and briefly explain the hypotheses in this study as follows:

H1 : the waste infrastructure factor has an effect on a municipal solid waste.
H2 : the public participation factor has an effect on a municipal solid waste.
H3 : the economic place factor has an effect on a municipal solid waste.
H4 : the Sosio Economic factor has an effect on a municipal solid waste.

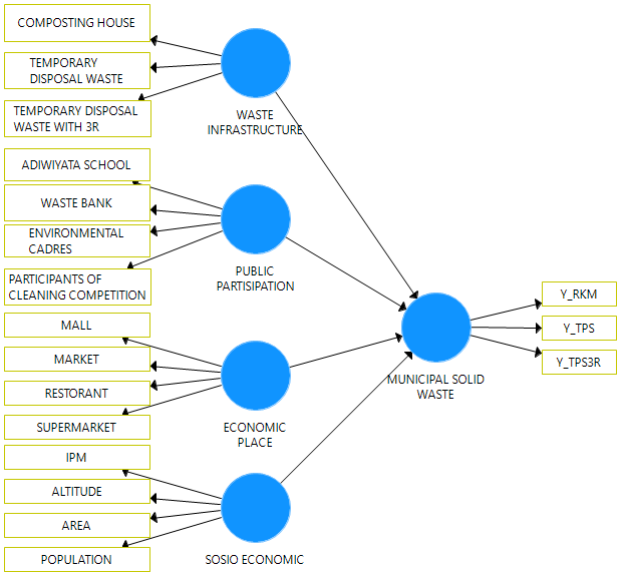


Figure 1. SEM of Municipal Solid Waste

4. RESULTS

4.1. The Confirmatory Factor Analysis (CFA) test

The Confirmatory Factor Analysis (CFA) test aims to test the validity of the outer model (the relationship between the manifest variable and the latent variable). Outer Loading value > 0.5 indicates that the indicator can adequately represent the latent variable.

Table 2. The Confirmatory Factor Analysis (CFA) test

Indicator	Outer loading	Interpretation
ADIWIYATA SCHOOL	0,836	valid
ALTITUDE	-0,134	reduced
AREA	-0,120	reduced
COMPOSTING HOUSE	0,850	valid
ENVIRONMENTAL_CADRES	0,868	valid
IPM	0,646	valid
MALL	0,443	reduced

MARKET	0,828	valid
PARTICIPANTS OF _CLEANING COMPETITION	0,905	valid
POPULATION	0,785	valid
RESTORANT	0,794	valid
SUPERMARKET	0,633	valid
TEMPORARY SHELTERS	0,697	valid
TEMPORARY SHELTERS _WITH 3R	-0,402	reduced
WASTE BANK	-0,031	reduced
Y_RKM	0,738	valid
Y_TPS	0,823	valid
Y_TPS3R	-0,476	reduced

4.2. **Validity and Reliability Test**

In assessing whether the indicators we have tested have shown their reliability, we can see from the level of construction reliability. If the value of composite reliability (CR) or the value of Croncbach's alpha (CA) is > 0.7, then the indicator can be declared reliable and consistent. While the validity of the indicator can be seen from the value of the Average Variance Extracted (AVE). The AVE value shows the amount of variance or diversity contained by the latent construct. If the AVE value is > 0.5, it means that the construct indicator can explain 50% or more of the variance of the latent variable.

Table 3. The Validity and Reliability test

	Cronbach's Alpha	Composite Reliability	Average Variance Extracted (AVE)	Original Sample	T Statistics	P Values	Interpretation
ECONOMIC PLACE -> MUNICIPAL SOLID WASTE	0,700	0,795	0,567	0,515	3,392	0,001	valid and reliable
PUBLIC PARTISIPATION -> MUNICIPAL SOLID WASTE	0,843	0,903	0,757	-0,127	0,697	0,486	valid and reliable
SOSIO ECONOMIC -> MUNICIPAL SOLID WASTE	0,150	0,690	0,537	0,090	0,495	0,621	Valid, not reliable
WASTE INFRASTRUCTURE -> MUNICIPAL SOLID WASTE	0,588	0,819	0,696	0,586	4,354	0,000	valid and reliable
MUNICIPAL SOLID WASTE	0,493	0,797	0,663				valid and reliable

From the test results above, it is shown that the Economic place, waste Infrastructure, public Participation, Socio-Economic have a fairly good discriminant validity at the construct level (latent variable). Meanwhile, at the indicator level, it can be concluded that the indicator of the number of Adiwiyata schools, the number of enviromental caldre, the number of SGC participants, the number of composting houses, the number of TPS, the IPM index, the population, the number of markets, the number of restaurants, the number of supermarkets, the amount of garbage collected in the composting house and the amount of waste collected at the TPS has a fairly good discriminant validity at the indicator level.

4.3. Inner Model Test

The structural model testing is to measure the relationship between variables, significance value and R-square of the research model. The inner model testing is as follows:

a. The Path Coefficients Testing; this test is to evalute the direct effect of an exogenous variable to endogenous variables. Measurement of path coefficients is carried out to see the significance and the relationship between exogenous variable and endogenous variables
b. The Effect size testing; This test is to evaluate the effect of exogenous variables to endogenous variables.
c. The Coefficient of determination testing; this test is to evaluate how much the endogenous construct can be explained by the exogenous construct. The higher the R2 value, the greater the ability to explain the structural model and the better the prediction of endogenous constructs.

Table 4. The Inner model test

	f2	R2	Path Coefficients	T Statistics
ECONOMIC PLACE -> MUNICIPAL SOLID WASTE	0,616	0,777	0,515	3,392
PUBLIC PARTISIPATION -> MUNICIPAL SOLID WASTE	0,029		-0,127	0,697
SOSIO ECONOMIC -> MUNICIPAL SOLID WASTE	0,016		0,090	0,495
WASTE INFRASTRUCTURE -> MUNICIPAL SOLID WASTE	1,348		0,586	4,354

From the test results above, it is shown that the variable of economic place and waste infrastructure has a significant impact and has a large effect on municipal solid waste generation. while the variables of public participation and socio-economic have an insignificant and moderate effect on municipal solid waste generation.

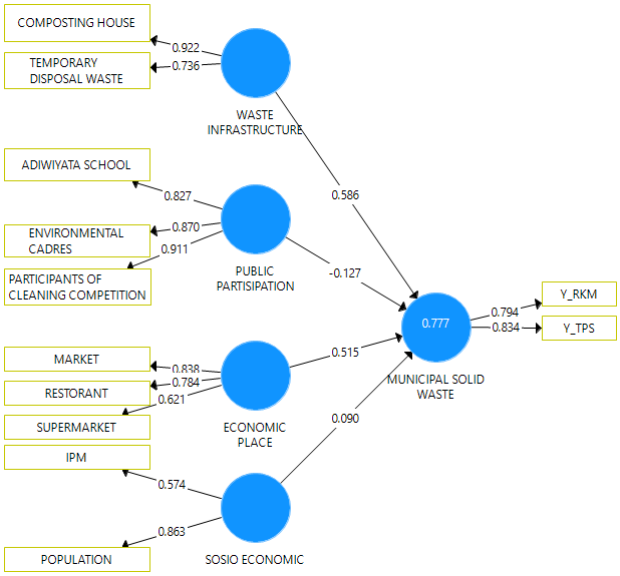


Figure 2. structural model of Municipal Solid Waste

From the structural model above, it can be concluded that the mathematical equation is as follows:

Municipal solid Waste Generation = 0.586 waste Infrastructure – 0.127 public Participation + 0.515 economic place + 0.090 Socio-Economic + ζ

5. CONCLUSIONS

Based on the overall results of the analysis that has been carried out in this study, the following conclusions can be drawn:

1. Waste generation modeling is very important in efforts to control waste generation in the future. With the limitation of the capacity of the Final Processing Site (TPA), a systematic, effective and efficient waste reduction effort based on a proper treatment approach to key variables is very much needed in the city's cleanliness management.
2. Based on previous literature studies, it can be proven that 77,7% waste generation in Surabaya City is influenced by the variables Number of TPS, Number of Composting Houses, number of Environmental Cadre, number of public Participation in Environmental Management, Number of Adiwiyata Schools, Number of Traditional Markets, Number of Restaurants, Number of Supermarkets, total population and the HDI index of the community.
3. From the ten predictor variables, there are 2 key variables that significantly affect for the municipal solid waste generation in the Surabaya City, that is the Number of waste infrastructure, the Number of Composting Houses and the Number of economic place.

REFERENCES

Azadi, S., & Karimi-Jashni, A. (2016). Verifying the performance of artificial neural network and multiple linear regression in predicting the mean seasonal municipal solid waste generation rate: A case study of Fars province, Iran. *Waste Management*, *48*, 14–23. https://doi.org/10.1016/j.wasman.2015.09.034

Cangur, S., & Ercan, I. (2015). Comparison of model fit indices used in structural equation modeling under multivariate normality. *Journal of Modern Applied Statistical Methods*, *14*(1), 152–167. https://doi.org/10.22237/jmasm/1430453580

Chin, W. W. (1998). *The Partial Least Squares Approach to Structural Equation Modeling The Proactive Technology Project Recovery Function: A Methodological Analysis View project Research Methods View project*. https://www.researchgate.net/publication/311766005

Daniel Hoornweg and Perinaz Bhada-Tata. (2012). *What a Waste, A Global Review of Solid Waste Management*.

Díaz-Villavicencio, G., Didonet, S. R., & Dodd, A. (2017). Influencing factors of eco-efficient urban waste management: Evidence from Spanish municipalities. *Journal of Cleaner Production*, *164*, 1486–1496. https://doi.org/10.1016/j.jclepro.2017.07.064

E Ummi, M. S. (2013). *Structural Equation Modeling-Partial Least Square untuk Pemodelan Derajat Kesehatan Kabupaten/Kota di Jawa Timur*.

Elyasa, M. D. (2020). Analisis Pengaruh Nilai IPM dan Jumlah Penduduk Terhadap Timbulan Sampah di TPA Se provinsi Kepulauan Bangka Belitung. *Jurnal Green Growth Dan Manajemen Lingkungan*, *8*(1), 1–8. https://doi.org/10.21009/jgg.081.01

Enri Damanhuri Tri Padmi, D. (2010). *Pengeloalaan Sampah*.

Franzese, M., & Iuliano, A. (2018). Descriptive statistics. In *Encyclopedia of Bioinformatics and Computational Biology: ABC of Bioinformatics* (Vols. 1–3, pp. 672–684). Elsevier. https://doi.org/10.1016/B978-0-12-809633-8.20354-3

Hair, J. F., Black, W. C., Babin, B. J., & Anderson, R. E. (2019). *Multivariate Data Analysis - Eighth Edition*. www.cengage.com/highered

Henseler, J., Ringle, C. M., & Sarstedt, M. (2015). A new criterion for assessing discriminant validity in variance-based structural equation modeling. *Journal of the Academy of Marketing Science*, *43*(1), 115–135. https://doi.org/10.1007/s11747-014-0403-8

Kannangara, M., Dua, R., Ahmadi, L., & Bensebaa, F. (2018). Modeling and prediction of regional municipal solid waste generation and diversion in Canada using machine learning approaches. *Waste Management*, *74*, 3–15. https://doi.org/10.1016/j.wasman.2017.11.057

Kusumawardhani, V., Hadi Sutjahjo, S., Komala Dewi, I., & Fransiska Panjaitan, N. (2016). *Waste Management Infrastructure Provision in Urban Slum of Bandung City* (Vol. 11, Issue 2).

Leeabai, N., Areeprasert, C., Siripaiboon, C., Khaobang, C., Congsomjit, D., & Takahashi, F. (2022). The effects of compost bin design on design preference, waste collection performance and waste segregation behaviors for public participation. *Waste Management*, *143*, 35–45. https://doi.org/10.1016/j.wasman.2022.02.018

lo Storto, C. (2021). Effectiveness-efficiency nexus in municipal solid waste management: A non-parametric evidence-based study. *Ecological Indicators*, *131*. https://doi.org/10.1016/j.ecolind.2021.108185

Niska, H., & Serkkola, A. (2018). Data analytics approach to create waste generation profiles for waste management and collection. *Waste Management*, *77*, 477–485. https://doi.org/10.1016/j.wasman.2018.04.033

Pathak, P., Roshani, W., & Aniket, D. (2018). *Solid Waste Management*. www.ijtsrd.com

Peter Schübeler. (1996). *Conceptual Framework for Municipal Solid Waste Management in Low-Income Countries*.

Struk, M., & Boďa, M. (2022). Factors influencing performance in municipal solid waste management – A case study of Czech municipalities. *Waste Management*, *139*, 227–249. https://doi.org/10.1016/j.wasman.2021.09.022

Sugiyono. (2013). *Metode Penelitian Kuantitatif, Kualitatif, dan RD*.

Surahma Asti Mulasari, A. H. H. N. M. (2014). *Kebijakan Pemerintah dalam Pengelolaan Sampah Domestik*.

Zurbrugg, C. (2003). *Solid Waste Management in Developing Countries* *. www.sanicon.net

PERFORMANCE ALIGNMENT OF RESOURCE AND INFORMATION TECHNOLOGY MANAGEMENT USING COBIT 2019 (CASE STUDY: PT XYZ)

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ABSTRACT

This research focus on resources and IT management at PT XYZ where it was found that has several weaknesses, for example, there is no data collection on supporting facilities management, maintenance for measurement tools is not well organized, and also there is no internal management audit. This lack of internal management often affects the performance of its employees, and become indirectly affects the business processes of PT XYZ.

In this research, the COBIT 2019 framework is used as a guide, because COBIT 2019 has a maturity level that can help to provide assessment of the organization management. There are three stages that have been carried out, the first stage is determining Enterprise Goals through a Google Forms survey, the second stage is determining the Alignment Goals as the basis for determining the objectives to be used in this research and the last stage is the preparation of developing recommendations for the management of PT XYZ.

The result of this research, there are 6 selected objectives consisting of EDM04, APO07, APO14, BAI03, BAI08, and BAI09. Then based on a survey for assessment of the as-is condition in Level 1, it was found that only the objectives BAI03 is fully achieved and for EDM04, APO07, APO14, BAI08, and BAI09 is not achieved. This result shows that the resources and IT management of PT XYZ is lack of basic capability for internal management, and incomplete to toward the purpose of governance and management objectives. Also based on this reason, the maturity level of PT XYZ management mostly become Level 0. To achieve the target of Level 4 (Quantitively Managed) needs to prioritize aligning and improving management performance based on these objectives by referring to the recommendations that have been prepared such as, make monthly report in google sheet with some graphic or chart that can represent the evaluation of undergoing management. Such as the data of measurement tools condition, the data of training schedule, and also the monitoring data of laptops usage. Also provide division or team with person in charge to monitor the management.

Keywords: COBIT 2019, resource management, information technology management

1. INTRODUCTION

Novita (2014), stated that IT governance (Information Technology) is one of important factors to drive the business transformation process toward into a good governance. To support the management of IT governance, competent IT HR (Human Resources) is also needed. Fitria (2016), also stated that along with the rapid advancement of information technology, the application of

information can be an opportunity for companies to increase their productivity. The application of information technology can also support a company to increase competitiveness in this very tight competition.

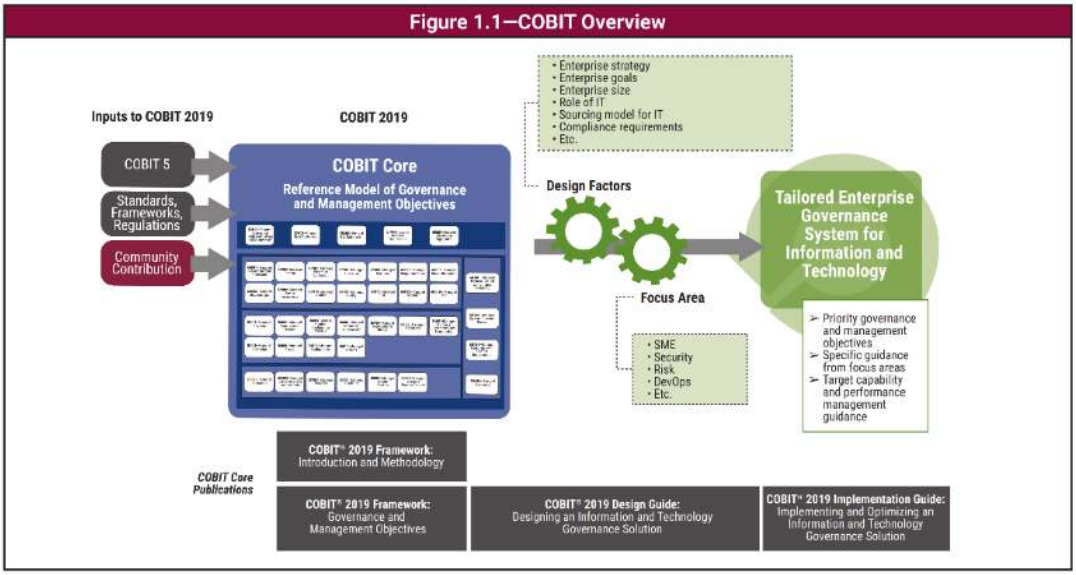
This research focus on resources and IT management of PT XZY which is a private company engaged in the telecommunications industry with business processes providing equipment and systems for radio communications, radar, and telemetry. The purpose of this company are going to have a good relation with an government companies in Indonesia, such as BPBD, BMKG, and others. To support its business processes, good and effective IT and resource management is needed.

It was found that resource and IT management at PT XYZ has several weaknesses, namely the lack of organized data collection on the company's supporting equipment ranging from stationeries, printers, laptops, servers, and NAS, also the lack of maintenance of measuring instruments, laptops, and servers, and the uneven distribution of workload to each employee and there is no person in charge to help manage the management. In addition, PT XYZ has never conducted an internal management audit, so the company does not yet know the current level of management performance. Therefore, IT and resource management at PT XYZ needs to be developed and aligned according to the standard framework.

Intending to align the performance of IT and resource management at PT XYZ, this study used the COBIT 2019 framework, which according to Sulistyoati (2021), stated that COBIT 2019 is a framework that has a broad discussion and includes other frameworks, namely ISO and ITIL, besides COBIT 2019 is a development of COBIT 5 in which several objectives are added. The COBIT 2019 framework will be used as a reference in the management performance assessment and in the preparation of recommendations.

2. LITERATURE REVIEW

COBIT stands for Control Objective of Information and Related Technology. Sulistyoati (2021) stated that COBIT itself is a framework for governance and management of information and information technology, which is intended for all areas within an organization. Enterprise IT means all the technology and information processing that an organization undertakes to achieve its objectives, regardless of and where this occurs within the organization. COBIT can be described as a control tool for information and related technology and is a standard for control over information technology developed by the Information System Audit and Control Association (ISACA). COBIT defines internal control as a policy, procedure, and organizational structure and practice designed to provide reasonable assurance that organizational goals can be achieved and that adverse events can be prevented or detected, and corrected. An overview of COBIT 2019 will be shown in Figure 1 below.



Source: ISACA, (2018), COBIT 2019 Framework: Governance and Management Objectives.

Figure 1. Overview of COBIT 2019

Based on Sulistyoati (2021), learned that the difference between the COBIT 2019 Core Model and the COBIT 5 process reference model is that there are 3 additional new objectives. In total, COBIT 5 has 37 processes, while in COBIT 2019 there are 40 governance and management objectives. The following are additional 3 objectives at COBIT 2019, namely:

1. APO14 – Managed Data
2. BAI11 – Managed Projects
3. MEA04 – Managed Assurance

Several upgrades in COBIT 2019 show that this latest release of COBIT will not be a rigid and static framework, but more open, flexible, and good adaptability. Table 1 below will show a summary of the comparison between COBIT 2019 and COBIT 5.

Table 1. Comparison between COBIT 2019 and COBIT 5.

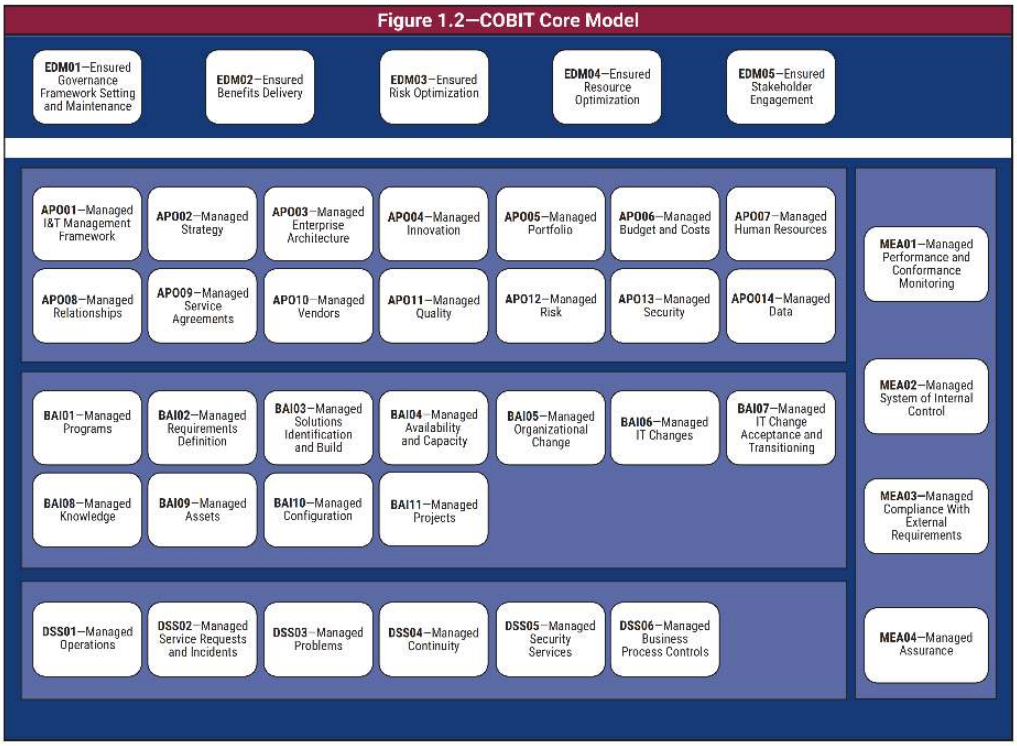
COBIT 2019	COBIT 5
6 Governance Principles	5 Governance Principles
40 Objectives	37 Objectives
Terminology "Ensured" is used for process management	Terminology "Ensured" is used for process management
Terminology "Managed" is used for process management	Terminology "Managed" is used for process management
Governance framework principles have been added	No governance framework principles

Source: Dwi Sulistyoati, R.V. Hari Ginardi, (2021), Manajemen Data Dan Informasi Menggunakan COBIT 2019 Di Biro Humas dan Protokol Pemerintah Provinsi Jawa Timur

Based on research of Sulistyoati (2021), also explained that the governance and management objectives at COBIT 2019 are grouped into five domains. Where each domain has a name with a verb that expresses the main purpose and field of activity in it, which will be explained as follows.

1. The Governance Objectives at COBIT 2019, are grouped in the Evaluate, Direct, and Monitor (EDM) domain. In this domain, the manager will evaluate strategic options, direct senior management on selected strategic options, and monitor strategy achievement.
2. Management Objectives at COBIT 2019, are grouped into four domains, namely:
   - Align, Plan, Organize (APO) discusses the overall organization, strategy, and support activities for information technology.
   - Build, Acquire and Implement (BAI) treats the definition, acquisition, and implementation of information technology solutions and their integration into business processes.
   - Deliver, Service, and Support (DSS) addresses the operational delivery and support of information technology services, including security.
   - Monitor, Evaluate, and Access (MEA) addresses the monitoring of performance and conformance of information technology to internal performance targets, internal control objectives, and external requirements.

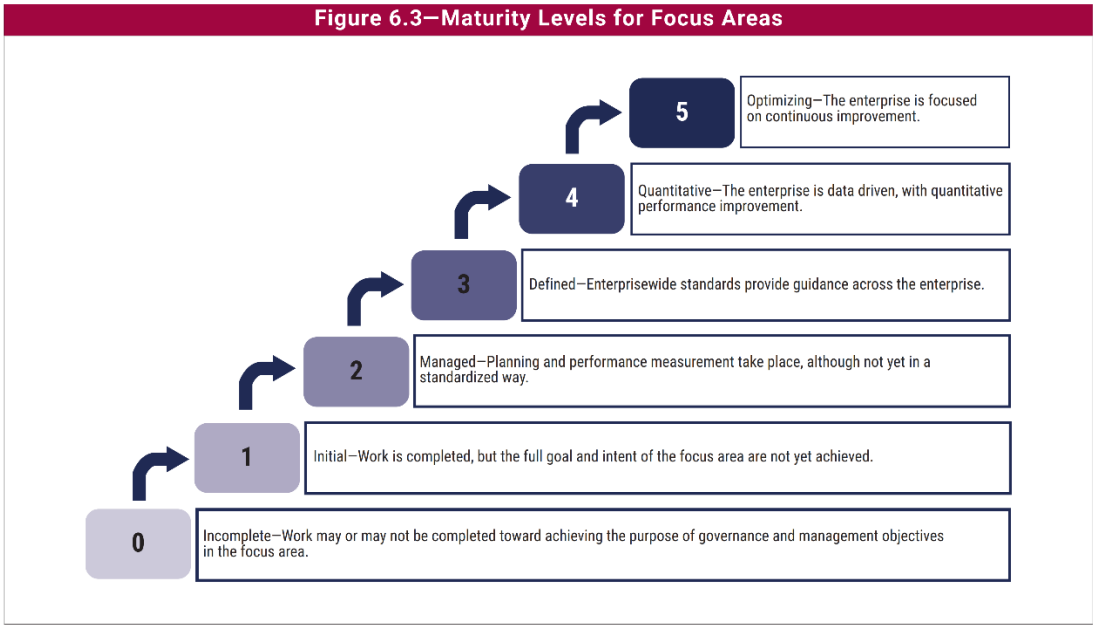
The domain in COBIT 2019 will be shown in Figure 2 below.



Source: ISACA, (2018), COBIT 2019 Framework: Governance and Management Objectives.

Figure 2. Objectives of COBIT 2019.

Capability levels for processes of COBIT 2019 is based of *Capability Maturity Model Integration* (CMMI) schemes. The processes in each governance and management objective can operate at various levels of capability, ranging from 0 to 5. In this research focus area on maturity levels is used as a guidance for objectives assessment. Figure 3 below will show an overview of the focus area of maturity levels of IT governance in an organization/company.



Source: ISACA, (2018), COBIT 2019 Framework: Governance and Management Objectives.

Figure 3. Maturity Level of COBIT 2019.

3. METHODS

The methodology used in this research consists of five stages, as shown in Figure 4 below.

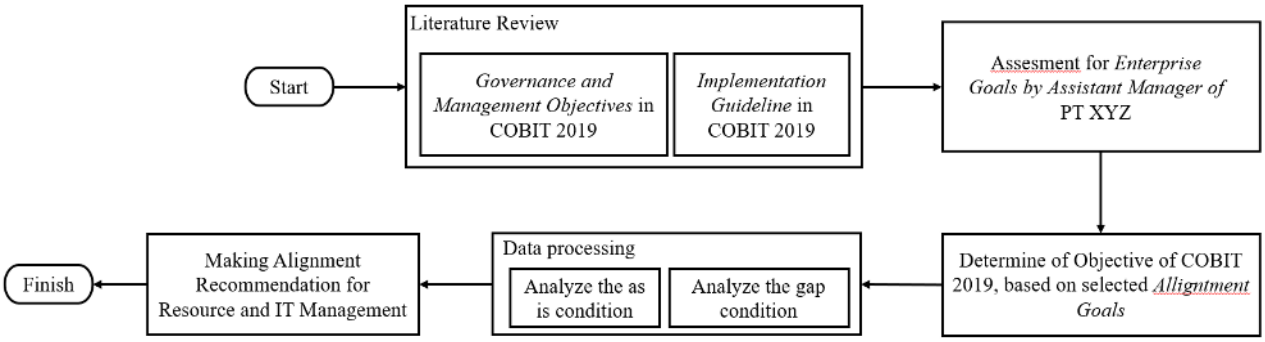


Figure 4. Research methodology.

3.1. Literature Review

The first stage of this research is a literature review on the COBIT 2019 Governance and Management Objectives framework as a reference for aligning the performance of resource management and information technology at PT XYZ. As well as a literature review on the Implementation Guideline in COBIT 2019 as a reference for the preparation of recommendations for developing company management performance.

3.2. Determination of Enterprise Goals

The next stage is knowing the Enterprise Goals (EG) of PT XYZ, which used as the basis for selecting objectives at COBIT 2019. To find the Enterprise Goals (EG), is done by a survey using Google Forms addressed to the Assistant Manager at PT XYZ. The reason for choosing the Assistant Manager as a resource person in this study is because the Assistant Manager plays a very important role in the running of business processes at PT XYZ. After all, it has great duties and responsibilities related to company resource management and company IT management. Then the selected Enterprise Goals (EG), used as the basis for determining Alignment Goals (AG) at COBIT 2019.

3.3. Determination of COBIT 2019 Objectives

After selecting the Enterprise Goals (EG), then determining the Alignment Goals (AG) by looking at the mapping of the EG-AG table in the COBIT 2019 books. Alignment Goals with the status of "P" or primary is used to determine the objectives for this study by looking at the mapping of the AG-Objective table.

3.4. Data Processing

Each objective in COBIT 2019 has activity points that can be used as a guide for managing the management of an organization. Therefore, these activity points will be used as a guide in preparing questions and statements for the survey. In the assessment of objectives which is carried out through a questionnaire survey, it will be assessed by used maturity level COBIT 2019 at Level 1 (Initial) which is the initial stage of governance with very weak control and management. The assessment of maturity level in COBIT 2019 is done by 4 stages, consist of as below.

1. N = Not Achieved (0 – 15%)
2. P = Partially Achieved (16 – 50%)
3. L = Largely Achieved (51 – 85%)
4. F = Fully Achieved (86 – 100%)

These 4 stages are used to assess the performance achievement at the maturity Level 1 of the current management performance (as-is) at PT XYZ, the questionnaire of survey that has been done also used to assess the expected management performance targets (to-be). So that the comparison of as-is and to-be values, will produce a gap value which is used as the basis for the preparation of management development recommendations.

3.5. Recommendation

At this stage, a recommendation plan for developing the performance of resource management and information technology will be drawn up at PT XYZ. So that the current management performance can be more developed and in line with the COBIT 2019 framework. Development recommendations that will be compiled in this research include the development of asset management, facility management, and resource management. As well as the development of information technology management as a support for business processes from PT XYZ.

4. RESULTS

4.1. Determination of Enterprise Goals

The first stage of the research that has been done, namely determining Enterprise Goals through a survey in the form of Google Forms addressed to the Assistant Manager of PT XYZ. In the assessment of EG there are divided by 2 judgements, consist of 1 (needed) and a 2 (not needed). In the purpose of alignment resource and IT management performance, Assistant Manager will choose among the 13 Enterprise Goals in COBIT 2019. In Table 2 below, the results obtained in the survey of determine the Enterprise Goals will be shown.

Table 2. Selected Enterprise Goals.

Enterprise Goals	**Description**
EG01	Portfolio of competitive products and services
EG07	Quality of Management Information
EG010	Staff Skills, Motivation, and Productivity
EG012	Managed Digital Transformation Programs

4.2. Determination of COBIT 2019 Objectives

In the next stage, based on the selected Enterprise Goals, will be used to determine the Alignment Goals by looking at the mapping of the EG-AG table in the COBIT 2019 books. Table 3 below will show the results of determining the Alignment Goals.

Table 3. Selected Alignment Goals.

Alignment Goals	Description
AG03	Realized Benefits from I&T-enabled Investments and Services Portfolio
AG04	Quality of Technology-related Financial Information
AG05	Delivery of I&T Services in Line with Business Requirements
AG06	Agility to Turn Business Requirements into Operational Solutions
AG08	Enabling and Supporting Business Processes by Integrating Applications and Technology
AG09	Delivering Programs on Time, On Budget, and Meeting Requirements and Quality Standards
AG10	Quality of I&T Management Information
AG12	Competent And Motivational Staff with Mutual Understanding of Technology and Business
AG13	Knowledge, Expertise, and Initiatives for Business Innovation

The selected Alignment Goals will be used as the basis for determining the objectives of COBIT 2019, that has done by looking at the mapping of the AG-Objective table. Table 4 below will be shown the results of the determining of objectives.

Table 4. Selected Objectives.

Objective	Description	Purpose
EDM04	Ensured resource optimization	Ensuring adequate and available IT and resources to support the company's business processes
APO07	Managed human resources	Provide a structured approach to human resource management both internally and externally
APO14	Managed data	Manage company data assets effectively, from creation, maintenance, and storage to delivery
BAI03	Managed solutions identification and build	Maintain products and services related to business processes, technology, and workflows, so that they are in line with company goals
BAI08	Managed knowledge	Maintain the availability of relevant, current, validated, and reliable management information. To support and facilitate the decision-making process regarding the company's IT management
BAI09	Managed assets	Manage the company's IT assets by ensuring that equipment is maintained both functionally and physically

There are 6 objectives selected in this study, wherein the activity points in each objective will be used as a reference in the preparation of survey questions and statements. As previously explained, the objective assessment is carried out at the maturity level of Level 1, so in Table 5 below, the results obtained in the assessment of the current management condition (as-is).

Table 5. Assessment of as-is at Level 1.

No	Objective	Result	Maturity Level
1	EDM04	L	0
2	APO07	N	0
3	APO14	N	0
4	BAI03	F	1
5	BAI08	N	0
6	BAI09	N	0

Based on Table 5 above, assessment at maturity Level 1 shows that only objective BAI03 got fully achieved, and the other objectives such as EDM04, APO07, BAI08, and BAI09 got not achieved. This result shows that the maturity level of performance resources and IT management at PT XYZ mostly become Level 0, at this level indicates that company's management may or may not be completed toward achieving the purpose of governance. In Table 6 below, the existing, the expected management targets, and the gap value will be shown.

Table 6. Comparison of Management Maturity Level.

No	Objective	Value Comparison		
		Existing (as is)	Expected (to be)	gap
1	EDM04	0	4	4
2	APO07	0	4	4
3	APO14	0	4	4
4	BAI03	1	4	3
5	BAI08	0	4	4
6	BAI09	0	4	4

Based on Table 6 above, shows that the gap between as-is and to-be is quite high. Which means the existing of performance management is far from expected, lack of basic capability for internal management, and also incomplete to toward the purpose of governance and management objectives. For example, data collection on facilities is not carried out properly, and maintenance of measuring instruments is also not carried out so employees have not been given training. Therefore, objectives that got a gap value of 4 can be used as a top priority to be improved, to increase the maturity level of management from Level 0 to Level 4 (Quantitively Managed).

The result for objectives EDM04, APO07, APO14, BAI08, and BAI09 that got not achieved at maturity Level 1 is because several weaknesses were found, namely as follows:

1. EDM04, regarding the evaluation of enterprise resource management.
   - The company has not evaluated the management and use of its laptops, stationaries, printers, servers, NAS, measuring instruments, and electronic instrumentation equipment.
   - There is no division to manage the company's supporting facilities.

- The placement and use of company support facilities are often irregular, thus hampering employees in the event of a breakdown or out of equipment.

2. APO07, regarding human resource management.
   - The company has not distributed the job desks to each employee in a balanced manner, so it often happens that some employees have a higher workload than other employees.
   - The company has not provided skills training to every employee.
3. APO14, regarding enterprise data management
   - The company has not established an IT division to manage the company's IT equipment.
   - There are no regulations regarding the use of company data
   - Server and NAS maintenance are not done regularly.
   - Software for antivirus use is often not updated.
   - The company has not performed regular data backups.
   - Management of the company's unorganized data storage area, employees often struggle to find the data they need.
4. BAI08, regarding the management of information and corporate knowledge.
   - The company has not conducted an audit to evaluate the company's internal management.
   - The company has not run management per the standard framework.
5. BAI09, regarding the management of company assets.
   - There is no data collection related to the use of laptops, stationery, printers, servers, NAS, and measuring instruments owned.
   - Equipment maintenance that is less than optimal, so that the equipment is damaged when it is needed.
   - The company has not scheduled the calibration of the equipment, thus making the measurement results inaccurate during use.
   - There is no data collection related to permits to bring in/out company assets.
   - Maintenance of storage warehouses that are less than optimal, and the absence of numbering according to the function of each equipment.

And the result for objective BAI03 that got fully achieved at maturity Level 1 is because PT XYZ already made an initial stage of products management, but still not well organized and some weaknesses were found, namely as follows:

1. BAI03, regarding the management of owned products.
   - The company does not yet have a website containing company profiles and product catalogs.
   - Print-out product catalogs are often not updated according to the latest products.
   - There is no product and catalog management division.
   - There is no warehouse as a place for quality checking for each product to be sold.

4.3. Recommendation

So based on some of the deficiencies or problems found, the following development recommendations are prepared:

1. Recommendations for objective EDM04:
   - Make monthly report in google sheet with some graphic or chart that can represent the evaluation of undergoing management. Such as the data of measurement tools condition, the data of training schedule, and also the monitoring data of laptops usage.
   - Held a meeting once a month to evaluate the management of the company's supporting facilities, which is useful to find out the shortcomings and obstacles that occur during

management. So that the evaluation can be used as a lesson learned for further management improvement.
- Provide an internal audit to evaluate the management.
- Establish the regulations, based on organization purposes, and provide sanctions related to violations, theft, and negligence in using company support facilities.

2. Recommendations for the APO07 objective:
   - Have a training and certification schedule as once a year to employees, especially engineers by the areas of expertise needed in the job.
   - Establish a Human Resources division to manage their human resources.
   - Make monthly report of employee's activity and productivity.
   - Make a monthly agenda for every division.
   - Make a monthly objective for every division.
   - Assign job desks fairly, for example, sales to manage sales and engineers to manage operations. The company needs to rotate employees to each division, so that each employee can know all the work being done and if one employee already has an extra workload, then other employees can help each other.
3. Recommendations for APO14 objectives:
   - Make a monthly report using google sheet for data backup, server maintenance, involved users, and the license of security software.
   - Make monthly schedule as twice a month for cleaning server room. And will be recorded by data monitoring from google sheet.
   - Make weekly schedule as once a week for data backup. And will be recorded by data monitoring from google sheet.
   - Making regulations regarding the use, backup, and deletion of company data. And held monthly meeting to ensure the data management is well organized.
   - Provide a password for each company data storage location on the NAS. As well as recording all accounts and passwords into a google sheet to help employees in times of need.
   - Divided the storage for each team and division to make the data management easier.
   - Divided the network into 2 types, such as external network (for guests) and internal network (for employees), thereby reducing the risk of hijacking company data.
   - Make a record for the usage of software license by google sheet, to ensure that the license always updated based on lifetime period.
   - Establish an IT division as well as the person in charge to manage and report once a month related to the management and use of company data.
4. Recommendations for objective BAI03:
   - Create a website that contains company profiles and products owned.
   - Updating the catalog according to product developments.
   - Make a record for every product using google sheets to make it easier for employees when they need a catalog or list of products they have.
   - Delegate a Marketing division and person in charge to manage the owned products catalogues, and also who have responsible to report the products management.
   - Rent or build a warehouse, to make it easier for companies to carry out quality control for each product to be sold.
   - Make a monthly report for products management, such as sold products, postpone products, broken products, and the quality control of products.

5. Recommendations for BAI08 objectives:
   - Rent an auditor as once a month to evaluate the internal management, such as facilities, measurement tool, electronics, and owned products.
   - Provide some online storage to keep the confidential information, supported by administrator password to access the storage. This storage can provide the needed information to all employees.
   - Delegate IT division with person in charge who responsible to manage the storage and activity reporting.
6. Recommendations for objective BAI09:
   - Make google sheets to facilitate data collection related to management of stationery, printers, servers, NAS, laptops, measuring tools, and owned electronic instrumentation. From this data collection, employees can easily monitor the usage and the condition of each equipment.
   - Perform cleaning and maintenance every 1 month for each piece of equipment owned. Supported with reporting by google sheet.
   - Make a purchase order once a month for each stationery that will run out based on the data collection that has been made.
   - Carry out warehouse cleaning and maintenance. Supported with activity report with photo, and record the activity into google sheet.
   - Clean and maintain the storage room once a month, so that the condition of the equipment is maintained. Supported with activity report with photo, and record the activity into google sheet.
   - Calibrate measuring instruments every 6 months to ensure the measuring instruments are still functioning properly. Supported with recording of calibration certificate, and record the activity into google sheet.
   - Carry out disposal procedures for any equipment that is no longer in use. By using disposal services from other companies, so that the disposal process can be carried out properly and correctly. Supported with recording of disposal letter with photo, and record the activity into google sheet.
   - Use original software to reduce the risk of application errors. Supported with recording software used by google sheet.
   - Install an antivirus software for every laptop used, and ensure that the antivirus license is always updated. Supported by google sheet that maintain the software lifetime.
   - Provide storage for document reporting, such as facilities management, warehouse management, data backup management, disposal management, and software-license management.
   - Held monthly meeting to evaluate and align the existing resources management based on organization purpose.
   - Delegate IT division with person in charge who responsible to report the resources management.

5. CONCLUSIONS

The results obtained in this study are that there are 6 selected objectives, namely EDM04, APO07, APO14, BAI03, BAI08, and BAI09. Which is then used to evaluate management performance based on the maturity level of Level 1. The result is only objective BAI03 got fully achieved at maturity Level 1, and the others objectives such as EDM04, APO07, APO14, BAI08, and BAI09 got not achieved. This result shows that the resources and IT management of PT XYZ is lack of basic

capability for internal management, and incomplete to toward the purpose of governance and management objectives. Also based on this reason, the maturity level of PT XYZ management mostly become Level 0, and to achieve the target of Level 4 (Quantitively Managed) needs to prioritize aligning and improving management performance based on these objectives by referring to the recommendations that have been prepared such as, make monthly report in google sheet with some graphic or chart that can represent the evaluation of undergoing management. Such as the data of measurement tools condition, the data of training schedule, and also the monitoring data of laptops usage. Also provide division or team with person in charge to monitor the management.

REFERENCES

Rahmi Novita, Eko Nugroho, Sujoko Sumaryono, (2014), "Penilaian Tingkat Capability Tata Kelola TI Pada Aspek Manajemen Sumber Daya Manusia", ISSN: 2302-3805, Seminar Nasional Teknologi Informasi dan Multimedia.

Fitria, Apol Pribadi Subriadi, (2016), "Pembuatan Model Pengembangan Karir Sumber Daya Manusia Teknologi Informasi Berbasis Kompetensi (Studi Kasus: Bidang Teknologi Informasi PT Pembangkit Jawa Bali)", Undergraduate Thesis, Institut Teknologi Sepuluh Nopember Surabaya, Surabaya.

Dwi Sulistyoati, Raden Venantius Hari Ginardi, (2021), Manajemen Data Dan Informasi Menggunakan COBIT 2019 Di Biro Humas dan Protokol Pemerintah Provinsi Jawa Timur. Thesis, Institut Teknologi Sepuluh Nopember Surabaya, Surabaya.

ISACA, (2018), COBIT 2019 Framework: Governance and Management Objectives.

Ari Kurnia Setiawan, Johanes Fernandes Andry, (2019), "IT Governance Evaluation Using COBIT 5 Framework on The National Library", Journal of Information Systems.

Gigih Mathori Basil, Nadiyasari Agitha, Moh. Ali Albar, (2019) "Analisis Tata Kelola Teknologi Informasi Untuk Meningkatkan Mutu Sumber Daya Manusia Menggunakan Kerangka Kerja Cobit 5 (Studi Kasus: Politeknik Pariwisata Negeri Lombok)", ISSN:2657-0327, Jurnal Teknologi Informasi.

Andika Putra Agustian, Melissa Indah Fianty, (2021), "Penerapan Tata Kelola Teknologi Informasi Menggunakan Framework COBIT5 pada Urusan Bisnis dan Strategi TI di PT XYZ", Bachelor Thesis.

Rijal Khusni Wicaksono, Sri Handayaningsih, (2013), "Perancangan Model Tata Kelola Teknologi Informasi Berbasis COBIT 4.1 Pada Proses Mengelola Sumber Daya Manusia IT (Studi Kasus Bagian Pengelolaan Data Kab. Kendal)", Jurnal Sarjana Teknik Informatika.

Vira Septiyana Kasma, Sarwono Sutikno, Kridanto Surendro, (2019), Sistem Tata Kelola Keamanan Sistem Pemerintahan Berbasis Elektronik (SPBE) Menggunakan COBIT 2019 (Studi Penerapan di Badan X), Thesis, Institut Teknologi Bandung, Bandung.

Yuni Candra, Rahmat, Sapta Eka Putra, (2021), Komunikasi Dan Manajemen Organisasi, *Community Engagement & Emergence Journal*, Vol.2 No.3, hal.44-51.

RISK ANALYSIS OF EXECUTION POWER PLANT EPC PROJECT – CASE STUDY OF XYZ PROJECT

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ABSTRACT

Risk is uncertain event or condition which if it occurs could have a positive or negative impact to project objectives. Several previous EPC Power Plant projects in Indonesia encountered various obstacles during execution, which resulted in cost overruns, poor quality, and project delays. Since the beginning of the project, many work results have been found that are not in accordance with the contract requirements that causing cost over-run and project delays. This research aims to identify risks by evaluating project events and identifying dominant risks. The research method in risk analysis is based on ISO 31010:2016 and Standard Practice of Project Management Institute. The risk identification process was carried out by brainstorming and Consequence/Probability Matrix was used for risk analysis. This research is a case study on XYZ Project with a qualitative approach carried out by Focus Group Discussion by the Owner and Project Management Consultant. The results obtained there are 17 of 30 events that are considered to have a negative impact on the project. This research identified 55 risk registers. Risk analysis obtained 7 dominant risk variables and 5 risks with the highest level of risk, namely emergency and response plan has not been defined yet, there may be personnel working on critical activities without full health and safety training, EPC Procurement schedule has not been disclosed yet, project schedules might not be aligned, procurement plan have not been defined.

Keywords: risk analysis, consequence/probability matrix, dominant risk, Power Plant EPC project.

1. INTRODUCTION

The concept of project risk is a measure of the probability and consequences of not achieving a predetermined project goal (Kerzner, 2017). Identified risks may or may not materialize in a project. Project teams endeavor to identify and evaluate known and emergent risks, both internal and external to the project, throughout the life cycle. Project teams seek to maximize positive risks (opportunities) and decrease exposure to negative risks (threats). Threats may result in issues such as delay, cost overrun, technical failure, performance shortfall, or loss of reputation. Opportunities can lead to benefits such as reduced time and cost, improved performance, increased market share, or enhanced reputation (PMI, 2021). The Engineering, Procurement, and Construction (EPC) project contract includes design, engineering, procurement, and construction which refers to the contracting company in accordance with the contract, so quality, safety, schedule, and costs are the full responsibility of the Contractor for the entire project (Qin, 2017).

Funding a project is very important in completing an EPC project (Juniarta, 2020). Chinese EPC contractors with large capital offer their willingness to run power plant projects at competitive costs and easy payment terms for project Owners (Shalati & Simanjuntak, 2019).

China's EPC contractors promote suppliers from China considering more competitive equipment prices. Several previous EPC projects with Contractors and Suppliers from China experienced various obstacles in the process, resulting in cost overruns, poor quality, and delays in project execution time(Yahya, 2011). Since the start of the project, many work results were found that were not in accordance with the contract requirements. This leads to cost overruns and project delays.

Various inhibiting factors and possible risks will arise in project execution which results in delays in the project schedule. Efforts that have been made to overcome the risk of events that have occurred that have an impact on project delays need to be evaluated and reviewed. This is crucial and important so that the same risk does not happen again and can reduce the impact so that it can be accepted with more effective efforts. Based on the conditions and background of the problem above, this research is needed to find out what dominant risks can occur in the sustainability of the project. Early handling of risks that arise during the project implementation will help the success of a project, and project completion in accordance with the requirements, quality, and schedule agreed in the contract.

2. LITERATURE REVIEW

Risk Management

Risk management is a coordinated activity to direct and control the organization in relation to risk (SNI 8615- ISO 31000, 2018). In the project, risk management is defined as an area of project management knowledge that identifies and manages project risks that can impact the cost, schedule, or scope baseline (PMI, 2019) as shown in **Figure 1**. Identifying, analyzing, and mitigating risks is an obvious part of the risk management process. However, it is also important to capture and document lessons learned from implementing the risk management process. It is important to document issues related to effective risk mitigation strategies that can be used in future projects. In addition, methods that are not or less effective should be documented with recommendations for modification or removal. Lessons learned from previous projects are very useful for managing future projects effectively(Oberlender, 2014).

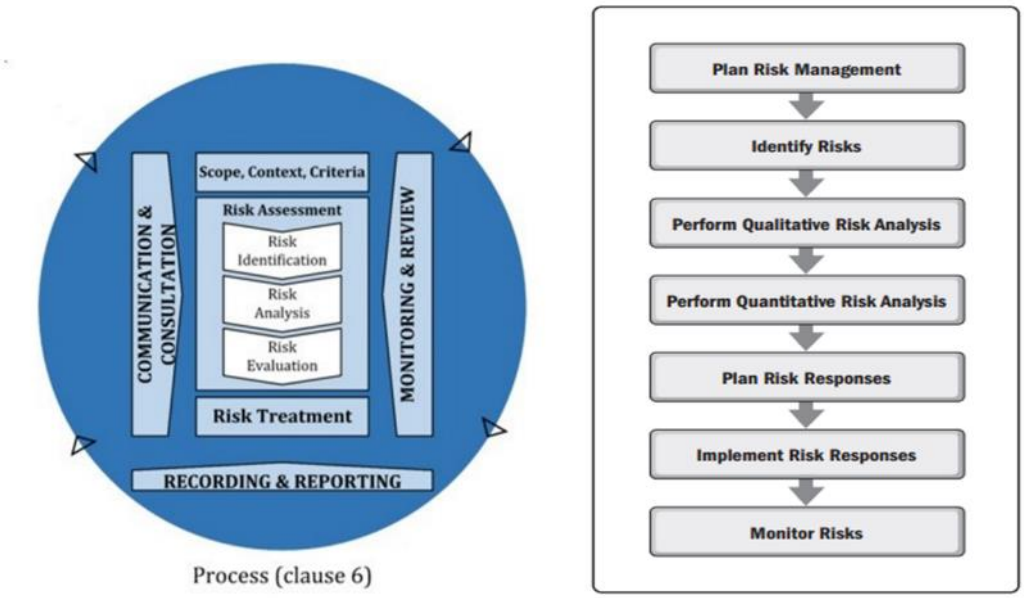


Figure 1. Risk Management Process based on ISO 31000: 2018 (left) and PMI 2019 (right)

Risk Analysis Method

The methods used in analyzing risk can be qualitative, semi-quantitative, or quantitative. The level of detail required will depend on the particular application, the availability of reliable data, and the decision-making needs of the organization. Some of the methods and levels of detail of the analysis may be determined by legislation.

Qualitative assessment defines consequences, probabilities, and risk levels with significance levels such as high, medium, and low, can combine consequences and probabilities, and evaluates the resulting risk level against qualitative criteria. The semi-quantitative method uses a numerical rating scale for consequences and probabilities and combines them to produce a risk level using a formula. The quantitative analysis estimates the practical value for consequences and their probabilities and generates values for the level of risk in certain units defined when developing the context (SNI IEC/ISO 31010, 2016).

In construction projects, qualitative methods of risk assessment are used more often than quantitative techniques. By combining qualitative and quantitative risk analysis techniques, risk management can be improved (Banaitiene & Banaitis, 2012).

Consequence/Probability Matrix

The consequence/Probability Matrix is one risk analysis that categorizes as semi-quantitative. The consequence/Probability Matrix was carried out to determine the level of risk based on probability and impact. Consequence/probability matrix are a way of combining qualitative or semi-quantitative assessments of consequences and probabilities to produce a risk level or risk rating. The consequence/probability matrix is used to sort risks, risk sources, or risk treatment based on the level of risk. It is usually used as a screening tool when several risks have been identified, for example, to determine which risks require further or more detailed analysis, which risks require prior treatment, or which need to be referred to a higher level of management. It can also be used to select risks that do not require further consideration (SNI IEC/ISO 31010, 2016).

Risk Breakdown Structure (RBS)

A common way to compile risk categories is with a Risk Breakdown Structure (RBS), which is a hierarchical representation of potential risk sources. RBS helps the project team consider the various sources from which individual project risks may arise. This can be useful when identifying risks or when categorizing identified risks. The organization may have a generic RBS that will be used for all projects, or there may be multiple RBS frameworks for different types of projects, or the project may develop a customized RBS. If the RBS is not used, the organization can use a specific risk categorization framework, which can be a simple list of categories or a structure based on project objectives (PMI, 2019).

Power Plant

A steam Power Plant as called PLTU is a generator that relies on the kinetic energy of steam to produce electrical energy. The PLTU Generating Unit uses coal as the main fuel and fuel oil (HSD) as fuel at Start-Up. The working principle of PLTU is to convert chemical energy in fuel into electrical energy (Murti et al., 2020). In operation, PLTU generally has components as shown in **Figure 2** (Rianta, 2020):

- Boilers & their accessories. The boiler functions to convert water (feed water) into superheated steam which will be used to turn the turbine. Here the chemical energy of the fuel is converted into heat energy from the steam.

- Turbine & auxiliary equipment. Turbine serves to convert the heat energy contained by the steam into rotary energy (mechanical energy). The turbine shaft is coupled to the generator shaft so that when the turbine rotates the generator also rotates.
- Condenser & accessories. The condenser serves to condense the used steam from the turbine (steam that has been used to turn the turbine).
- Generator & auxiliary equipment. The generator functions to convert rotary energy from the turbine into electrical energy.

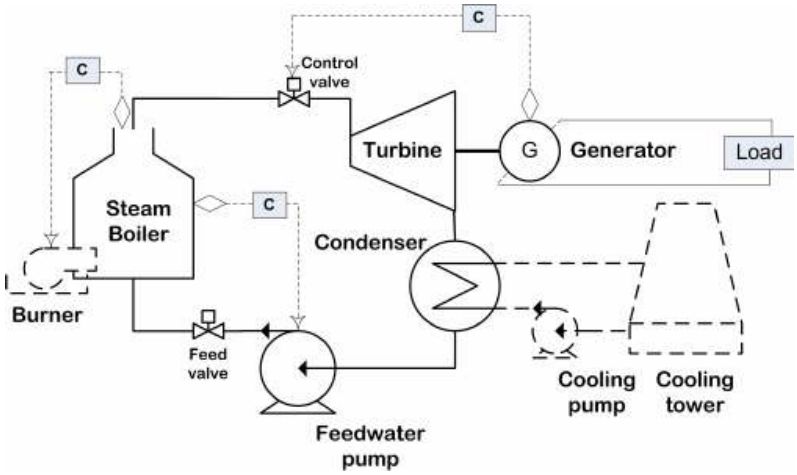


Figure 2. Components of the Thermal Power Plant

3. METHODS

This research is a case study on the XYZ Project with a qualitative approach carried out by Focus Group Discussion (FGD) with a project team consisting of the Owner and Project Management Consultant (PMC). The research methodology refers to ISO 31000:2018 and PMI:2019. The research was started by evaluating past events and any mitigation action that was done to reduce or eliminate risks of the execution of the EPC power plant. The risk identification process is carried out by brainstorming and risk analysis was carried out by using the probability and impact matrix of the risks that could potentially arise in the remaining time of the project execution.

Data collection in this study was divided into two types based on how to get it, namely primary and secondary data. Primary data collection in this study was carried out by Focus Group Discussion (FGD). Secondary data included data such as lessons learned from typical projects, books, journals or references, reports, and others. The respondents involved in this FGD are consisting Project Technical Director, Project Control Manager, Power Plant Manager, Procurement and Logistics Specialist, Project Engineer, Site Engineer, Project Manager, Engineering Manager Project Procurement Manager, QA/QC Manager, Site Manager, HSE Manager, Project Control Engineer and Project Engineer who are all respondent involved in the XYZ project. **Figure 3** shows the percentage of respondents' experience involved in FGDs. By involving personnel who are experienced and have the ability (capability) in their field, it is hoped that the discussion obtained will be more specific and more applicable to the XYZ project under the case study.

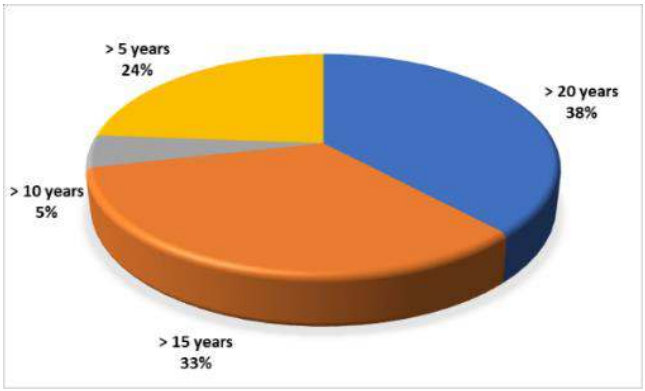


Figure 3. Percentage of Experience of FGD Respondents

This risk management plan was agreed to use a 5 x 5 matrix, namely the use of the impact and probability scale which can be seen in **Table 1** and the risk consequence scale can be seen in **Table 2**.

Table 1. Classification of Probability

Likelihood			
Level		Description	
Practically Certain	32	It is practically certain that it will occur under normal circumstance	90% Chance of Occurrence
Probable	16	Probably will occur	70% Chance of Occurrence
Possible	8	May occur at some moment	50% Chance of Occurrence
Very Unlikely	4	It may occur, but it very unlikely	30% Chance of Occurrence
Rare	2	It could happen, but only in extraordinary circumstances	10% Chance of Occurrence

Table 2. Classification of Impact/Consequence

	Severity Table						
Level	**Cost**	**Schedule**	**Health and Safety**	**Environmental Impacts**	**Reputational Damage**	**Quality**	**Operability**
Very High	Variation greater than 5% of the project's total value (1 M USD)	Over 14 dys	Fatality due to direct exposure.	Impacts that have repercussions in regions distant from the site, or directly over the critical resources for populations or legal protection areas	Exposure of company's image on a national and international level or friction with national authorities	Unusable (Unsafe, Not meet code)	Incapable of achieving operation objectives/goals or a better success than the expected minumum
High	Variation between 2% and 5% of the project's total value (750 K)	up to 14 days	Serious injuries or hospitalization of many people	Impacts to the site's immediately neighboring and get complains from community	Involve Regional authorities or friction with local stakeholders	Not best practice used	Incapable of achieving multiple operation objectives/goals, but it is still possible to achieve a better success than the expected minumum
Moderate	Variation between 1% and 2% of the project's total value (500 K)	It can affect the project's critical path, but it is possoble to avoid delays with replanning	Hospitalization of 1 individual or need for medical care for many people	Impacts localized on site, difficult to contain	Local authorities (District) can identify the problem	Deficiency might affect the longevity (not as efficient)	Incapable of achieving any operation objective/goal, but the other objectives/goals can be achieved and represent a better success than the expected minumum
Low	Variation of up to 1% of the project's total value (350 K)	There may be delays in some activities, but the project's critical path is not affected	Accidents, with minor injuries or first aid care	Small impacts localized on site, easily contained	Problem may be resolved internally in the company	Can live with deficiency (inconvenient)	Minimum consequences over objectives/goals of the operation
Insignificant	Insignificant impacts, can be absorbed by project without affecting project cost (100 K USD)	Insignificant impacts, it can be absorbed by project	Minor impact on quality of life. Incident.	Insignificant impacts (ex: minor dust, minor noise)	Problem may be resolved internally to the project	Can be fixed easily with minimal effort	Minimum consequences over objectives/goals of the operation

The FGD also determined the scale of risk in measuring potential risks by considering their probability and consequence/impact. This scale uses an ordinal measure so that it can determine the rating of risk. The following **Table 3** is referred to as the Risk Matrix which is used to summarize, measure potential risks, and analyze risks in the execution of the XYZ Project. Then from the risk matrix, categories are also determined according to **Table 4** which shows the risk level in the XYZ Project. It was agreed in the FGD that the definition of dominant risk is a risk whose level of risk is unacceptable (see **Table 3**), in this case Very High and High Risk

Table 3. Consequence/Probability Matrix

			Probability				
			10%	30%	50%	70%	90%
		Weights	2	3	5	8	13
Consequences	Weights		Rare	Very Unlikely	Possible	Probable	Practically Certain
	32	Very High	64	96	160	256	416
	16	High	32	48	80	128	208
	8	Moderate	16	24	40	64	104
	4	Low	8	12	20	32	52
	2	Insignificant	4	6	10	16	26

Table 4. Risk Level

Risk Level	Criteria
Very High (>160)	Unacceptable risk - Mitigation and risk reduction measures must be implemented as soon as possible.
High (80 to 128)	Unwanted risk - Implementation of preventive control measures and risk reduction measures, as well as re-evaluation of risks at regular intervals
Medium (26 to 64)	Acceptable risk with control – Risks must be reduced to the lowest possible level.
Low (10 to 24)	Acceptable Risk
Very Low (4 to 8)	Negligible risk

Implementation of Risk Identification is carried out by brainstorming through Forum Group Discussion (FGD) activities. Data is collected from lessons learned and study literature and then processed to obtain a list of negative risks that can affect the achievement of project objectives. A typical Risk Breakdown Structure (RBS) is used as a hierarchical framework to identify and get the category of risk variables. At this stage, the RBS referred to as the company's Risk Management Procedure is used to obtain the typical 10 categories of risk variables for the power plant EPC project as shown in **Table 5**. After risk identification is carried out, the data analysis process begins by determining the level of risk based on probability and consequences.

Table 5. RBS of power plant EPC project

RBS Code	Project RBS
1	Health & Safety
2	Environmental
3	Stakeholder Relations
4	Planning
5	Engineering
6	Procurement
7	Construction
8	Operational readiness
9	Human Resources / Staffing
10	External Risks

4. RESULTS

The Execution phase of the XYZ project is during the 2020-2023 period, while the research is carried out in 2022. It is necessary to examine events that have occurred in the 2020-2022 period which will later be used for evaluation and identify potential risks that may occur until the project is completed in 2023. Based on data of the project found thirty (30) events that have a negative impact on the project. These events have occurred previously that can be used as a reference in risk identification as lessons learned for risk analysis of XYZ Project execution. By evaluating events that have occurred, one of the goals is to identify the risks that exist. From the FGD there were 17 events of the 30 events that were previously obtained, which were included in the risk register for further analysis.

The next FGD stage produces a tabulation of risk registers and their risk levels after determining the probability level and its consequences, which are summarized 55 risk variables have been identified with details consisting of 12 Very High (22%), 18 High (33%), 5 Medium (9%), 17 Low (23%), and 7 Very Low (13%). The percentage of each type of risk is shown in **Figure 4.**

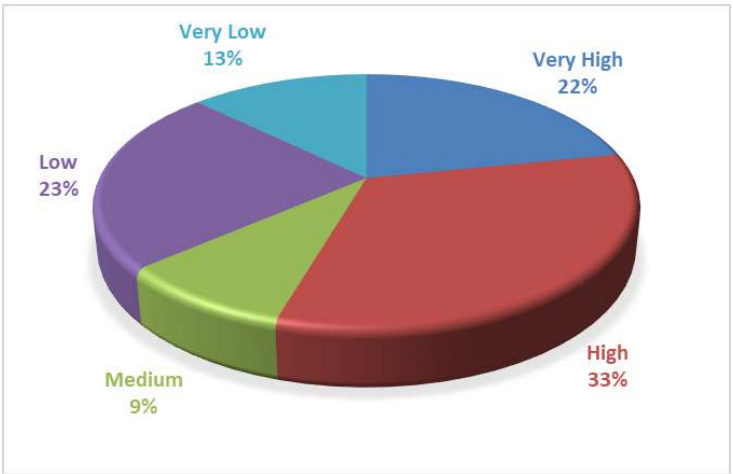


Figure 4. Percentage of each Risk Level

This shows the totally unacceptable level of risk based on **Figure 4**, which is 55%, which indicates the possibility of uncertainty having a negative effect on the objectives of project XYZ Project. In addition, it is also known that the results of the risk variables that most often appear with the level of risk "Unacceptable" are Two (2) categories, “High”: 12 risk variables as in **Table 6** and “Very High”:18 risk variables as in **Table 7** which in total there are 30 risk variables.

Table 6. "High" Risk Variables

SCENARIO'S INFORMATION					PURE RISK SCORE		
RISK ID	RBS 1	RBS 2	Risk Description	Consequences	PURE CONSEQUENCE	PURE PROBABILITY	PURE SCORE
T-EW-HSE-001	1 Health & Safety	1.1 Legal and regulatory requirements for health and safety	Level of HSE coverage is deficient.	Possible injury to personnel, damage to facilities and the environment	High	Possible	High
T-EW-HSE-002	1 Health & Safety	1.1 Legal and regulatory requirements for health and safety	Common Health & Safety culture between Owner/PMC, EPC Contractor and subcontractors has not been implemented.	Health & Safety	High	Possible	High
T-EW-HSE-003	1 Health & Safety	1.1 Legal and regulatory requirements for health and safety	Medical facilities may not follow minimum specifications required by legislation.	Health & Safety	High	Probable	High
T-EW-HSE-006	1 Health & Safety	1.3 Health and Safety Training	Daily Safety toolbox meeting Knowledge deficient	Health & Safety	Moderate	Practically Certain	High
T-EW-HSE-007	1 Health & Safety	1.3 Health and Safety Training	Site Safety Officer for training workers contractors in execution phase has not been mobilized.	Possible injury to personnel, damage to facilities and the environment	High	Probable	High
T-EW-HSE-009	1 Health & Safety	1.4 Fire prevention and Fire Fighting	Fuel tank on site. After inspection, project team did not find adequate fire protection. Quantity of extinguisher might not be enough.	Possible injury to personnel, damage to facilities and the environment	Very High	Very Unlikely	High
T-EW-ENV-004	2 Environmental	2.2 Waste and Emissions	Solid waste management: The material is disposed in a reserved zone. Currently material is only dumped but not managed.	Environment	High	Possible	High
T-EW-PLN-006	4 Planning	4.3 Planning	Submission of Vendor drawings in a timely fashion to suit Engineering design milestones and release of IFC deliverables	Schedule	High	Probable	High
T-EW-PLN-007	4 Planning	4.3 Planning	Late vendor data	Schedule	High	Probable	High
T-EW-ENG-003	5 Engineering	5.4 Detailed Engineering development	Early release of IFD steel drawings early to support EPC's schedule could lead to significant rework in construction	Schedule, Quality	High	Probable	High
T-EW-ENG-004	5 Engineering	5.6 Structure	The sizing of steel structures may be undergoing alterations in their quantities due to delays in the final drawings issued (load plan).	Schedule, Quality	High	Probable	High
T-EW-ENG-005	5 Engineering	5.7 Piping	Basic piping layout might be frozen without preliminary stress analysis	Schedule, Quality	High	Probable	High
T-EW-ENG-004	5 Engineering	5.12 Quality	Chinese equipment supply without Western company oversight and QA/QC in many instances	Quality	High	Probable	High
T-EW-ENG-006	5 Engineering	5.12 Quality	Supplier quality management w.r.t. Engineering issues and specification / datasheet / FAT conformance Inspector qualifications	Quality	High	Probable	High
T-EW-PRO-004	6 Procurement	6.6 Vendors qualification	Failure of EPC to follow Vendor list agreed with Owner / PMC	Quality	High	Possible	High
T-EW-PRO-003	6 Procurement	6.6 Vendors qualification	Technical capability of EPC's Chinese vendors is unknown	Quality	High	Possible	High
T-EW-PRO-002	6 Procurement	6.7 Contract Management	Project does not have in place a formal mechanism to prevent corruption including Whistleblowing, anti-corruption training and audits of internal controls	Cost, Image	High	Probable	High
T-EW-CTR-003	7 Construction	7.10 Construction Execution	Project may experience problems with local availability of construction material such as cement, sand and rebar, etc.).	Schedule	High	Possible	High

Table 7. "Very High" Risk Variables

SCENARIO'S INFORMATION					PURE RISK SCORE		
RISK ID	RBS 1	RBS 2	Risk Description	Consequences	PURE CONSEQUENCE	PURE PROBABILITY	PURE SCORE
T-EW-HSE-004	1 Health & Safety	1.2 Emergency and response plan	Emergency and response plan has not been defined yet.	Possible injury to personnel, damage to facilities and the environment	Very High	Practically Certain	Very High
T-EW-HSE-005	1 Health & Safety	1.3 Health and Safety Training	There may be personnel working on critical activities without full health and safety training. For example, Heavy duty operator might not have the proper license to operate heavy duty equipment.	Possible injury to personnel, damage to facilities and the environment	Very High	Practically Certain	Very High
T-EW-HSE-008	1 Health & Safety	1.4 Fire prevention and Fire Fighting	Fire in the region in the dry season. Firefighting measures implemented might not be efficient in case of fire.	Possible injury to personnel, damage to facilities and the environment	Very High	Probable	Very High
T-EW-ENV-001	2 Environmental	2.1 Environmental conditions and studies	Conditions might not be in compliance because monitoring might not been properly done	Environment, Image	Very High	Possible	Very High
T-EW-ENV-007	2 Environmental	2.3 Permitting process	Permits to be obtained directly by EPC contractor: Permit list is still in progress. Might not be complete.	Schedule, Cost Environment	Very High	Possible	Very High
T-EW-PLN-005	4 Planning	4.3 Planning	EPC Procurement schedule has not been disclosed yet.	Schedule	Very High	Practically Certain	Very High
T-EW-PLN-003	4 Planning	4.5 Team	Scheduler on site with limited skills on Primavera. Resources loading has not been done. Schedule only has durations. Control of schedule might not be done properly.	Schedule	Very High	Probable	Very High
T-EW-PLN-001	4 Planning	4.14 Planning Integration	Power Plant and Alumina plant schedules might not be aligned.	Schedule	Very High	Practically Certain	Very High
T-EW-ENG-006	5 Engineering	5.12 Quality	If EPC flowsheet is incorrect, the plant will not meet production rates and quality specifications	Schedule, Quality	Very High	Possible	Very High
T-EW-PRO-001	6 Procurement	6.1 Procurement plan	Procurement Plan: Equipment/ Packages have not been defined for the full scope of work including the early works.	Schedule	Very High	Practically Certain	Very High
T-EW-CTR-001	7 Constructio n	7.6 Equipment logistics	Transportation of material from China to Site through the Port. Equipment might be lost during transportation.	Schedule, Cost	Very High	Possible	Very High
T-EW-HR-001	9 Human Resources / Staffing	9.2 Resources	Amount of manpower required for execution phase may not be sufficient in the project region.	Schedule	High	Practically Certain	Very High

Further by processing data in **Table 6 and Table 7**, as can be seen in **Figure 5**, it was found 7 risk variables that the most frequently occurring (dominant) are Safety and health risk variables 30%, followed by Engineering 20%, Planning 17%, Procurement 13%, Environment 10%, Construction 7%, and HR/Staffing at 3%.

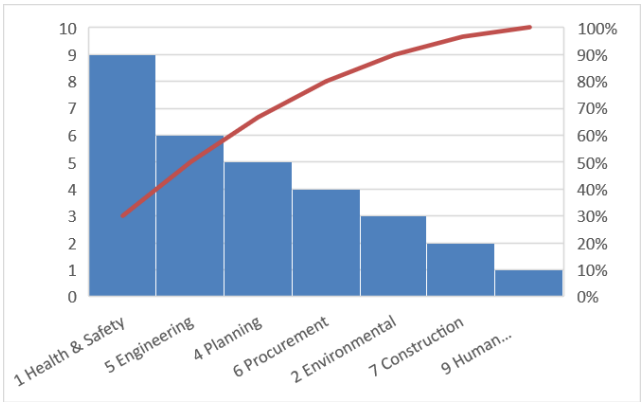


Figure 5. Percentage of Unacceptable Risk based on RBS

Based on the results of the analysis above, several dominant risks are categorized as high and very high risks or called unacceptable risks. Around 80% of the total unacceptable risk, such as the sum of risk variables for Health & Safety, Engineering, Planning, and Procurement will cause a fairly large risk impact on the Project. As a result of these risk factors, it is possible that the objectives of the project will not be achieved. Then, managerial implications that can be carried out by management are as follows: EPC contractor and the Owner shall increase awareness regarding the dominant risks in project execution, including their causes and impacts, to avoid them as much as possible. Improvements shall be made by EPC contractor for internal managerial system need to be carried out, by improving the performance of planning/scheduling, engineering, procurement, and construction by doing the resources involved in the project must be qualified, meet the expected qualifications and have experience in their field. In addition, it is necessary to appoint a competent EHS Manager and make an EHS Plan as needed at the Site.

6. CONCLUSIONS

In this research, it could be concluded that 1) From the results of the FGD, information, and data were obtained showing that there were 30 events that had a negative impact on the XYZ project and the efforts that had been proposed to be carried out. The results of the evaluation of the data can then be used for lesson learning to identify risks in the completion of the XYZ power plant EPC project. There were 17 events that were entered into the risk register for further analysis. 2), This research identified 55 risk registers, and risk analysis obtained 7 dominant risk variables categorized as unacceptable risk namely Health & Safety risk, engineering capability, lack of planning, procurement process problems, environmental issues, construction problems, and availability of competent resources. From 7 dominant risk variables, there are 5 risks with the highest level of risk, namely emergency and response plan has not been defined yet, there may be personnel working on critical activities without full health and safety training, EPC Procurement schedule has not been disclosed yet, project schedules might not be aligned, procurement plan have not been defined.

REFERENCES

Banaitiene, N., & Banaitis, A. (2012). Risk Management in Construction Projects. *Risk Management - Current Issues and Challenges*, *Chapter 19*. https://doi.org/10.5772/51460

Juniarta, I. K. P. (2020). *Analysis Models and Financial Risk Mitigation Strategies in Decision Making for Feasibility of Investments on the Development of the Messian Gas Power Plant Project Development in Riau Province* . Universitas Sumatera Utara.

Kerzner, H. (2017). *Project Management - A Systems Approach to Planning, Scheduling, and Controlling* (12th Edition). John Wiley & Sons, Inc.

Murti, A. S., Manuaba, I. B. G., & Arjana, I. G. D. (2020). Optimization of Coal-fired Power Plant Units Using the Lagrange Method at PT. Indonesia Power UP Suralaya . *Jurnal SPEKTRUM*, *7*(1).

Oberlender, G. D. (2014). *Project Management for Engineering and Construction* (3rd Edition). McGraw-Hill Education.

Project Management Institute. (2019). *The Standard for Risk Management in Portfolios, Programs, and Projects.* Project Management Institute, Inc.

Project Management Institute. (2021). *The standard for project management and a guide to the project management body of knowledge (PMBOK guide).* (7th Edition). Project Management Institute Inc.

Qin, H. (2017). The Advantages of BIM Application in EPC Mode. *MATEC Web of Conferences*. https://doi.org/10.1051/

Rianta, M. G. (2020, February 4). Steam Power Plant (PLTU). https://indonesiare.co.id/id/article/pembangkit-listrik-tenaga-uap-pltu

Shalati, S. N., & Simanjuntak, J. (2019). *Study of Chinese Investment in Indonesia's Coal Power Generation Sector*. http://aeer.info

SNI 8615- ISO 31000 (2018). *SNI 8615:2018 ISO 31000:2018 Risk Management- Guidelines*. www.bsn.go.id

SNI IEC/ISO 31010 (2016). *SNI IEC/ISO 31010:2016 Risk Management- Risk Assessment Techniques*. www.bsn.go.id

Yahya, I. N. (2011). *Risk Management of 10,000MW PLTU Development Project in Order to Improve Cost Performance*. Universitas Indonesia.

MEASUREMENT OF ORGANIZATIONAL READINESS USING IMPROVISATION READINESS INDEX SCORE (IRIS) FRAMEWORK AT UNIVERSITY X IN CRISIS SITUATION

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ABSTRACT

The COVID-19 pandemic is the worst crisis which has had a global impact in the last ten years. Many companies in the world are affected operationally and financially, including University X as a higher education institution in Indonesia. They planned a strategy to become a Research and Innovative University in 2025 in spite of the uncertain condition. Under the highly uncertain condition, organizations need to evaluate their initial assumptions and prepare improvisation strategies to anticipate unexpected events. Organizational Readiness needs to be measured to achieve their target based on planned strategies. Measurement of organizational readiness is rarely discussed in the context of environmental conditions that are dynamic and full of uncertainty. Through strategic improvisation, many companies in the world can survive, adapt, or even thrive in times of the crisis. This study aims to measure the level of readiness of the organization's strategic improvisation to deal with pandemic conditions. The measurement is carried out using the Strategic Improvisation Readiness Index Score (IRIS) framework to evaluate several strategic aspects of the organization. The results of the study will show the level of organizational readiness.

Keywords: Crisis, Organizational Readiness, Strategic Improvisation Readiness Index Score, University

1. INTRODUCTION

COVID-19 pandemic is the worst crisis which has had a global impact in the last ten years. Many companies in the world are affected operationally and financially. Based on a survey conducted by the Badan Pusat Statistik (2020) involving all business sectors in Indonesia, only 6 out of 10 companies are still operating as usual as a result of the implementation of physical distancing policy by the Indonesian government.

About 27 out of 100 institutions in the educational sector are operating as usual or conducting offline activities by implementing health protocols (Badan Pusat Statistik, 2020). University is required to be able to anticipate changes and formulate strategies that can improve the quality of the educational process. Based on Katadata (2020), some universities had a drastic decremental income during pandemic. The factor of the decreased income is due to individual income that also decreasing, which has implications for a decremental interest when entering higher education, about 60-90% of that income derived from students. In addition to declining income, universities have to continue their effort to deliver effective learning with all of their limitations. Effective learning

methods and the number of graduated students will be directly proportional. According to the Minister for Human Development and Culture, the goals of higher education are expected to contribute to develop an excellent human resource so that they can become one of the factors for achieving 'Indonesia Maju' in 2045 (Effendy, 2021).

University X planned a strategy to become a Research and Innovative University in 2025. Based on the strategic plan document for University X at periods 2021-2025, there is an assumption that the strategy will be divided into 2 parts. The first year (2021-2022), the strategy will mainly focus on the adaptation effort of University X to handle pandemic, meanwhile the next 3 periods will be focus on the new normal era. University X cannot just to rely on the strategic plan that has been determined, since crisis situation might generate unexpected things that might be hard to be anticipated by the organization (Hermann, 1963; Rosenthal, Boin, & Comfort, 2001; Stern & Sundelius, 2002);

Organizational Readiness needs to be measured to achieve their target based on the planned strategies. Organizational readiness measurement is rarely discussed in the environmental context that are dynamic and full of uncertainty. Through strategic improvisation, many companies in the world can survive, adapt, or even thrive in the crisis period. Therefore, this study aims to measure the level of readiness of the organization's strategic improvisation to deal with pandemic conditions. The results of this study can be used as a guidance for the other higher education institution to manage their strategies during crisis.

2. LITERATURE REVIEW

Table 1 Literature Review

Author	Objective	Method	Measurement Conditions	
			Normal	Crisis
Kaplan and Norton (2004)	Provide a methodology for measuring the readiness of intangible assets within the organization	Measurements on human, information, and organization capital readiness	V	
Quantisoft (2013)	To measure the effectiveness of the organization in producing the planned output	*Holistic Organizational Effectiveness (HOE) Survey*	V	
Antony (2014)	Provide a theoretical basis in identifying the readiness factors needed in the implementation of Lean Six Sigma (LSS) programs or projects that are applied to the higher education sector	Identification through secondary data	V	
Scaccia et al. (2015)	Provide a theoretical basis in identifying components that play a role in organizational readiness to implement innovation programs	Identification through secondary data	V	
Wandersman Center (2020)	Research extension from Scaccia et al. (2015) which can be used as the disruption context	*Readiness for recovery and resilience* (RRR)		V
Hughes et al. (2020)	Measurement of the organization readiness level in terms of their strategy to handle the crisis	Strategic Improvisation Readiness Index Score (IRIS)		V

Measurement of organizational readiness in crisis conditions has its own challenges and the treatment is different with normal or stable conditions. Based on the literature review above, most of the research related to organizational readiness was carried out under normal conditions. The use of a relatively wider scope of readiness makes the research of Hughes et al. (2020) have the opportunity to conduct general to specific analysis related to organizational strategic readiness. Based on these considerations, the authors refer to Hughes et al. (2020) research because the University X has a broad strategic context and does not only focus on innovation strategies

3. METHODS

IRIS is an instrument to measure the readiness level of strategy improvement which using strategic imperative basis as the guideline of the evaluation process. IRIS refers to 10 C strategic imperative that constituted by fundamental value as the enablers factor either explicitly or implicitly. The 10 C framework which contained in the strategic imperative described as follows.

Table 2 Strategic Imperative Definition

Strategic Imperative	**10 C**	**Definition**
Resource Fluidity Imperatives	*Capital*	Organization's resources
	Capability	Management capability of the strategic decision making
Strategic Leadership	*Cognition*	The approach that taken when making a strategic decision. The decision made by considering the evidence of information provided either limited or more based on the intuition.
	Confidence	The management's confidence believe that any crisis can be well-handled.
Strategic Posture	*Clarity*	Making strategic decision might generate different value with the result of the previous implementation. Therefore, the management should show their willingness to modify the strategy in order to adapt with the different condition that should be handled.
	Coordination	Discuss with the stakeholder that related with the decision-making context.
Organizational Resilience	*Climate*	The internal organization's environment that willing to accept the non-conventional condition and the discipline to support the generation of strategic improvement.
	Collaboration	Collaboration between the individual person, team, group, department and functional level to provide growth space for any experiment, new idea potency and new strategy to be arisen.

Strategic Imperative	10 C	Definition
Innovative Proclivity	*Creativity*	The willingness to conduct the experiment and discover the idea of new solution in the uncertain condition and the limited time.
	Customer Centricity	Take the consumer as the main objective of formulating the strategy

IRIS methodology gives evaluation item that have to be filled out by the executive level of an organization by answering the statement of conformity by using 5 point of Likert scale. The item of the statement is made based on the 10 C framework, which consist of 5 statements in every framework point. The questionnaire consists of 2 types of statement which refer to left extremity (equal to 1) and right extremity (equal to 5) for each C.

The total value for each C is equal to 25, while the great amount for all 10 C is 250. The average value indicates the readiness of the organization against any particular strategic imperatives. The higher the value for each strategic imperatives the better the organization to maximize the strategy improvement for any particular parameter that related to the value. Furthermore, the higher IRIS value, the more alternative strategy can be taken to handle the crisis. IRIS total value also can be normalized to perceive the phase of handling crisis, which consist of survive / adapt / thrive phase. Any organization which able to generates > 0,8 IRIS value is having thrive condition, which indicates that the organization have good ability to adapt, able to exit from the crisis condition and know what should be done in order to handle crisis in the future. The value of 0,6 - 0,8 indicates adapt condition, and value < 0,6 indicates survive condition which refers to the condition of the organization that difficult to improve the strategy.

This research involves four vice rectors of University X as respondents who have various expertise such as academics, finance, human resource, and innovation. Rector of University X couldn't participate because of full agenda while this research has time limitation.

4. RESULTS

The next step is calculating the collected data by calculating the questionnaire statement which represent the 10 C aspect with the related strategic imperative. Furthermore, that value then averaged for all participant as the representatives of the evaluation for all 10 C aspect and the strategic imperatives. The final result of IRIS questionnaire is to find out the grand total value of all strategic imperatives which indicates the improvisation readiness level of University X. In this case, the normalized readiness index is 0,72. That value classified as the 0,6 - 0,8 range of value. Meaning that University X able to adapt in crisis condition. Based on the calculation, total value of the organization's readiness level can be narrowed based on the 5 strategic imperative aspects. Figure 1 represents the organization's readiness level based on the strategic imperatives. If the value of strategic imperatives equal to or near with the maximum value, then the point on the graph will be come near with the outer line. Figure 1 shows the low level of readiness especially on the strategic leadership of the strategic imperatives. This low level of strategic leadership is influenced by the 10 C value which related with cognition and confidence aspects.

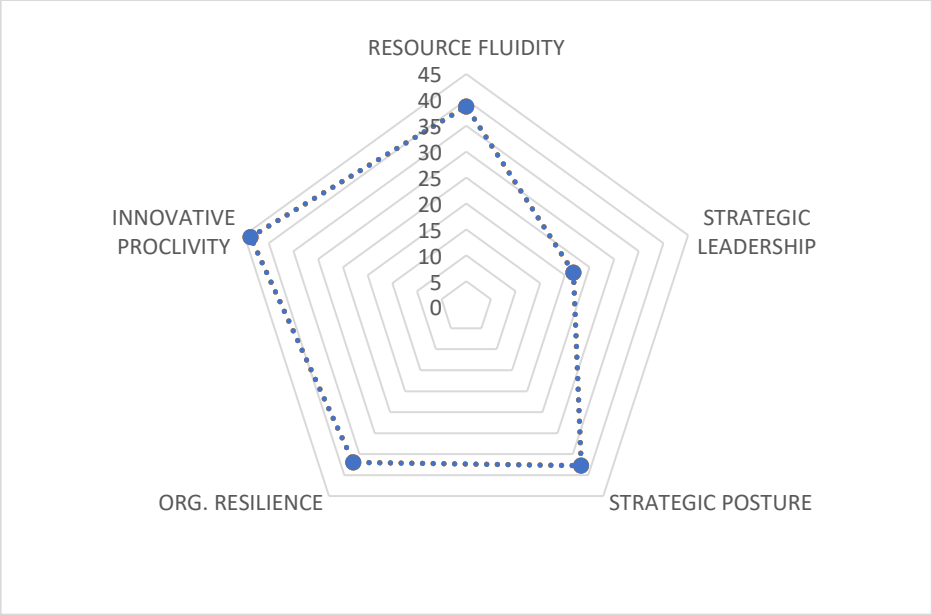


Figure 1 Organization Readiness Map Based on Strategic Imperative

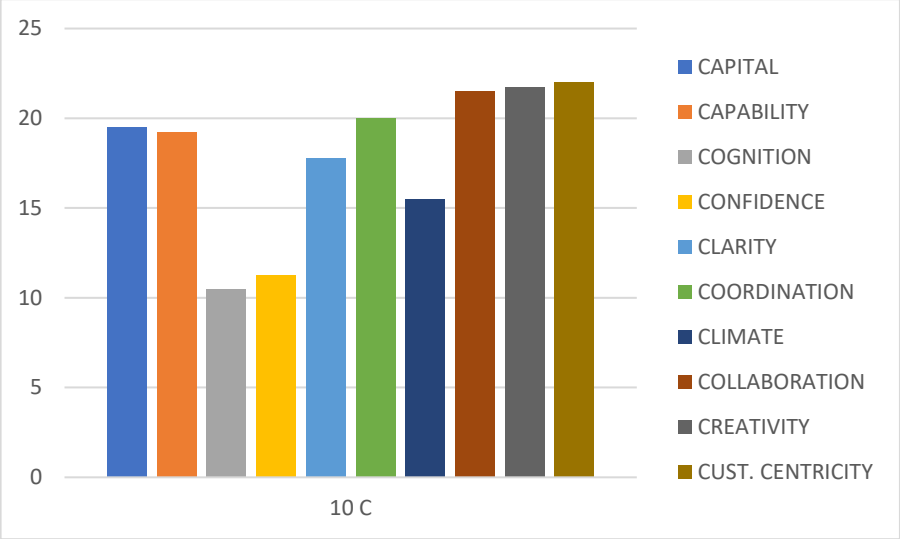


Figure 2 Organization Readiness Based on 10 C Aspect

5. ANALYSIS

Innovative proclivity level becomes one of the valuable aspects which having a better final result of readiness level compared to another aspect. Based on University X Annual Report, all performance indicators that related to innovative proclivity aspect are able to achieve their target in 2021. Most of the performance indicators are related to the publication of research. This shows one of the universities functions that is research function is not obstructed by the crisis conditions. This finding shows that the crisis phenomenon which has a global impact able to give an opportunity for University X to contribute more in research and community services.

The resource fluidity level is one of the important aspects to be assessed, since the affected resources was so many and their usage have to be managed for executing the functions of the

university. One of the resources that support the online learning implementation is the existence of the e-learning platform that is integrated with other modules, making it easier to execute several academic activities. Based on the annual report in 2020, University X is in the advanced stage of developing an e-learning platform to accommodate online lectures at that time. This phenomenon shows that University X already has the resources prepared for the long-term education plan in the industrial 4.0 era. Even though the government launch a regulation to limit face-to-face lectures, University X already had strong basis in carrying out online lectures by utilizing its platform. Correspond to the results of the IRIS questionnaire which states that University X is classified as an organization that is able to adapt in times of crisis, the organization already had the resources that have been prepared in that period even before the crisis happened. Then when a crisis occurs, organizations can rely on existing resources to face the challenges ahead.

Organizational Resilience level related to the cooperation and organizational climate aspect. The achievement of performance indicators for study programs and diplomas in collaboration with partners in times of crisis able to develop mutual benefit opportunities for both parties. The success of University X in expanding its network of cooperation with partners is a valuable asset to be able to adapt in times of crisis. Collaboration also conducted by translating the idea that stated on research becomes the real output. Here, University X has the high level of readiness level, especially in the innovative proclivity aspect. In the crisis era, University X collaborating with another University to develop the technology of giving treatment to COVID-19 patient. This phenomenon showing that the combination between University X strength in the innovation aspect and the collaboration aspect will bring the organization to be able to adapt in the crisis condition and also able to grow and create the new added value which their benefit can be perceived by the organization as well as the society.

Strategic Leadership aspect is one of the strategic imperatives aspects which has the lowest readiness level. This is represented by the low level of cognition and confidence aspect as shown in Figure 2. One of the evaluation statements on the cognition aspect that having the lowest value is related with the tendency of the organization for prioritizing the rational approach based on the provided fact and evidence. The high level of uncertainty in the crisis condition will be ended and generates an unexpected condition. That's why an urge response from the leader is needed. Intuition approach for decision making is suitable in a condition that characterized by the lack of information. In the confidence aspect is assessed by how confidence the organization when conducting their strategy. In this case, University X tend to be more careful and conservative for all actions. It is contradictive with the confidence fundamental which needed in the crisis condition. The high confidence level indicates that a particular organization able to execute the strategy that different with the common activities conducted before crisis happened.

Strategic posture aspect related with the effort of the organization to accommodate the improvement of the strategy and coordinate with related stakeholder to support conducting the strategy. Following the left extremity, which indicates the careful-handed actions, University X has the flexibility to conduct the improvisation of the strategy. One of the policies that frequently amended is the policy that related to the work systems and the lecturing systems that applying the hybrid systems. The alteration is implemented by looking at the pandemic situation. The "cautious actions" is the consequences of the pandemic situation. Different with previous crisis conditions, crisis that related with the human healthcare will generates broader effect in terms of the organization's operational aspect.

6. CONCLUSIONS

The result of IRIS questionnaire explains that University X has 0,72 normalized readiness index which indicates that University X able to adapt in the crisis conditions based on its readiness aspect such as resource fluidity, innovative proclivity, and organizational resilience that can support higher educational function. Innovative proclivity aspect has been the highest aspect score that indicates the research function is not hampered by crisis. This finding shows that the crisis phenomenon that has a global impact, gives an opportunity for University X to contribute more in research and community services.

REFERENCES

Antony, J. (2014). Readiness factors for the Lean Six Sigma journey in the higher education sector. *International Journal of Productivity and Performance Management*, 257-264.

Badan Pusat Statistik. (2020). *Analisis Hasil Survei Dampak COVID-19 terhadap Pelaku Usaha.* BPS RI.

Badan Pusat Statistik. (2020). *Analisis Hasil Survei Dampak COVID-19 terhadap Pelaku Usaha #2.* BPS RI.

Burhan, F. A. (2020, Agustus 8). *Kampus di Masa Pandemi: Pendapatan Turun, Uang Kuliah Minta Dipotong*. Retrieved from Katadata.co.id: https://katadata.co.id/desysetyowati/berita/5f2e58cfa0341/kampus-di-masa-pandemi-pendapatan-turun-uang-kuliah-minta-dipotong

Burhan, F. A. (2020, Agustus 8). *Kuliah Online Dinilai Lebih Fleksibel, Tapi Terkendala Infrastruktur*. Retrieved from Katadata.co.id: https://katadata.co.id/desysetyowati/berita/5f2e8219e6bd3/kuliah-online-dinilai-lebih-fleksibel-tapi-terkendala-infrastruktur

Hughes, P., Morgan, R. E., Hodgkinson, I. R., & Kouropalatis, Y. (2020). A diagnostic tool to determine a strategic Improvisation Readiness Index Score (IRIS) to survive, adapt, and thrive in a crisis. *Industrial Marketing Management*, 485-499.

Institut Teknologi Sepuluh Nopember. (2020). *Draf Rencana Strategis ITS 2021-2025.* Surabaya.

Institut Teknologi Sepuluh Nopember. (2021). *Laporan Kinerja Institut Teknologi Sepuluh Nopember Berdasarkan Perjanjian Kinerja Kemendikbud Tahun 2020.* Surabaya.

Institut Teknologi Sepuluh Nopember. (2022). *Laporan Kinerja Akhir Tahun 2021 Institut Teknologi Sepuluh Nopember.* Surabaya.

ITSOnline. (2021, September 20). *ITS Resmi Berlakukan Kembali Perkuliahan Hybrid*. Retrieved from ITS NEWS: https://www.its.ac.id/news/2021/09/20/its-resmi-berlakukan-kembali-perkuliahan-hybrid/

ITSOnline. (2022, Maret 4). *Cegah Penyebaran Covid-19, ITS Serahkan CoFilm+ Antivirus Coating ke RSUA*. Retrieved from ITS News: https://www.its.ac.id/news/2022/03/04/cegah-penyebaran-covid-19-its-serahkan-cofilm-antivirus-coating-ke-rsua/

Kaplan, R. S., & Norton, D. P. (2004, Februari). *Measuring the Strategic Readiness of Intangible Assets.* Retrieved from Harvard Business Review: www.hbr.org

Quantisoft. (2013). *The Holistic Organizational Effectiveness Survey.* Retrieved from Holistic Organizational Effectiveness: www.quantisoft.com

Risalah, D. F., & Fakhruddin, M. (2021, Desember 19). *Menko PMK: Pentingnya Peran Perguruan Tinggi dalam Pembangunan SDM Unggul*. Retrieved from Republika.co.id: https://www.republika.co.id/berita/r4bphc327/menko-pmk-pentingnya-peran-perguruan-tinggi-dalam-pembangunan-sdm-unggul

Scaccia, J. P., Cook, B. S., Lamont, A., Wandersman, A., Castellow, J., & Katz, J. (2015). A Practical Implementation Science Heuristic for Organizational Readiness: R=MC2. *Journal of Community Psychology*, 484-501.

Wandersman Center. (2020). *Using Readiness - Readiness for Recovery and Resilience (RRR) Tool*. Retrieved from Wandersman Center: https://www.wandersmancenter.org/using-readiness.html

DIGITAL MARKETING INNOVATION FOR THE DEVELOPMENT OF BATIK ENTERPRISE IN SURABAYA CITY

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ABSTRACT

The development of information technology causes entrepreneurs to switch from conventional marketing to digital, especially when using the internet to broaden their marketing reach. However, there aren't many Batik micro enterprises in Surabaya that can fully benefit from digital marketing. The most popular methods for promoting products are still offline fairs and word-of-mouth advertising. Based on the circumstances and requirements of these enterprises, this study seeks to offer suggestions for new digital marketing approaches. This study uses the Design Thinking method to ensure that the innovations provided to the enterprises consider the needs and the actual context. Design Thinking in this study consists of five phases: empathizing with the digital marketing issues faced by Batik Micro Enterprises, identifying the challenges (pain) and benefits experienced by the persona of Batik Micro Enterprise actors, developing digital marketing ideas based on those needs, selecting ideas with the entrepreneur owners, and testing ideas. The study provides insight into the elements that encourage Surabaya Batik Micro Enterprise to accept new concepts as well as potential challenges to the implementation of digital marketing.

Keywords: Design thinking, Digital Marketing, Batik, UMKM, Innovation.

1. INTRODUCTION

In 2021, the number of Internet users in Indonesia increased by 11 percent, from 175.4 million to 202.6 million (Agustini, 2021). The rapid growth of information technology should motivate micro, small, and medium-sized enterprise (MSME) actors to create as many innovations as possible to compete with competitors in both domestic and international markets.

The present development of digital marketing prompts businesses to consider shifting to digital marketing from conventional marketing. Internet-based digital marketing is more likely to expand the reach of marketing. However, there are MSMEs that have not adopted digital marketing, even though they are located in regions with a highly developed information technology infrastructure, such as the Batik MSMEs in Surabaya, which is the second largest city in Indonesia. This study discusses in detail the situation experienced by Batik Enterprises Surabaya in implementing digital marketing using ethnographic design thinking. Enterprises appointed as subjects in this study were Batik MSMEs that have not used digital marketing optimally, such as Batik "A". Due to a lack of resources for digital marketing, MSME Batik A has only employed a word-of-mouth marketing approach.

2. LITERATURE REVIEW

Numerous scholars have examined digital marketing in the Batik industry. Mucholil et al. (2021) conducted research on the development of digital marketing for Batik businesses in villages by utilizing social media such as Instagram and websites. In line with previous research, Mucholil et al. (2021) claimed that by implementing digital marketing in the industry, they were able to improve sales by up to 30 percent. Imron et al. (2021) explored digital marketing to boost Jepara Batik's competitiveness. Imron et al. (2021) investigated the efficacy of marketing techniques applied by SMEs, and they discovered that SMEs enjoyed sales increases. In line with other researchers, Qurrata et al. (2021) examined the evolution of the digitalization marketing mix and technology through a case study of Batik SME in Malang Regency. Qurrata et al. (2021) also ran experiments to increase production by using batik equipment and dye baths in the coloring process, besides improving the quality of marketing. According to Qurrata et al. (2021), it is required to conduct training activities for strategic content development, digital marketing mix, management training, and the introduction of financial technology in order to improve the quality of marketing. Slightly different from the four previous researchers, Damastuti (2020) examined the adoption of digital marketing innovations by MSME Tie Dye Batik using the phenomenological method. Damastuti (2020) discovered that technology adoption in batik digital marketing was relatively low due to the fact that the majority of artisans were slow to adapt to technology (late majority) due to their age and socioeconomic status.

The digital marketing research in the batik business that has been conducted by Mucholil et al. (2021), Imron et al. (2021), and Qurrata et al. (2021) applies a top-down action research approach. Meanwhile, Damastuti (2020) attempts to comprehend the situation. The disadvantage of the top-down approach is that what works in one context does not always work in another. Therefore, a comprehensive awareness of the context is required prior to introducing an innovation. Design thinking is an innovation strategy that begins with a process of understanding the context before proposing a solution. A design-thinking-based study on digital marketing in the Batik industry has not yet been conducted. There is a researcher who discusses digital marketing and design thinking, but the topic is unrelated to batik. Ngamvichaikit (2021) conducted research in the field of Pharmaceutical Digital Marketing. He recommends proposals for appropriate and practical digital marketing guidelines in the pharmaceutical industry, as well as suggestions for establishing professional teleconsultation with online pharmacies that must be legitimized and standardized.

3. METHODS

This research employs a qualitative methodology and a design thinking approach to generate strategic recommendations for micro, small, and medium-sized batik enterprises. The design thinking theory refers to the Double Diamond UK Design Council theory, which consists of four phases: discover, define, develop, and deliver.

The primary data collection involves two techniques: observation and interviews. Observations include examining the enterprise's marketing activities MSME batik A on Brongglan Sawah Surabaya, as well as its utilization of social media and online marketplaces. MSME batik A has started a business for six years. Employees were close friends of Eka when she was at school. In marketing their products, MSMEs still rely on conventional marketing, namely on several close friends, exhibitions, and sales centers. Meanwhile, semi-structured interviews were done with the digital marketing team or individuals involved in online marketing operations. Secondary data is acquired from relevant publications, journals, and books on digital marketing, Batik, and design thinking.

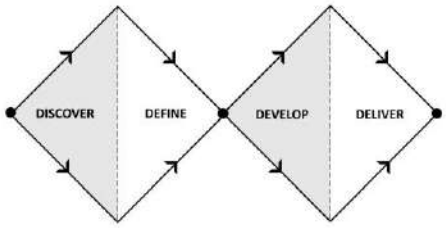


Figure 3.1 The Design Thinking Phase using Double Diamond Framework (UK Design Council, 2006)

a. Discover is the first step in understanding the research context. The researcher designed the interview questions and collated the observational criteria. Researchers looked closely at how the informants used Instagram to market their products, focusing on the problems they ran into and the biggest ones. It included observing informants' activities related to digital marketing.
b. Define. The interview results were synthesised and shown using Persona, User Journey Map, and Empathy Map. Through this representation, it is able to identify each activity step's most significant challenges in great detail. A comprehensive understanding of the challenges that arise may generate innovative ideas.
c. Develop. The generation of new concepts is conducted by brainstorming technique focused on the end user rather than the researcher.
d. Deliver. Researchers draw conclusions on the most crucial difficulties and recommend digital marketing methods for the Batik business. Following these recommendations, the enterprises provided feedback on the implementation regarding the ideation concepts.

4. RESULTS

4.1 Discover

At this stage, the initial step is to review the relevant studies, followed by in-depth interviews with the persona, the owner of the Batik enterprise, using semi-structured interview techniques. The interview is to discover the informant's digital marketing background for their business. Enterprise A is a batik enterprise in Surabaya that was founded in 2016 and is still in operation. Let's say the owner of this company is Eka, not his real name. Eka has been using traditional word-of-mouth marketing by participating in various Surabaya City Government-sponsored batik shows. Enterprise Batik A rarely performs online marketing.

Eka, 25 years old, graduated from a vocational high school in Surabaya with textile expertise. Eka started her batik business in 2016 and now has three employees who are all close friends. Eka enjoys studying and exploring batik patterns. Eka pursues the batik business to meet the needs of life while preserving culture. Eka possesses a moderate level of canting and sketching ability. Eka worries about inadequate teamwork while running his business and sometimes becomes bored with the monotonous and repetitive work of making batik patterns.

The next phase, following the discovery of the persona's background profile, is to investigate the behavior and pain-gain experienced by the enterprise in digitally marketing its products. Eka uses Instagram for online product promotion.

Eka had heard that marketing on Instagram was simple, but he found that the photo-sharing program Instagram was not meant for marketing activities. Eka uses Instagram to enrich references and monitor the prices of competitors' products. Eka believes that Instagram is an effective source of information.

Eka wants to use Instagram advertisements but is unsure if it will significantly enhance sales. Eka creates Instagram content using a free app, but he hopes it won't be a problem to attract potential buyers. Eka is pleased when consumers do not require much customization.

Eka acknowledges that his Instagram marketing strategies are inconsistent. Eka rarely responds to direct messages on Instagram because he doesn't notice the message notifications. In addition, Eka believes that those who ask via direct messaging do not want to purchase and are merely inquiring.

Eka felt exhausted when he had to personally respond to Instagram's direct messages. In addition, he frequently lacks inspiration when determining what to post on Instagram. Eka was dissatisfied when he shared images of his batik creations to Instagram, but no one inquired.

4.2 Define

Eka undertakes all product marketing activities for Enterprise Batik A. This is because Enterprise A has limited personnel; therefore, the employees concentrate on batik production. However, Eka also frequently steps in to assist his employees throughout the batik production process. The enterprise's low human resources is one of the reasons why it cannot do digital marketing at an optimal level.

On the basis of the preceding remark, it can be implied that this enterprise has not prioritized brand awareness to prospective buyers and the larger community. In reality, creating brand awareness is a crucial aspect of internet/digital marketing.

According to Eka, numerous orders have been obtained through offline marketing. Eka is satisfied with the marketing activities carried out, although digital marketing presents a significant possibility to increase sales. Eka does not make further attempts to generate buyer interest using digital marketing, except via Instagram. However, Eka has not leveraged Instagram to its full potential to create client trust in Batik A's business.

Next, the researcher observed the social media account of Enterprise Batik A, managed by Eka. There are 224 Instagram feed posts with 457 followers. However, some photos are not clearly visible because they are hazy, too dark, or taken from too great a distance. Moreover, copywriting is rarely added to every photo content so there is not much information that can be obtained by potential buyers.

In conclusion, the content of Instagram feeds is poorly prepared and constructed. This is evidenced by the number of accounts who like this post ranges from 2 to 40, while the number of comments ranges from 2 to 5 each post. User or customer engagement to uploaded posts is still relatively low. Observing these problems, the researcher interviewed Eka to dig deeper into his digital marketing activities.

USER JOURNEY MAPPING UMKM A - Instagram

Phase	Preparation	When	After	After
Step Activity	They are preparing equipment before photo and photo booth setup.	Doing product photos in the living room.	When viewing photos in the photo gallery	Photo editing using the "Griddy" app
Emosi	😐	😐	😕	😟
Keterangan Pengalaman	• The size of the photo background is too large, while the photo location does not have a vast space • The photo background is wrinkled because of the cloth storage area in the pile of fabric	• Using a Samsung cellphone camera so that the photo resolution is small • The cloth is attached to the mannequin and clamped using hair clips so that when the photo takes place, the clamp often comes off, and the fabric falls from the mannequin	• There are shadows in the photos due to a lack of lighting. • The photo background looks wrinkled. • Details of the batik motif are not visible.	• When cropping photos, some ads appear, so you have to wait a while until the ads disappear. • The "Griddy" application is for cropping photos to make them look like puzzles when uploaded to Instagram feeds, but photos become a lower resolution.
Analisis Kebutuhan	It takes a photo background that adjusts the size of the photo spot and bright lighting.	• Camera tool is needed.	• Knowledge of photo-taking techniques required • Supporting tools are needed so that the photos are better	• It takes a photo editor application that does not display ads so as not to waste time.

USER JOURNEY MAPPING UMKM A - Instagram

Phase	Preparation	When	After
Step Activity	Upload photos on social media Instagram	Get comment notifications	Receive orders
Emosi	😟	😐	🙂
Keterangan Pengalaman	• Because the previous feed design for MSMEs is shaped like a puzzle so that when uploading, it is quite long, and each part posted is not always captioned, it is difficult for customers to understand • The uploaded photos are a little blurry.	• Not responding and tends to get rid of notifications from the notification bar. • MSMEs do not respond and tend to remove notifications from the notification bar.	• Asking for a phone number and diverting the purchase process on Whatsapp, but not all customers want to switch to WhatsApp because they feel that the phone number is customer privacy or just asking questions.
Analisis Kebutuhan	It takes the concept of uploading photos on Instagram to make them more attractive to consumers and more informative	Need a quick response to customer comments	• It takes a sense of trust from customers

Table 4.3 User Journey Mapping MSME Batik A

After participating in Eka digital marketing activities for the Batik business, there are a number of significant points to mention, including:

a. The personas do not yet comprehend what potential customers require, therefore the content uploaded on Instagram doesn't yet have a clear concept that meets customer needs to attract interest.
b. Batik A's business has limited financial resources for a promotional budget.
c. Batik A's business has not considered the importance of optimally building the trust of potential customers.

To answer these problems, in the next phase, researchers generate questions that lead to ideation, which will be discussed further in the "Develop" stage.

4.3 Develop

After knowing the problems occurred in Batik Enterprise in Surabaya, the next step is to create a Point of View (POV) and HMW Questions. Those tools can provide a broad scope to consider the solution based on the needs of the current state of persona, so that it will probably make a brainstorming in creating a few of alternative ideas which are possible for MSME Batik to do. Figure 4.4 is POV of MSME Batik A in using Instagram.

POV & HMW UMKM A - Instagram

User	Needs	Insight	POV
 UMKM	Spacious and adequate photo booth for product photos.	Adequate photo space can affect the space to make photos wider.	A wider space will increase concentration in taking photo concepts.
	Adequate tools include photo backgrounds that are not easily wrinkled and cameras that can produce better photos.	• A wrinkled background will not look good when posted on Instagram. • A low resolution will affect the sharpness of the uploaded photo.	Clear and informative photos will attract customers to buy
	Learning related to taking photos and creating content to attract customers	Customers will be interested if there is interesting content on Instagram.	Creating engaging content and following current trends will increase customer engagement with content.
	Speed in responding to customers on Instagram	Limited time causes delays in responding to customers who will buy products.	A quick response or response will influence buyers in buying products.
	Trust in making transactions.	Some customers canceled buying batik because they had a bad experience buying an item on Instagram.	There is confidence in the success of the transaction (real transaction)
	Knowledge related to product promotion	Instagram content tends to be monotonous and never does promotion.	Increase customer interest in the product
	User-friendly interface for generation X	Instagram users tend to be difficult adequate photo space can affect the space to make photos wider.	Using features that are easy to use or often used by Generation X will attract customers.

Table 4.4 POV UMKM Batik A In Using Instagram

After find out the needs of each persona, the next step to do is making HMW Questions in which those questions are related with the ideation stage. HMW Questions are created according to the shared needs of the three MSME Batik as well as in Table 4.5.

According to the HMW Questions, it was conducted a brainstorming to obtain some alternative ideas. Brainstorming was carried out together with expertise in digital marketing, including copywriters, digital marketers, advertisers and content creators. Every expertise has five until seven years of experience in his field. Figure 4.1 is a brainstorming process which carried out together with expertise through an affinity diagram.

IDEASI - Instagram

HMW Question	Goals	Ideasi
How can we recommend suitable photo location specifications and tools to use in content creation so that the content looks interesting on Instagram?	• The photos are not blurry (real image) • A photo spot that has a lot of light coming in	• Outdoor photo spots can be used as a solution if you don't have a studio with a good background. • A photo with a plain background showing the details • Make a mini studio box. • Use a DSLR camera if you don't have a cellphone with real image camera specifications. • Choose the photo hour when the lighting is good, like daylight or when the golden hour is about 1 hour at sunrise and sunset. • For photo booths, if you can't rent a studio, you can buy plain cloth along with the cloth stand and also a mini ring light. • You can also take advantage of places like Coffee Shops with supportive interiors. • You can also take advantage of places like Coffee Shops with supportive interiors.
How can we provide a way to make good and correct photography concepts for batik SMEs so that the photos they produce can be interesting?	• Have a concept of taking photos • There are no distortions in the photos. • Understanding composition in taking photos	• See Tiktok and Youtube references (Youtube: Glen Prasetya) • Adjusting the focus to get a clear shot • They are making the concept of the batik production process can be a concept. • Benchmarking with several competitor accounts that have a better batik concept • What are the advantages and disadvantages of the product? • For photo-taking techniques, you can focus on the characteristics/ details of the product, for example, on the fabric's pattern. • Take photos in good light. • Taking photos from an angle that shows the uniqueness of the product

IDEASI - Instagram

HMW Question	Goals	Ideasi
How can we provide a way to create interesting content for batik SMEs?	• Feed Instagram yang menarik (memiliki konsep pada konten) • Adanya keterlibatan pengikut terhadap konten	• Teaches how to make video reels because there are a lot of video reel responses • Teach the functions of existing features on Instagram, such as question boxes, polls, add yours, etc • The importance of creating giveaway content • Hiring part-time with a young age requirement (22-27 years) • Using agency services for at least one year • Make benchmarking on several products. • Content can be interspersed with product photos, product videos, giveaways, education, games, and others. • Maximize the use of editor applications (canva, VN video, cup cut) • See Tiktok or Youtube references to find out what content is trending. • Attend online seminars/webinars • Take advantage of moments like when exhibitions can be used as the content material
How can we provide a way to foster a sense of trust in MSMEs toward customers?	• Increasing the number of buyers so that there is a lot of review content • Instagram followers increases	• Included a telephone number where you can be contacted • Ask the customer's opinion about the product • Creating a Brand Image • Create testimonial content from customers • Respond to customers • Consistently create content and organize feeds/Instagram stories • Create attractive packaging designs • Highlight the uniqueness of the product that makes it different from other products • Fully responsible to the customer
How can we provide a way to promote content on Instagram?	• Lots of customer engagement on Instagram • Instagram followers increases	• Make a giveaway by tagging some friends in the comments column, and also sharing on Instagram stories, and following the user's Instagram account • Creating reels content because the reach of reels is more • Doing Paid Promote, endorsement to influencers when there is a giveaway or exhibition moment • Take advantage of the Instagram Ads feature • Using hashtags in captions • Join the batik community for the youth market and then can follow @remajanusantara, @pemudaberkain.sub • Create attractive copywriting (soft selling) • Reposting posts on Instagram Stories, so followers know there is new interesting content • Fully responsible to the customer • Create Google business

Table 4.5 HMW Question



Figure 4.1 Brainstorming With Afinity Diagram

Based on those ideas, MSME Batik A chose the ideas that are compatible of doing digital marketing through Instagram. Here are the following ideas that have been chosen by MSME Batik A:

FINAL IDEAS

HMW Question	Goals	Ideasi
How can we recommend suitable photo location specifications and tools to use in content creation so that the content looks interesting on Instagram?	• The photos are not blurry (real image) • A photo spot that has a lot of light coming in	• Outdoor photo spots can be used as a solution if you don't have a studio with a good background. • A photo with a plain background showing the details
How can we provide a way to make good and correct photography concepts for batik SMEs so that the photos they produce can be interesting?	• Have a concept of taking photos • There are no distortions in the photos • Understanding composition in taking photos	• See Tiktok and Youtube references (Youtube: Glen Prasetya) • Benchmarking with several competitor accounts that have a better batik concept
How can we provide a way to create interesting content for batik SMEs?	• Attractive Instagram feed (has a concept on content) • Follower engagement with content	• Teaches how to make video reels because there are a lot of video reel responses • Teach the functions of existing features on Instagram, such as question boxes, polls, add yours and others
How can we provide a way to foster a sense of trust in MSMEs toward customers?	• The number of followers increases • Increasing the number of buyers so that there is a lot of review content	• Include a telephone number where you can be contacted • Create testimonial content from customers
How can we provide a way to promote content on Instagram?	• Lots of customer engagement on Instagram • The number of followers increases	• Using hashtags in captions • Create attractive copywriting (soft selling)

Figure 4.7 Final Ideas UMKM Batik A

Those ideas are going to be a strategy for MSME Batik A of doing digital marketing through Instagram. It can be concluded that personas require more basic knowledge in doing digital marketing, therefore based on the ideas that have been chosen, intensive coaching will be carried out on MSME Batik A for a week

4.4 Deliver

Deliver is the last stage in the design process thinking. In this stage, testing was carried out based on the ideas chosen by the persona. This test examined testing with users method to understand each persona for which a solution has been made. Therefore, it will be a consideration in everything that can be learned about solution and personas.

Within one week of coaching, MSME Batik A showed their enthusiast in following the coaching of several selected ideas. For that one week, MSME Batik A could create two contents which included two Instagram feeds content and one Instagram story content. Whereas, before this guidance was carried out, within one week MSME Batik A was inconsistent in uploading content. In addition, the number of followers engagement with the content was also very low. MSME Batik A had also understood the feedback obtained after trying to use Instagram Ads. Here are the differences before and after on the contents that have been created



Figur 4.2 Content Before The Following Coaching



Figure 4.3 Content After the Following Coaching

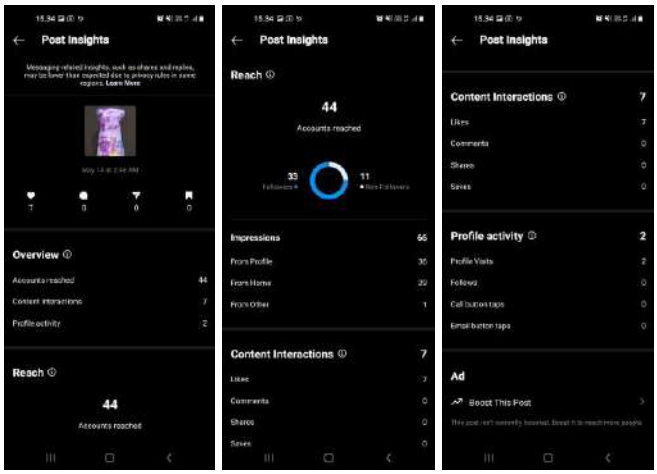


Figure 4.4 Content Engagement Before The Following Coaching

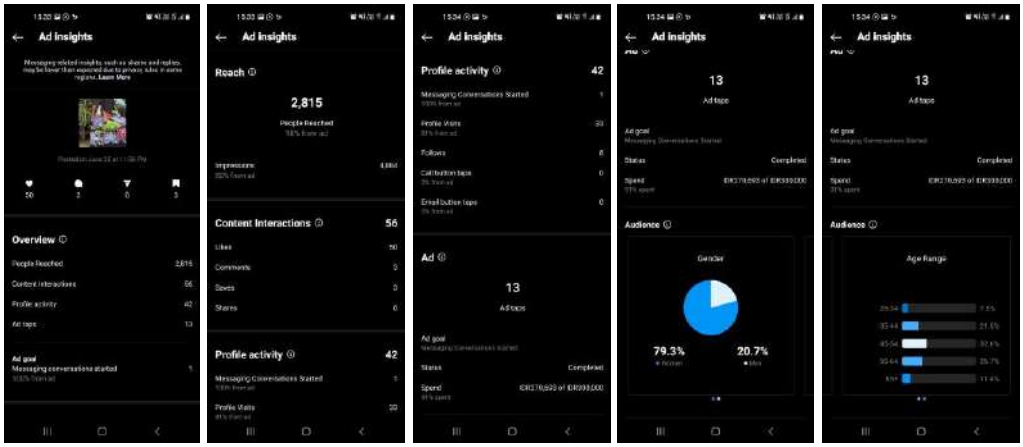


Figure 4.5 Content Engagement After The Following Coaching

Before they participated in training, in uploading content on Instagram MSME Batik A was not accompanied a clear caption and unclear product photo details. However, after participating the coaching MSME Batik A in uploading content was quite clear and accompanied by a caption. In creating content MSME Batik A had already involved education content that could attract the followers. After trying to use Instagram Ads in one of the posts, the involvement

of the content was very good and MSME Batik A got one buyer from Instagram Ads which can be seen in Figure 4.5

After that, the persona was asked to provide feedback from the coaching activity. It was occurred to find out and fix the prototype. Here is the following feedback capture matrix that was used to capture the feedback given by the persona.

Like	Criticisms
• By being given capital to use ads so that you can feel the benefits directlyIt turns out that in creating content, you don't always have to market the product, but it can be in the form of education that can attract people so that the community can continue to follow it. • By making small groups, the material is easier to understand	• Not so much time • Execution time can be done a little longer. • Implementation can be done on holidays (weekends) • More varied material
Question	**Ideas**
• How to manage time in creating content? • How to get used to creating content? • What if the content that has been created already attracts our version but not for the customer version?	• Workshop events can be carried out directly, not via zoom, so that the material given the previous day can still be remembered • Free workshop and given funding capital like the current ad creation • Direct guidance to MSMEs every week (weekends).

Table 4.8 Feedback Capture Matrix.

6. CONCLUSIONS

At this time, based on the discussion, several MSMEs felt that they were in their comfort zone, where they preferred to market their products through words of mouth. In fact, they need to realize with the development of technology, every activity will be digitalized. Therefore, we should have prepared that this MSME Batik is ready to face the digitalization later. So that, this Batik MSME can run well to grow.

For the next researchers, they may do kind of test with personas in a longer time and with several other batik MSMEs. The writer expected that this can find out how far the MSMEs are really able to be consistent in doing digital marketing

REFERENCES

Agustini, P. (2021, September 12). *Warganet Meningkat, Indonesia Perlu Tingkatkan Nilai Budaya di Internet*. Retrieved Februari 3, 2022, from Kementrian Komunikasi Dan Informatika RI: https://aptika.kominfo.go.id/2021/09/warganet-meningkat-indonesia-perlu-tingkatkan-nilai-budaya-di-internet/

Design Council (2006). Double Diamond Design Process. http://www.designcouncil.org.uk/

Damastuti, R. (2020). Adopsi Inovasi Media Komunikasi Pemasaran UMKM Batik Jumputan Di Era Digitalisasi. *Jurnal Ilmu Komunikasi*, 6(2), 160-170.

Imron, M., Maryoni, H. S., Ali, A., & Nuraeni, H. (2021, November). Pemasaran Digital Marketing Untuk Meningkatkan Daya Saing Batik Jepara. In *Prosiding Seminar Nasional Industri Kerajinan dan Batik* (Vol. 3, No. 1, pp. D-07).

Mucholil, Oka, I. G., Iswari, I., Fahmi, R. S., Indra, B. P., & Linggar, M. S. (2021). Pengembangan Pemasaran Desa Batik Jetis Di Era Digital. *Prapanca: Jurnal Abdimas*, 1(1), 60-68.

Ngamvichaikit, A. (2021). Leveraging Design Thinking for Pharmaceutical Digital Marketing. *Asian Journal of Business Research*, 11(1).

Qurrata, V. A., Yusida, E., Sudjatmiko, S., & Prastiwi, L. F. (2021). Pengembangan Industri UMKM Batik Khas Kabupaten Malang melalui Digitalisasi Marketing Mix dan Teknologi. *Abdimas: Jurnal Pengabdian Masyarakat Universitas Merdeka Malang,* 6(3), 347-357.

Work Accident Risk Analysis with Fault Three Analysis Method on Multi-Storey Building Construction Project

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ABSTRACT

Risk is the possibility or uncertainty of the occurrence of an event that's unexpected when doing work that can harm the party carrying out the activity. Work accidents in the construction sector are the result of inacurate risk mitigation in dealing with the risk of work accidents. High rise building construction is one of the construction project with a high risk of work accidents. One of the efforts that can be done to minimize risk of work accidents is to identify the cause and the probability of the risk which can be used to create a more eficient risk response planning. This research will discuss the source of risk analysis of work accidents using the Fault Tree Analysis. The stages that will be done include literature review to identify the risk, Fault Tree Analysis to analyze the cause and the probability of the risk. The results obtained from this research are the cause of the risk of workers falling from a height caused by 17 basic events. The probability of workers falling from a height acording to their cause is 0.99996 which can be categorized into very critical or it always happens when there is no risk respond planned.

Keywords: Work Accident, Building Construction, Probability Based Fault Tree Analysis, Probability for the cause of work accident.

1. INTRODUCTION

Any action performed by a human being is always followed by risks that may arise. Risk is the possibility or uncertainty of the occurrence of an event that is not expected when doing work that can harm the party who is carrying out the activity. In activities, one of the risks that may arise is the risk of work accidents, work accidents can occur in all fields of work, one of which is the construction field. Work accidents in the construction sector are actually the result of risk mitigation that is not on target in dealing with the risk of work accidents. Work accidents can be caused by several main factors, namely factors of environmental conditions, work equipment, and the workers themselves. Therefore, in order to minimize the number of work accidents, it is necessary to manage the risk of work accidents in construction projects for the safety of workers and the success of a project.

According to the International Building Code 2021, the High Rise Building is a building that has a height of more than 25 meters, with a fairly high height, high rise buildings have a considerable risk of work accidents. Lack of stakeholder awareness of the importance of occupational safety, improper implementation methods, and lack of accuracy in work can pose a risk of accidents. According to the Indonesian static agency, in 2018 there have been 109,215 work accidents in Indonesia, with 29,472 casualties, 13,315 serious injuries, and 130,571 minor injuries, as well as losses worth 218.866 billion Rupiah. This proves that the number of work

accidents in Indonesia is still high so it needs to be given special attention in order to overcome it. With the risk of work accidents that are quite high, the respond of the risk of work accidents should be carried out properly so as not to have an impact on the safety of workers and also the success of the project.

In risk respond planning, an analysis is needed related to the causes of the risk and the possible causes of the risk to occur. The cause of a risk and the possibility of a risk are considered important to know because based on the cause of the risk obtained, appropriate risk management can be planned. Probability theory has been used for decision making on risk management during modern civilization Hasset (2013) in the presence of probabilities of a risk, the decision-making to plan its handlers will be more appropriate by paying more attention to risks that have a high probability. Therefore, it is necessary to conduct an analysis that can determine the probability of that risk based on its cause so that the respond of the cause of the risk can be carried out more precisely.

Previously, research has been carried out related to the risk of work accidents using the Fault Tree Analysis method on the UINSA Campus II Building Construction project Gusti (2021), but in this previous research, the basic event was still obtained from the point of view of 1 project only and did not include views from other projects so that it was considered less representative for general use. In addition, in the research that has been carried out, there is no calculation of the probability of each basic event, while according to Purba (2015) in Fault Tree Analysis (FTA), the probability of a top event is the result of a basic probability function so it is necessary to calculate the probability of each basic event to determine the probability of a risk occurring which is used as a top event.

Therefore, a more in-depth research is needed related to the risk of work accidents consisting of an analysis of the causes of risks and their probabilities. From the analysis that will be carried out, a prediction of the risks that will occur in the future will be carried out based on the probability of risks that have occurred and other factors.

2. LITERATURE REVIEW

Hazard is anything that includes situations or actions that have the potential to cause accidents or injuries to humans, damage or disturbance to humans, damage or other disorders Ramli (2010). Based on the Project Management Body of Knowledge, the risk in the project is an uncertainty that occurs due to the activities that have been carried out, and will have an impact on the objectives of the project.

The cause of work accident based on the research conducted by Gonzalez (2016) work accidents can be caused by personal factors and work factors. The following are factors that can cause work accidents based on personal factors and work factors.

Cause of work accident based on personal factors are lack of judgement, low level of coordination, inadequate initial training, inappropriate height/weight/size/strength/reach, fatigue due to the weight or the duration of a task, lack of preparation, restricted movement, insufficient experience, lack of positive efforts for correct behaviors, body movement ability, lack of experience, sporadic operation, deficient orientation, slow reaction time, standard performance causes discontent, fatigue due to pressure or time limitations of a mental task, inability to understand, and allergies or sensitivity to substances.

Cause of work accident based on work factors Insufficient programming or planning of work, insufficient instruction and/or /orientation, insufficient evaluation of needs and risks, insufficient identification and evaluation of exposures to loss, inadqueate definition of policies,

procedures, practices or action steps, inadequate standards or specifications, inadequate storage of materials, inadequate control and inspections of construction sites, inadequate handling of materials, inadequate maintainance of standards, following work flows, updating, control of the use of standards/processes/rules, inadequate usage planning, lack of attention to ergonomic/humana factors, inadequate adjustments/repairs/mataintence, insufficient evaluation of the apt operating conditions, insufficient evalution of the exposure to losses, lack of understanding of supervisory/administrative work, inadequate identification of risky items, inadequate inspection of reception and acceptance, inadequate inspection or control, inadequate maintainence, excessive prolonging of the shelf life of an element, and inadequate transport of materials

According to Thomas Pyzdek (2002), Fault Tree Analysis (FTA) is a diagram model consisting of several combinations of errors (faults) in parallel and sequentially that can cause the beginning of a predetermined failure event. In simple terms, FTA can be described as an analysis technique where an undesirable state concerns the fault of a system that is analyzed in the context of its operation and environment to find all reliable causes in fault events that can occur.

The Fault Tree Analysis method is a quantitative risk analysis method with a graph and logic model that displays a combination of possible events, namely bad or good, that occur in a system, the application can include a system, equipment and so on. This fault tree analysis has an important value in the completion of Megasari (2005).

The advantages of using the FTA method are :

1. Easy in explaining all the differences in causal interactions to generate losses
2. The basic and logical causes in the causes of losses are understandable
3. Can make appropriate precautions to minimize the basic causes so that the same losses will not appear again

Can calculate the qualitative evaluation of losses The stages for analyzing problems with Fault Tree Analysis (FTA), are as follows Priyanta (2000):

1. Defining the problems and boundary conditions of a system under review
2. Create a Fault Tree graphic model image.
3. Find a minimum cut set of Fault Tree analysis
4. Conduct qualitative analysis of the Fault Tree
5. Conducting quantitative analysis of the Fault Tree

Probability theory is fundamental in Fault Tree Analysis because probability theory can support analytical treatment for an event, and events are a basic component of fault trees Vesley (1981). In calculating the probability in fault tree analysis, you can use Boolean Algebra for the calculation process, the following is a table of Boolean Algebra that can be used to calculate the probability for the top event in fault tree analysis.

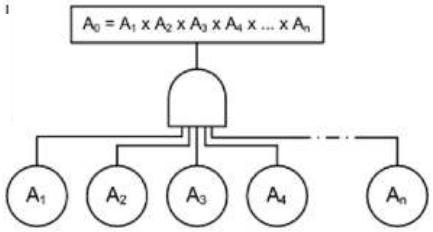


Figure 1. Boolean And Gate

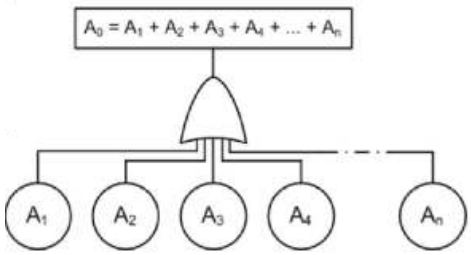


Figure 2. Boolean Or Gate

From the figure above, a formula is used to interpret Gate AND and Gate OR into a mathematical formula as follows Purba (2015):

$$P(A \cap B) = P(A)\, x\, P(B)$$
$$P(A \cup B) = P(A) + P(B)$$

In fault tree "0" is interpreted as a failed event that did not occur and "1" is interpreted as a failed event that occurs. And the probability assessment of each basic event is based on the probability rating criteria owned by Heldman (2005) as in the following table:

Table 1. Probability Rate Criteria**.**

Score	Description	Definition
0.8	Very critical	It always happens
0.6	Critical	Frequent occurrences
0.4	Significant	Sometimes it happens
0.2	Negligible	Less likely to happen
0.05	Very negligible	Never happened

3. METHODS

The first step of this research was literature review from previous research to determine the top event of fault tree analysis. This step was done based on the previous research that have been conducted regarding on work accident risk in the high rise building in Surabaya. Second step on this research is literature review to determine the basic events or cause of the analized risk and the connection between each basic event to draw the fault tree diagrams. Next step is an interview with the HSE division in the high rise building project in Surabaya regarding the diagram results of the fault tree analysis that has been made by the researcher by literature review. After that, cut set and minimal cut set analysis will be conducted to find out the combination of basic events and

probability calculation formula based on the fault tree diagram that have been confirmed by the HSE division from the high rise building project in Surabaya.

After the cut set and minimal cut set analysis, the questionnaires for risk probability assessment will be conducted based on its basic events with respondents workers of high rise building construction projects in Surabaya. This respondent selection is in accordance with the research objectives which indeed discuss the risk of work accidents in high-rise buildings and also the respondent needs to have a same characteristics with the previous research object done by Gusti (2021) because this research will be a continuation of that reset, which the characteristics was project with high rise building type and is located in the city of Surabaya. The last step of this research after the researcher have obtained the quisionare data is the calculation of top event probability based on the average value of the basic event probability quisionare and the equation obtained from the cut set and minimal cut set analysis.

4. RESULTS

4.1 Respondent

The respondents who were successfully obtained in this study were 33 people from 4 high rise building projects in Surabaya, namely UINSA II Campus Building Project, UBAYA Hospital Building Project, The Trans Icon Building Project, Grand Dharmahusada Lagoon Apartement Building Project. The posisition from this reset respondent was vary from a Project Manager, HSE manager, HSE officer, site manager, project production manager, engineer, site worker, HSE supervisor, quality surveyor, MEP site manager, and MEP supervisor. With the majority of this research respondent was from the HSE division. The experience of the respondent in this research was vary from 1 – 18 years experiences in construction. With the experiences and the position of this research respondent it can be concluded that this research respondent have a capability to give their opinion about this research.

4.2 Fault Tree Analysis

First step of this research was to determine the risk for further analysis in the fault tree analysis method from the previous research conducted by Gusti (2021). The obtained risk for further analyzed in this research is the risk of workers falling from a height in the concrete work. Researcher choose this risk because this was the highest risk rank which is extreme based on the previous research by Gusti (2021). Apart from the risk rank, researcher find that this was the most relevant risk for high rise building projects because in high rise building project worker ofter do their task in the high environtment so this risk was choosen to further analysis in this research.

Next step, is the literature review regarding the cause or basic event and intermediate event for the fault tree diagram. After that the literature review to determine the connection between each and every cause or basic event and intermediate event for the diagram was conducted. After the literature review, the next step is an interview with HSE division from 4 project that have been choosen as a responden to confirm the result of fault tree diagram. This is the result from the literature review and interview with HSE division of 4 high rise building projects in Surabaya about the fault tree diagram.

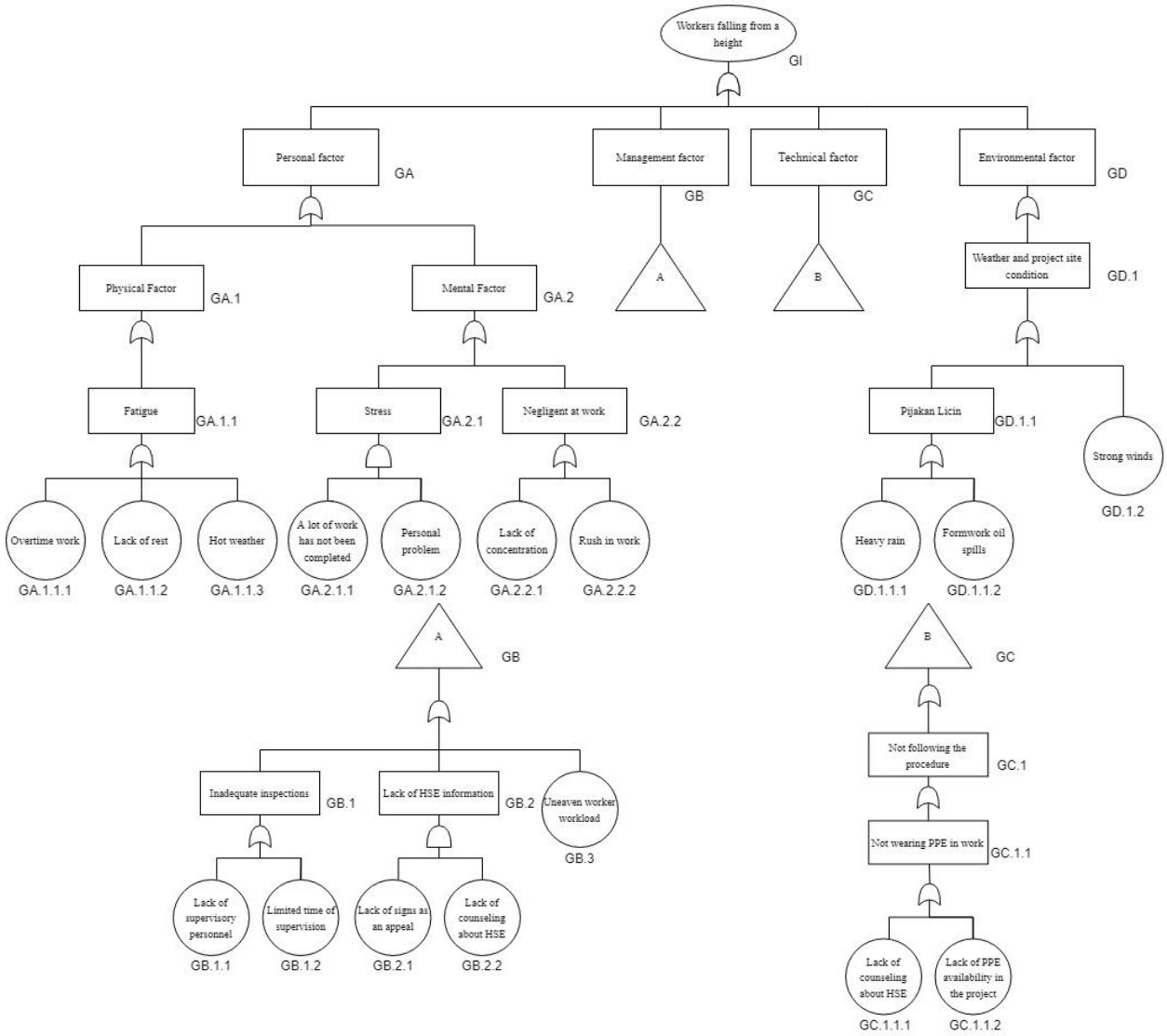


Figure 4. Fault tree diagram of workers falling from a height.

Based on **Figure 4**, cut set and minimal cut set analysis was conducted to obtain the equation for the probability calculation of the top event or the risk of workers falling from a height. This method was done by analysing the gate or connection between each event that will lead to the occurance of workers falling from a height. This is the equation that researcher obtained.

P FTA ={(GA.1.1.1 + GA.1.1.2 + GA.1.1.3)+((GA.2.1.1 x GA.2.1.2) + (GA.2.2.1 + GA.2.2.2))}
+ {((GB.1.1 + GB.1.2) + (GB.2.1 x GB.2.2) + GB.3} + {GC1.1.1 + GC.1.1.2} +
{(GD.1.1.1 + GD.1.1.2) + GD.1.2}

Based on the equation that researcher have obtained, the top event probability calculation will be done based on the probability value in **Table 3** that have been obtained from questionnaire to 33 respondents with vary positions and experiences from 4 high rise building projects in Surabaya.

Table 3. Minimal cut set workers falling from a height

Gate	Basic Event	Probability
GA.1.1.1	Overtime work	0.5455
GA.1.1.2	Lack of rest time	0.5030
GA.1.1.3	Hot weather	0.5348
GA.2.1.1	A lot of work has not been completed	0.5152
GA.2.1.2	Personal problems	0.5879
GA.2.2.1	Lack of concentration	0.6000
GA.2.2.2	Rush in work	0.5697
GB.1.1	Lack of supervisory personnel	0.5030
GB.1.2	Limited time of supervision	0.5636
GB.2.1	Lack of signs as an appeal	0.5212
GB.2.2	Lack of counseling about HSE	0.4667
GB.3	Uneven worker workload	0.4667
GC.1.1.1	Lack of counseling about HSE	0.4788
GC.1.1.2	Lack of PPE availability	0.5091
GD.1.1.1	Heavy rains	0.5045
GD.1.1.2	Formwork oil spills	0.4742
GD.1.2	Strong winds	0.4682

Based on the average probability of each basic event above, the top event probability calculation was conducted with the equation that have been obtained based on probability calculation concept. This is the calculation that have been conducted by researcher

P GA.1.1 = P.GA.1.1.1 + P.GA.1.1.2 + P.GA.1.1.3 = 0.5455 + 0.5030 +0.5348 -(0.5455 x 0.5030) - (0.5455 x 0.5348) - (0.5030 x 0.5348) + (0.5455 x 0.5030 x 0.5348) = 0.895
P GA.2.1 = P.GA2.1.1 x P.GA.2.1.2 = 0.5152 x 0.5879 = 0.303
P GA.2.2 = P.GA2.2.1 + P.GA.2.2.2 = 0.6000 + 0.5697 – (0.6000 x 0.5697) = 0.828
P GA.2 = P GA.2.1 + P GA.2.2 = 0.828 + 0.303 – (0.828 x 0.303) = 0.880
P GA = P GA.1.1 + P GA.2 = 0.895 + 0.880 – (0.895 x 0.880) = 0.987

P GB.1 = P GB.1.1 + P GB.1.2 = 0.5030+ 0.5636– (0.5030 x 0.5636) = 0.783
P GB.2 = P GB.2.1 x P GB.2.2 = 0.5212 x 0.4667 = 0.243
P GB = P GB.1 + P GB.2 + P GB.3 = 0.783 + 0.243 + 0.467 - (0.783 x 0.243) - (0.783 x 0.5348) - (0.243 x 0.467) + (0.783 x 0.243 x 0.467) = 0.912

P GC = P GC.1.1.1 + P GC.1.1.2 = 0.4788 + 0.5091 – (0.4788 x 0.5091) = 0.744

P GD.1.1 = P GD.1.1.1 + P GD.1.1.2 = 0.5045 + 0.4742 – (0.5045 + 0.4742) = 0.739
P GD.1.2 = 0.468
P GD = P GD.1.1 + P GD.1.2 = 0.739 + 0.468 – (0.739 x 0.468) = 0.861

P FTA = P GA + P GB + P GC + P GD = 0.9996

Based from the calculation conducted above, the result of the probability of workers falling from a height is 0.99996 which is categorized into very critical risk.

In the analysis that have been carried out, 17 basic events and 9 combinations of basic events have been obtained that can cause workers to fall from a height on a construction project. The following is a discussion of each basic event that has been studied.

The first Basic Event is overtime work which can cause fatigue, according to research related to the relationship between overtime work and work accidents carried out by Caldwell (2019) it can be concluded that the existence of overtime work does cause an increase in the possibility of work accidents. In this study, the probability of overtime work obtained from the calculation results was 0.545 which can be categorized as significant. This considerable probability can occur because in fact construction projects often use overtime to pursue the progress of the work that must be completed.

The 2nd Basic Event is the lack of rest, this can happen because the reduction of rest time can cause fatigue Caldwell (2019) which will later lead to work accidents. In this study, the probability of lack of rest obtained from the calculation results was 0.503 which can be categorized as significant. The probability of lack of rest time is quite large because if it is not planned for the form of handling, the amount of work that must be completed in a construction project that makes working hours quite long.

The 3rd Basic Event is hot weather that can cause fatigue, this is in accordance with field facts because this research was conducted in the city of Surabaya which has a hot climate. In this study, the probability of hot weather obtained from the calculation results is 0.535 which can be categorized as significant.

The 4th Basic Event is a lot of work have not been completed that can later cause workers to become stressed, this can happen due to a large workload on a worker and is not evenly divided. In this study, the probability of a lot of work have not been completed obtained from the calculation results is 0.515 which can be categorized as significant, the probability results of this basic event are quite large because indeed in the conditions in the field of work from a multi-storey building project is a lot so that if it is not planned carefully, there will be a lot of work piled up.

The 5th Basic Event is a personal problem that can later cause workers to become stressed, in a study conducted by Issever (2008) personal problems are indeed a factor that affects the occurrence of work accidents. In this study, the probability of personal problems obtained from the calculation results is 0.588 which can be categorized as significant, this can happen because construction workers are always under high work pressure so that the probability of personal problems occurs is high.

The 6th Basic Event is the lack of concentration that causes negligence in work, in the research conducted Gonzalez (2016) lack of concentration of workers is one of the biggest causes in work accidents, this can happen because if workers do not concentrate, they become negligent and ignore the dangers or risks that exist in a job being done. In this study, the probability of no concentration obtained from the calculation results is 0.6 which can be categorized as critical.

The 7th Basic Event is a rush in work that can cause negligence in work, when a worker is in a hurry then has a high probability of ignoring the surrounding conditions which can result in a work accident. In this study, the probability of rushing to work obtained from the calculation results is 0.57 which can be categorized as significant, this happens because of the large amount of work in a construction project so that workers want to quickly complete their work on that day.

The 9th Basic Event is the limited supervision time that causes a lack of supervision, this is in accordance with research conducted by Gonzalez (2016) where stating that lack of supervision is a factor that can cause work accidents, this happens because many workers still take HSE lightly

and work not according to procedures. In this study, the probability of limited supervision time obtained from the calculation results was 0.564 which can be categorized as significant.

The 10th Basic Event is the lack of signs as an appeal that leads to insufficient HSE information. This basic event can cause work accidents because if there is a shortage of signs, workers may not be aware of the dangers or risks that can occur. As in the research conducted by Gonzalez (2016) states that the lack of HSE information can lead to work accidents. In this study, the probability of the lack of signs as an appeal obtained from the calculation results is 0.521 which can be categorized as significant, this can happen because if not planned properly and correctly the HSE signs on the construction project will be less in number than the ideal number should be.

The 11th Basic Event is the lack of counseling about HSE which is the cause of insufficient HSE information, without counseling about HSE, workers may not know about the risks or dangers that exist in a job. As in the investigation conducted by Gonzalez (2016) states that the lack of HSE information can lead to work accidents. In this study, the probability of lack of counseling about HSE obtained from the calculation results is 0.467 which can be categorized as significant, this high probability is caused by the lack of construction project attention against HSE.

The 12th Basic Event is an uneven worker workload which is a contributing factor to management, with an uneven worker workload, a worker may do much more work than other workers and it will make workers unable to work optimally and safely, this can be the cause of a work accident. In this study, the probability of an uneven worker workload obtained from the calculation results was 0.467 which can be categorized as significant.

The 13th Basic Event is the lack of counseling about HSE which is the cause of workers not wearing PPE, without counseling about HSE, workers may not know about the risks or dangers that exist in a job so as to ignore the importance of wearing PPE. As in the research conducted by Gonzalez (2016) states that the lack of HSE information can lead to work accidents. In this study, the probability of lack of counseling about HSE obtained from the calculation results is 0.479 which can be categorized as significant, this high probability is due to the lack of attention from construction projects against HSE.

The 14th Basic Event is the lack of PPE availability in projects which is the cause of workers not wearing PPE, without PPE there is no tool that keeps workers from a work accident, according to Gonzalez (2016) the lack of PPE in a construction project can cause work accidents. In this study, the probability of lack of counseling about HSE obtained from the calculation results is 0.509 which can be categorized as significant, the probability of this basic event is quite high due to the lack of attension on the part of project management towards HSE, especially in small-scale projects.

The 15th Basic Event is heavy rain that can cause slippery footing, this is in accordance with field conditions because the project is located in Indonesia which is a tropical country with high rainfall. In this study, the probability of heavy rain obtained from the calculation results is 0.505 which can be categorized as significant.

The 16th Basic Event is a formwork oil spill that can be slippery, this can occur due to the slippery nature of formwork oil that endangers workers if it spills. In this study, the probability of a formwork oil spill obtained from the calculation results is 0.474 which can be categorized as significant, the high probability of a formwork oil spill occurs due to workers who sometimes use formwork oil with less care so that it is spilled into the work area.

The 17th Basic Event is a strong wind, this is in accordance with field conditions because the project under review is a high rise building project where in higher areas the wind speed is

stronger than at ground level. In this study, the probability of heavy rain obtained from the calculation results was 0.468 which can be categorized as significant.

From this result, the highest probability of basic event is the probability of lack of concentration with the code GA.2.2.1, the probability of that basic event is 0.6 which is categorized as critical. For the total probability of the top event of workers falling from a height is 0.9996 which is at values 0.8 and 1.0 with the meaning of being very critical or it can be concluded that this risk will occur in high rise building projects if not planned the form of a risk response.

5. CONCLUSIONS

The results of the risk cause or basic event analysis with Fault Tree Analysis of the accident workers falling from a height produced 17 basic events that can lead to the occurance of workers falling from a height. The probability calculation result is the probability of workers falling form a height is 0,99996 which sits between 0.8 and 1.0 probability value or can be categorized as very critical. This means if there is no risk respond planned, the risk of workers falling from a height in high rise building project will have a high probability to happen.

REFERENCES

Caldwell, J.A., Caldwell, J.L. (2019), *Fatigue and its Management in The Workplace*, Oak Ridge Associated Universities, Oak Ridge.

González, A., Bonilla, J. (2016), *Analysis of the Causes And Consequences of Accidents Occurring in Two Constructions Projects*, Universidad Cooperativa de Colombia, sede Neiva.

Gusti, R.N. & Wiguna, I.P.A. (2021), *Workplace Accidents Risk Analysis at UINSA Surabaya Second Campus Building Project*, Civil Engineering Sepuluh Nopember Institute of Technology, Surabaya.

Hassett, M.J., Stewart, D.G. (2013), *Probability for Risk Management*, Department of Mathematics and Statistics Arizona State University, Tempe.

Heldman, K. (2005), *Project Manager's Spotlight on Risk Management*, Harbor Light Press, Alameda.

International Code Council. (2021), *International Building Code*, United States of America.

Issever, H., Ozdilli, K. (2008), *Examination of Personal Factors in Work Accidents*, Istanbul University, Capa.

Megasari, A. (2005), *Modul Mata Kuliah Teknik Evaluasi Bahaya (Manajemen Resiko)*, Diploma of Work Health and Safety PPNS, Surabaya.

Priyanta, D. (2000), *Relability and Maintenance*, Sepuluh Nopember Institute of Technology, Surabaya.

Purba, J.H. (2015), *Fuzzy probability based fault tree analysis to propagate and quantify epistemic uncertainty*, National Nuclear Energy Agency of Indonesia (BATAN), Tangerang.

Pyzdek, T. (2002), *The Six Stigma Hand Book Edisi 1*, Jakarta: Salemba Empat.

Ramli, S. (2010), *Work Health And Savety Management System OHSAS 18001*, Dian Rakyat., Jakarta.

Vesely, W.E. dan Goldberg, F.F. (1981), *Fault Tree Handbook*, U.S. Nucelar Regulatory Commision, Wasington, D.C.

ESTABLISHMENT OF CAUSAL LOOP DIAGRAM MODEL ON FLEXIBLE PAVEMENT ROAD PROJECTS DELAY

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ABSTRACT

Indicator of the project success is measured by timeliness, not over budget, and according to spesifications. Delays can lengthen schedules, increase project costs, and compromise quality and safety. Delay cannot be analyzed partially, because the dynamics has a cause effect relationship characteristic between its variables with a quantity that changes with time. Therefore, the objective of the paper is to formulate a model of the relationship between variables causing delays in flexible pavement road projects. The survey was conducted to 8 experts. The research variables were formulated based on the results of a literature study regarding delays in road construction projects by measuring using the respondent's approval level scale. Subsequently, understanding system stage to understand the mechanism of the relationship of each variable with the causal loop diagram model. The causal loop diagram is formed from a literature study which will be verified by the respondents. It was observed that variables related to weather changes, material delivery delay, rework, project financing, skills and work supervision were the most significant causes of delays. The model provides with insights the interdependencies between key influencing variables in projects and can be used to process improvements in future flexible pavement road projects.

Keywords: Delay, Flexible Pavement Road, Causal Loop Diagram

1. INTRODUCTION

Schedule delays in transportation infrastructure projects are common. Almost every construction project, especially roads, experiences delays in implementation for various reasons and causes, with different consequences from project to project depending on management, technical knowledge, and skills in anticipate delays. Delays can prolong time, increase project costs, and compromise quality and safety (Orozco et al, 2011). For contractors, delays can cause work costs to be higher than planned. In extreme cases this can lead to a situation where the contractor suffers losses and has an impact on the contractor's image in the construction market, namely: understanding and using them (Gluszak & Lesniak, 2015). Therefore efforts to minimize delays in construction projects, especially flexible pavement types, are very necessary, because considering the impact it causes are very many, by knowing the mechanism in the actual system,

the main variables causing delays can be known so that solutions to minimize delays in pavement projects can be more flexible. right on target and efficient, one way to formulate a system that is easy to reach is by modeling. In addition, by using the model, we do not need to be afraid of the impact on the actual system when conducting experiments with various objectives of course (Suryani, 2006). Delays cannot occur directly, but based on events in which there are 2 or more variables. Causal loop diagram is a suitable model for analyzing delays in construction projects, especially flexible pavement projects, because it displays feedback loops or causal loops. Variables related to clients, contractors, consultants and designs are the main causes of delays (Das, 2015). These variables are interrelated with each other and function in a causal feedback mechanism that creates a chain of actions, which affects the occurrence of delays (Das, 2015). Therefore, in this study, apart from obtaining the key variables that cause delays in construction projects, especially flexible pavement type road construction projects, it also makes modeling of the relationship between the variables. The investigation was conducted using a survey research methodology. A total of 8 experts from Department of Public Works for Highways, which include managers, Heads of Divisions, and PPK, were surveyed through a questionnaire method and interviews to understand the main control variables that cause delays in flexible pavement construction projects. First, the initial questionnaire was distributed to the respondents to find out the relevant variables causing the flexible pavement type road project which was collected based on a study of several literatures. Furthermore, interviews with the same respondents were conducted to understand the mechanism of the relationship between each variable causing delays in flexible pavement type road projects. The initial hypothesis of the model uses a causal loop diagram as a tool to facilitate the interview process. The model developed based on the feedback relationship between variables will act as a tool to help stakeholders, such as clients, contractors, consultants, and project management teams to forecast the challenges of delays ahead at each stage of construction and take appropriate actions to address them.

2. LITERATURE REVIEW

The term delay simply means a portion of the execution time that cannot be utilized according to the plan. Delay is one of the most common, complex and risky phenomena that adversely affects the performance of construction projects (Sanchez & et al, 2020). Every construction project is exposed to delays due to various reasons and factors, with critical consequences that differ from one project to another (Santoso & Soeng, 2016). Delay is a problem that must be handled properly before it grows and seriously affects time, cost, and project quality (Santoso & Soeng, 2016). According to Orozco et al (2011) delay is one of the most common problems affecting the competitiveness of construction companies and the interests of all stakeholders, including owners, designers, general contractors, subcontractors, users, and others. Meanwhile, according to Albinu & Jagboro (2002) delay is a situation where the contractor, consultant, or client jointly or independently contributes to the delay in the project completion time as stipulated in the contract document. Construction delay is considered as a time lag in completing activities from the time specified according to the contract or can be defined as the late completion or early start of activities that are late with the basic schedule, directly affecting the specified costs (Yap, Rahman, & Chen, 2017). Construction delays are also considered as one of the most recurring problems in the construction industry and have an adverse effect on project success in terms of time, cost, quality, and safety (Mahamid, Bruland, & Dmaidi, 2012). Delays often occur in various construction projects, but the construction companies themselves may not be very able to identify the causes of construction project delays, which in turn, causes problems

in developing alternative solutions and selecting the best alternative (Aziz & Abdel-Hakam, 2016). The types of delays in construction projects according to Fugar & B. Agyakwah-Baah (2010) are divided into 2, namely non-excusable delay and excusable delay. non-excusable delay is a delay which is an error caused by the actions, omissions or mistakes of the project owner. Meanwhile excusable delay is a delay caused by events beyond the control of either the owner or the contractor. Meanwhile, according to Braimah (2008), the types of delay in construction projects are divided into 3, namely excusable delay and non-excusable delay, critical and non-critical delays, and concurrent delays.

Delay in road construction projects due to various reasons is a major problem facing construction professionals. The main function of roads is to provide accessibility and mobility. Therefore, road projects must be completed according to schedule to serve the urgent needs of stakeholders. There are several factors that cause project delays, especially flexible pavement type road construction projects. As an illustration, the factors causing delays in flexible pavement construction projects are external factors, namely high rainfall intensity (Santoso & Soeng, 2016). which can cause the flexible pavement project work to be delayed and there is no work progress. In addition, rain can reduce the quality of the asphalt that has been laid, because it reduces the adhesion of the asphalt, the asphalt will peel off easily so it needs to be dismantled and re-laid (Surya, 2017). This condition can increase the work time outside the planned schedule, so that the work is delayed and not on schedule. In addition, there are several other factors that cause delays in flexible pavement type road works, including improper work methods carried out by contractors, equipment damage, financing, and others.

From this study it was found that the causes of delays varied with the project context and environment. According to Khair et al (2018) there are 6 categories of groups that cause road construction project delays, namely financial-competence factors, project management, knowledge competency experience, teamwork trust, external factors, and technical skills. financial competence has a major influence on the delay in road construction projects, which is followed by time lags. Santoso and Soeng (2016) formulate that there are 10 main factors that cause delays, namely working during the rainy season, frequent damage to equipment, flooding, poor soil and terrain conditions, owner's financial problems, long borrowing distances, shortage of equipment, machinery and equipment, impact on community lands throughout the project, unreasonable project timeframes, and insufficient manpower. According to Islam et al (2015) there are 10 main delay factors related to contractors, owners and consultants that affect project delays which consist of lack of experienced construction managers, selection of the lowest bidder, lack of funds by owners, lack of proper management, planning and scheduling imprecise, unskilled, location constraints, contractor cash flow problems during construction, rising resource prices, and excessive contractor workloads. Meanwhile, according to Cenk Budayan (2018) the perception of three main stakeholders namely: consultants, private sector, and public sector about the causes of delays in Building Transfer Operations (BOT) projects in Turkey, resulted in the most important causes of delays related to uncertainty and change. According to Abbasi et al (2020) the causes are divided into eight main groups including contractors, owners, design, procurement, equipment, consultants, labor, and others. Financial problems play an important role in project delays in Iran's construction industry. Okasha et al (2018) modeled a caustic diagram and the factors causing project delays from 8 points of view, namely the capacity of human resources, construction processes, equipment and materials, clients, contractors, management, and causes related to the external environment. The model is still conceptual and general. Meanwhile Das (2015) also formulated a caustic model diagram of the factors causing delays in public road projects from the

client, contractor, consultant and design side of construction projects in India. However, the model has not yet been verified and validated.

In previous studies, which resulted in the main variables causing delays in general construction projects as well as on construction projects in particular, but not many studies have analyzed the form of the relationship between the variables, and modeling has been carried out to determine the causal relationship between variables. In research conducted by Das (2015) it is known that delays in general construction projects have a dynamic form which is described in the form of a causatic diagram. This means that the delay cannot be analyzed partially, this is because the dynamics has causal characteristics between the variables with a magnitude that changes with time. Although in previous research conducted by Das (2015) it was known that the relationship model between variables causing delays in general construction projects related to contractors, but in this study the model has not been validated and is still general construction. Therefore, in this construction research, apart from obtaining the key variables causing delays in flexible pavement type road projects, it also makes modeling of the relationship between construction variables using a causal loop diagram by verifying and validating the model.

3. METHODS

This research includes descriptive research with exploratory studies, where research is aimed at certain populations to explore an idea by describing several variables related to the problem in this study, extracting wider information about research variables using various sources that are considered relevant. This research was also conducted by forming a causal loop diagram model to see the relationship between variables in the real system. The data collection technique in this study was divided into 3 stages. The first stage is the identification of research variables by conducting a literature study using 7 previous research journals regarding the factors that cause delays that occur in road construction projects. Furthermore, validation of the variables according to the 7 authors of the journal was carried out. The second stage is the verification and validation stage of the variable causing delays in the flexible pavement type road project, which is the distribution of an initial questionnaire aimed at 8 expert respondents from Department of Public Works for Highways, with an average of S2 and S1 educational backgrounds, and serving as Manager, Head of Section, Coordinator, and PPK, and has experience of more than 15 years in the field of road construction, especially the type of flexible pavement. The 8 experts were chosen as respondents because they are considered to have mastered research issues including the level of decision making and know more about the details of the delay events that occur, and are more open in providing explanations about delay events that occur in flexible pavement projects compared to contractors. This verification and validation stage is to find out the relevance of whether the variables causing delays in flexible pavement type road projects that have been collected based on studies of several literatures actually occur in flexible pavement type road construction projects in the field, in this case respondents can add and subtract variables based on the experience and knowledge of each respondent. The research variable uses a combination of variables causing delays obtained from the results of 7 research journals regarding delays in road construction projects that have been carried out with initial validation. Based on the limitation of the research that looks at the causes of delays that occur during the construction process from the contractor's point of view, the variables related during the pre-construction period are not included in the variables causing project delays in this study. Variables are divided into 2 categories in order to be a reference perspective for respondents, so that respondents can add/subtract variables on the questionnaire. The third stage is the stage of understanding the system for the

Establishment of causal loop diagram model, namely interviews with the same 8 expert respondents to be able to understand the mechanism of the relationship of each variable that causes delays in flexible pavement type road projects. The initial hypothesis of the form of the model uses a causal loop diagram as a tool to facilitate the interview process, the causal loop diagram in this study was formed from the results of several literature studies which will be verified by the respondent, whether it is appropriate or needs changes to fit the real system used. happens in the field. The verified and validated causal loop diagram will then be used to develop a conceptual dynamic system model.

4. RESULTS

4.1 Factors Causing Delay in Road Construction Projects

Table 1 present the recapitulation of the factors causing delays that occur in road construction projects obtained from 7 previous research journals regarding delays in projects using case studies of road projects.

Table 1. Recapitulation of Factors Causing Delay in Road Construction Projects

Journal Writer		**Das (2015)**	**Aziz & Abdel-Hakam (2016)**	**Santoso & Soeng (2016)**	**Rivera dkk (2020)**	**Sohu dkk (2019)**	**Khair dkk (2018)**	**Maha-mid (2017)**
No.	**Factor**							
1.	Broken work unit/tools	√	√	√	√	√		
2.	Lack of work skills	√	√	√	√	√	√	√
3.	Less work experience	√	√	√	√	√	√	√
4.	Poor communication/coord.	√		√	√	√	√	√
5.	Low knowledge	√		√			√	√
6.	Less work productivity	√	√	√	√		√	√
7.	Less supervision	√	√	√		√		
8.	Poor quality management		√		√	√	√	
9.	Rework	√				√	√	√
10.	Delay payment	√	√	√	√	√	√	√
11.	Delay delivery of materials	√	√		√	√		√
12.	Contractor conflict with others	√	√	√			√	
13.	Bad work procedure	√	√	√		√	√	√
14.	Weather changes / floods		√	√	√		√	√
15.	Design changes	√	√		√	√		√
16.	Work accident		√					
17.	Licensing and legal disputes	√	√		√		√	
18.	Not effective construc. method	√	√					
19.	Bad location terrain conditions			√		√		√
20.	Material change	√			√	√		√
21.	Poor contract management					√		√

Desc:
√ = Variables Are in the Journal

From the results of the recapitulation of the factors causing delays that occur in road construction projects contained in Table 1, there are 5 variables causing delays that are not contained in the 4 journals above, namely variables number 16, 17, 18, 19, and 21. These variables not used in the questionnaire in this study because it is considered irrelevant, at least 4 out of 7 journal authors must have this variable, so that the variable is relevant as a variable causing delays in road construction projects. For this reason, the preliminary questionnaire for this research will include 16 variables contained in at least 4 journals in Table 1.

4.2 Verification and Validation of Variables that Cause Delay in Flexible Pavement Type Road Projects

The type of data collected is primary data, this data was obtained with the help of distributing consent questionnaires. Respondents were asked for their opinion as an expert judgment whether the expert agrees/disagrees with the variable in question is one of the variables causing delays in flexible pavement type road projects based on the perception of each respondent. The results of data collection on the first phase approval questionnaire distributed to 8 experts from the Department of Public Works for Highways, there are 16 variables stated as relevant as variables causing delays in flexible pavement type road projects. The recapitulation of the results of questionnaire can be seen in Table 2.

Table 2. Recapitulation of Questionnaire Result

No.	Variables Cause Delay in Flexible Pavement Road Construction Projects	Code	EXPERT A	EXPERT B	EXPERT C	EXPERT D	EXPERT E	EXPERT F	EXPERT G	EXPERT H	Result
1	Heavy equipment (Compactor and Asphalt Finisher) and damaged work equipment	X1	√	√	√	X	√	X	√	X	Relevant
2	Weak work skills of flexible pavement construction project workers	X2	√	√	√	X	√	√	√	√	Relevant
3	Lack of work experience in the implementation of flexible pavement construction projects	X3	√	√	√	√	X	√	√	√	Relevant
4	Poor communication and coordination during flexible pavement construction project implementation	X4	X	√	√	√	X	√	X	√	Relevant
5	Low level of formal and informal knowledge possessed Flexible pavement construction project worker	X5	√	X	X	√	X	√	√	X	Irrelevant
6	Productivity and work skills in flexible pavement road construction projects are lacking	X6	√	X	√	X	√	√	√	√	Relevant
7	Lack of strict supervision of workers during the construction process of flexible pavement projects	X7	√	√	√	X	√	√	√	√	Relevant
8	Not implementing quality management of flexible pavement construction projects or if ineffective implementation has been implemented	X8	X	√	√	√	√	√	√	X	Relevant
9	Rework flexible pavement road construction project work	X9	X	√	√	√	X	√	√	√	Relevant
10	Delay in payment of work progress of flexible pavement construction projects	X10	√	X	X	√	√	√	√	√	Relevant
11	Delay in delivery of hot mix asphalt and aggregate materials	X11	√	√	√	√	√	√	√	√	Relevant
12	Conflicts between contractors and other parties	X12	√	X	√	√	X	√	X	√	Relevant

No.	Variables Cause Delay in Flexible Pavement Road Construction Projects	Code	EXPERT A	EXPERT B	EXPERT C	EXPERT D	EXPERT E	EXPERT F	EXPERT G	EXPERT H	Result
13	Implementation of poor flexible pavement road construction project work procedures	X13	√	√	√	√	√	√	√	√	Relevant
14	Changes in weather / rain	X14	√	√	√	√	√	√	√	√	Relevant
15	Changes in the design of flexible pavement construction projects	X15	√	X	X	√	√	X	√	X	Irrelevant
16	Changes in asphalt hotmix and aggregate material specifications	X20	√	√	X	X	√	X	√	X	Irrelevant

Desc:
√ = Experts Agree
X = Experts Disagree

From the data from the questionnaire recapitulation in Table 2, there are 3 variables that have balanced values, namely variables with codes X5, X15, and X20. This variable was approved by 4 experts as the variable causing delay in flexible pavement type road projects, while the other 4 experts stated otherwise (disagree). The variable is declared irrelevant because at least 5 out of 8 people must agree that the variable is relevant as a variable causing delay in flexible pavement type road projects, in addition to this phase 1 questionnaire also obtained comments and input regarding the level of influence on several variables. There are several variables that according to experts do not have an effect on the occurrence of delays in flexible pavement type road projects when viewed from the point of view of the implementation of flexible pavement type road construction projects, especially in work areas that have been handled by experts, namely variables X1, X4, X6, and X12. Based on these questionnaire results, it can be concluded that the 9 variables in Table 3 are the variables causing delays in the flexible pavement type road project.

Table 3. Variable Cause of Delay in Flexible Pavement Type Road Project

No.	Variables Cause Delay in Flexible Pavement Road Construction Projects	Code
1.	Weak work skills of flexible pavement construction project workers	X2
2.	Lack of work experience in the implementation of flexible pavement construction projects	X3
3.	Lack of strict supervision of workers during the construction process of flexible pavement projects	X7
4.	Not implementing quality management of flexible pavement construction projects or if ineffective implementation has been implemented	X8
5	Rework flexible pavement road construction project work	X9
6.	Delay in payment of work progress of flexible pavement construction projects	X10
7.	Delay in delivery of hot mix asphalt and aggregate materials	X11
8.	Implementation of poor flexible pavement road construction project work procedures	X13
9.	Changes in weather / rain	X14

4.3 Establishment of Causal Loop Diagram Model

To establish the form of the relationship and the mechanism of influence of each variable causing delay in flexible pavement type road projects, the stage of understanding the system was carried out by interviewing respondent experts, each respondent expert was given the same

question, namely whether they had experienced delays in current road projects. / have they handled. If ever, the respondent expert was asked to tell how the flow of the process of delay occurred and how the interaction form of each variable was obtained so that a series of events was obtained until the project was delayed. The initial hypothesis of the form of the model uses a causal loop diagram based on literature studies as a tool to facilitate the interview process, the initial causal loop diagram in this study was formed from the results of several literature studies which will be verified by the respondent, whether it is appropriate or needs changes to fit with real systems that occur in the field. The results of the interviews and questionnaires in the survey resulted in the form of a causal loop diagram in **Error! Reference source not found.** as a representation of the shape and mechanism of the relationship between variables causing delays in the actual flexible pavement type road construction project in the field.

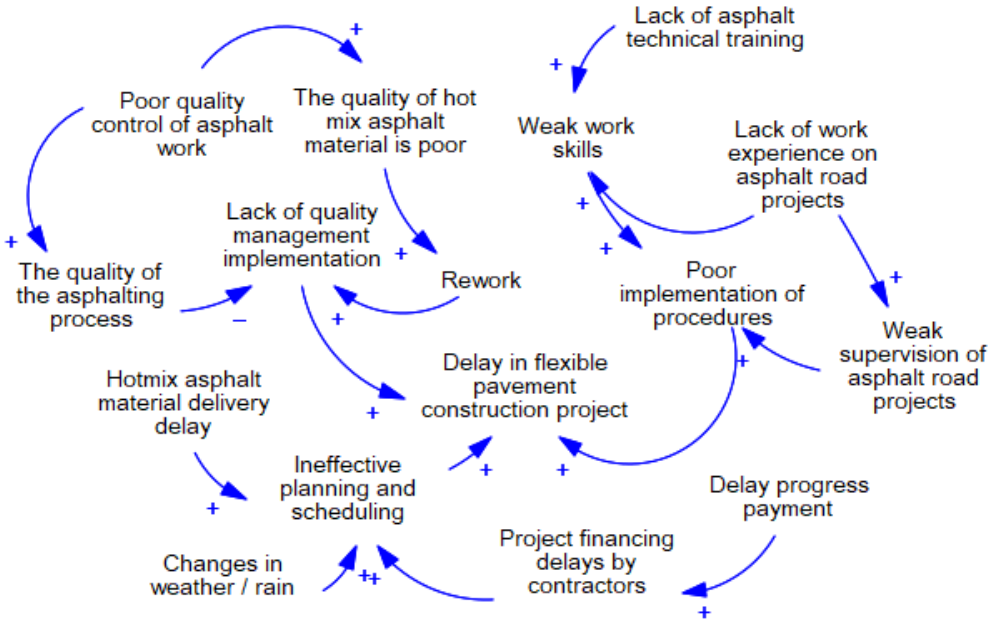


Figure 1. Causal Loop Diagram of the Process of Delay in Flexible Pavement Projects

Delay in flexible pavement construction projects is directly influenced by external factors, namely changes in weather/rain. These factors greatly affect the time, cost, and quality of a project, especially a road construction project. The higher the intensity of rain in road construction projects, it will result in project delays. Making proper plans and schedules to organize for project implementation outside the rainy season is recommended as a way to reduce this factor. Productivity of workers, will increase along with the increase in experience, skills and morale, with more training that is followed, it will be able to improve the skills and morale of workers. Contractors should improve the qualifications and skills of human resources by providing the necessary training to increase productivity, and to better manage and supervise the execution of the project. Lack of work skills and lack of intensive supervision causes poor implementation of work procedures and quality management in the field, poor work skills are caused by lack of work experience and lack of training regarding flexible pavement work, while poor work supervision is caused by lack of supervisory knowledge regarding supervised work and lack of work supervision. work experience in supervisory activities. The work procedure is a quality assurance so that the work has good quality and according to the plan if followed and implemented correctly, if a construction project, especially a road project with flexible pavement type, does not implement the

work procedures properly, it will cause defects or in the form of construction errors. . Which causes rework or activities in the field that must be reworked/more than once and causes the project to experience delays. Implementing poor work procedures can be reduced by implementing regular inspections, monitoring, and strict supervision. In addition, the delay in the delivery of flexible pavement type road construction materials also greatly affects the project delay. In this case, the sub base material (aggregate type B), base (aggregate type A), and asphalt material must be imported from outside the region, namely the Palu area, so that when there are delivery problems, work will be delayed because they are waiting for the arrival of the material. In addition, the quality of the material greatly affects the quality of the flexible pavement. So quality control needs to be done on materials and work equipment. Payment of work progress that is hampered is also one of the factors that causes project delays from the owner's side. This suggests that a review of the payment clauses in the contract may need to be considered. Procedures and timeliness and transparency must be stated explicitly in the agreement, and must be strictly followed by the government agency/owner responsible for making payments. Funding institutions must also actively monitor the proper implementation of payments.

6. CONCLUSIONS

Delays in road construction projects, especially flexible pavement projects, are a threat. This has a considerable cost and time impact, and also has an impact on the contractor's image. It was observed that variables related to weather changes, delays in material delivery, rework, project financing, skills and work supervision were the most significant causes of delays. The causal feedback model relationship between the conceptual models leads to the development of dynamic hypotheses to solve the challenges of delays in construction projects, especially flexible pavement projects. The causal feedback relationships reveals that there are 3 dynamic variables, which need to be considered to overcome the challenges of delays in construction projects, especially flexible pavement projects, including (1) causal feedback relationships involving ineffective planning and scheduling, weather changes, late material delivery, and late progress payments; (2) a causal feedback relationships that involves the implementation of poor quality management, rework, poor quality of asphalt hotmix material, poor quality control of asphalt work, and quality of asphalt process results; (3) a causal feedback relationships that involves poor implementation of procedures, weak work skills, lack of technical training, lack of work experience, and weak work supervision. The model provides insight into the interdependencies between the key influencing variables in the project and can be used for process improvement in future flexible pavement projects.

REFERENCES

Abbasi, O., Noorzai, E., Jafari, K. G., & Golabchi, M. (2020). Exploring the Causes of Delays in Construction Industry Using a Cause-and-Effect Diagram: Case Study for Iran. *American Society of Civil Engineers*.

Albinu, A., & Jagboro, G. (2002). The effects of construction delays. *Int. J. Project Manage*, 593-599.

Aziz, R., & Abdel-Hakam, A. (2016). Exploring delay causes of road construction projects in Egypt. *Alexandria Engineering Journal*, 1515-1539.

Braimah, N. (2008). *An Investigation into The Use of Construction Delay and Disruption Analysis.* Wolverhampton.

Budayan, C. (2018). Evaluation of Delay Causes for BOT Projects Based on Perceptions of Different Stakeholders in Turkey. *American Society of Civil Engineers*.

Das, D. K. (2015). Development Of Mechanisms By Using Conceptual System. *Construction Specialty Conference*.

Fugar, F. D., & B. Agyakwah-Baah, A. (2010). Delays in Building Construction Projects in Ghana. *Australasian Journal of Construction Economics and Building*.

Gluszak, M., & Lesniak, A. (2015). Construction delays in clients opinion – multivariate statistical. *Creative Construction Conference*.

Islam, M. S., Trigunarsyah, B., Hassanain, M., & Assaf, S. (2015). Causes of Delay in Construction Projects in Bangladesh. *International Conference on Construction Engineering and Project Management.* Busan, Korea: www.iccepm2015.org.

Khair, K., Mohamed, Z., Mohammad, R., Farouk, H., & Ahmed, M. E. (2018). A Management Framework to Reduce Delays in Road Construction Projects in Sudan. *Arab J Sci Eng* , 1925-1940.

Mahamid, I., Bruland, A., & Dmaidi, N. (2012). Causes of Delay in Road Construction Projects. *American Society of Civil Engineers*, 300-310.

Okasha, A., Arafa, A., & Amer, N. (2018). Identifying Major Project Delay Causes in Egypt and Assessing their Impacts Using System Dynamics. *International Conference on Civil and Architechture Engineering.* Cairo, Egypt.

Orozco, F., Serpell, A., Molenaar, K., ASCE, M., & Forcael, E. (2011). Modeling Competitiveness Factors and Indexes for Construction Companies: Findings of Chile. *American Society of Civil Engineers*.

Sanchez, O., & dkk. (2020). Delay Factors: A Comparative Analysis between Road Infrastructure and Building. *American Society of Civil Engineers*.

Santoso, S. D., & Soeng, S. (2016). Analyzing Delays of Road Construction Projects. *American Society of Civil Engineers*.

Surya, A. K. (2017). Scenario Development to Minimize Rework on Road Infrastructure Construction Works with a System Dynamic Approach. Surabaya.

Suryani, E. (2006). *Permodelan & Simulasi.* Yogyakarta: Graha Ilmu.

Yap, J., Rahman, H., & Chen, W. (2017). Collaborative model: Managing design changes with reusable project experiences through project learning and effective communication. *Int. J. Project Manage*, 1253–1271.

APPLICATION OF THE DEMATEL-ANP-TOPSIS METHOD IN THE SELECTION OF TRUCKING VENDORS IN 3PL COMPANY

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ABSTRACT

Logistics business is one of the business sectors that has a high growth rate. The WEF report states that the Indonesian logistics market is expected to experience an average Compound Annual Growth Rate of 7.9% in 2024. PT X, which is the grandson of PT Pertamina Group as well as a company engaged in logistics, has the same opportunities as other logistics companies. But until now, PT X only operates by exploiting a small part of the parent company's business potential. This is because of the management of PT X did not get enough trust from the management of the parent company in managing work in accordance with the core business. Therefore, PT X tries to increase the trust of the parent company management by improving the performance of all business operations carried out. One of them is the vendor performance evaluation process that has been used by PT X. Currently the evaluation variable that used by PT X in selecting trucking vendors are only cost and time. In this study, the evaluation variable in selecting trucking vendors will be expanded by using a structured and comprehensive approach. The DEMATEL-ANP-TOPSIS method will be used to determine the best vendor and evaluate vendor performance which will have an impact on increasing company performance. The determination of the three methods was chosen because the methods are able to solve problems by considering the interrelationships between elements or variables as well as considering the ideal solution in determining the best alternative. The results of this study are expected to provide an overview of the assessment of the existing vendor alternatives as well as provide recommendations for the selected vendor in the future.

Keywords: DEMATEL, ANP, TOPSIS, Vendor Evaluation

1. INTRODUCTION

Nowadays, logistic business is one of the high potential business types, this is because along with the increase of the people's daily needs in addition to the more sophisticated technology. Based on the data from Ken Research (2020), the logistic market in Indonesia from 2020 – 2024 is showing a positive trend, meaning that logistic business in Indonesia is always growing every year. Based on that report, the logistic market in Indonesia is estimated to have an average Compound Annual Growth Rate (CAGR) of 7.9% from income and up to US$ 300.3 billion by the year of 2024. The potential of this business includes freight transport, freight forwarding, warehousing, courier, express and parcel (CEP), value added services and cold chain logistics segments.

As a company who works in the energy sector, especially oil and gas, PT. Pertamina Group has a business network from upstream to downstream consisting of many types of Oil and gas operation. This includes exploration, exploitation, refinery, transportation, distribution, storage until the marketing and this is the core business, and all those operations is the gold mine of logistic business.

PT. X is the subsidiary of PT. Pertamina Patra Niaga as the Sub Holding Commercial and Trading. In that position, PT. X is given the flexibility to do business with other sub holdings but still within the scope or core business of logistics. Since 2019, the business's portfolio has focused on logistic and targeted to give a positive value in becoming a 3PL (Third Party Logistic) which will be adjusted with the company identity which is "Logistic". 3PL companies usually provide a storage and transport which can be adjusted to the clients/user needs and focus on the logistical activity with the goal of becoming a standard 3PL company with the business process of goods loading-unloading, storage, goods distribution, administration & delivery order, and fleet management.

In the year of 2020, there are work opportunities for transportation and logistics worth 20,5 trillion rupiah, which certainly could be taken by PT X with adjustments to the core business, namely the 3PL provider. However, in the internal of PT Pertamina group itself, there are several companies with almost the same business as PT X, becoming competitors in winning the available work opportunities. Business potential will be given to competitors within PT Pertamina group, supposing that PT X do not have the abilities to manage the business activities.

The competitiveness could be increased through service quality, where the higher the service quality provided, the greater the competitiveness will be in the industry. One of the sub variable that can represent the service quality is the number of customer complaints. Bigger number of customer complaints indicate that the service quality provided has not yet meet the customer expectations in deciding the vendor used by the company.

At this moment PT X could not reach a 100% of their goals because of the delayed of delivery to the customers location. As mentioned on the deals, if PT X could not fulfil their goals, then PT X will get the penalty.

To set the strategy of development, the company needs to do some evaluation to the work of the existing vendors so that the company could find out the performance of each vendor, then make it to the base of setting the strategy of development. The current process of the vendors trucking evaluation are based on two points (expense & time). With the result that a thorough evaluation process will be done, as the evaluation of performance of suppliers must be done from time to time using structured and comprehensive approach knowing the evaluation of performance of suppliers could be the thing to increase their performances to decide whether to search other suppliers or not.

In choosing the best alternative vendor and vendor performance evaluation, there are few variables which can be used as the indicator. Choosing a supplier or vendor is a multi-variable problem and it is quite complex because it is consisted of qualitative and quantitative variables and there are few variables that are trade-off (Alam-Tabriz, Rajabani, & Farrokh, 2014). ANP will represent the problem in broader and deeper so that ANP will provide more precise solution (Saaty T. L., 2004).

Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) can complement the ANP Method because this method considers ideal solution in deciding the best alternative option, which is the closest gap between positive value and furthest value from negative value, so with applying the TOPSIS method, we can decrease the amount of pair comparison and the the given solution can consider the variables or elements that are trade-off (AlamTabriz, Rajabani, &

Farrokh, 2014). In this case, TOPSIS will be very useful in solving the problem of choosing the best vendor because they can analysis a vendor in detail based on the gap between the positive value and negative value. Other than that, in this research, using the DEMATEL method which will be used as supporting method than can differentiate or prove the corelation between variables through the graph from the analysis, so it can help the creation of networks in ANP Method. The integration between DEMATEL-ANP-TOPSIS, is hoped to be able to help the research object in deciding the best vendor and their evaluation.

In general, this study aims to get the best recommendation of vendor at the PT X. In detail, it can be formulated into three main objectives in this research, namely:

1. To identify the criteria's which are the variables or element that can be used as the indicator for the best alternative vendor based on their performance
2. To analyse the corelation between the variable's using the DEMATEL method
3. To formulate the best vendor based on the result of the analysis using *Analytics Network Process* (ANP) and *Technique for Order Preference by Similarity to Ideal Solution* (TOPSIS) method.

2. LITERATURE REVIEW

DEMATEL (*Decision-Making Trial and Evaluation Laboratory)*

The DEMATEL method was introduced by The Battelle Memorial Institute through the Geneva Research Center which was developed to solve complex problems (Fontela & Gabus, 1974). Wu & Lee (2007) explained that DEMATEL is a comprehensive method for designing and analyzing the model structure of the causal relationship between several factors. The results of the DEMATEL method show that there is a reciprocal relationship between several components and can be used to determine which factors influence each other or affect each other.

DEMATEL method is the best method to apply in Multi Criteria Decision Making (MCDM) in visualize and construct a correlation between criteria and sub-criteria, for example, evaluating and choosing suppliers (Shahryar et al, 2012), continuous vendor performance evaluation (Chiou et al., 2011 in Elham 2012), and listing the central distribution priority in Supply Chain (Amiri et al., 201 in Elham 2012).

Table 1. Scoring Scale DEMATEL

Score	**Remarks**
0	No Influence
1	Low Influence
2	Medium Influence
3	High Influence
4	Very High Influence

ANP (Analytical Network Process)

According to Saaty (2003), Analytic Network Process (ANP) is the base theory of relative measurement which is used to reducing the composite priority ratio from individual priority ratio which reflects relative measurement from the influence of the elements that interact with each other regarding the control variable. ANP Structure is the network that does not necessarily state a rank or one way relation like in the hierarchy that is used in Analytic Hierarchy Process (AHP).

The core concept of the ANP Method is Influence, meanwhile the core concept in AHP Method is Preference.

Technique for Order Preferences by Similarity to Ideal Solution (TOPSIS) uses one of the Multi Criteria Decision Making Method which was introduced by Yoon and Hwang (1981. Base concept from the TOPSIS is the alternative, which is chosen as the alternative, using the difference between the Positive Ideal Solution and the biggest difference of Negative Ideal Solution. TOPSIS focuses on either the difference from positive ideal solution or negative ideal solution, by taking the closest correlation to the best or ideal alternative. By doing the comparison to both variables, the alternatives can be decided based on the differences (Kusumadewi, 2006).

The ANP method is a method of solving a problem that is not structured and requires a dependency relationship between its elements (several components). ANP is the development of the AHP method. There are two types of interrelationships or interrelationships in the ANP method, (1) Inner Dependence, elements in the same cluster can affect each other. (2) Outer Dependence, influence between elements in different clusters.

3. METHODS

Briefly explain what you do and how. This section should focus on methodology only. Do not write problem description, research objectives and conclusions in this section. Presenting flow chart is not compulsory in this section although many people did it to show the sequence of activities in their research process.

Collecting Data Stage

This step will explain the collecting data which is divided into Literature Study and Key Issue, Company Business Identification Process, and Criteria and Sub Criteria Identification. These data will be collected through interview and questionnaire.

Data Processing Step

Data Processing Step is where the data is processed by the researcher to draw a conclusion. The data processing step is divided into several steps, which is Identifying the correlation between the variables using the DEMATEL, ANP Network Creation, Comparison Matrix, Consistency Check, ANP Supermatrix Creation, and Deciding the Best Alternative Option using TOPSIS. This data processing will use the Microsoft Excel as supporting software for normal data processing, DEMATEL, Questionnaire and Interview Form Creation, and TOPSIS Data Processing. Other than that, this research will use the Superdecision Tools Software which commonly used as ANP Method Analysis.

Analysis and Conclusion

This step will analyze and interpret the data based on the data processing which has been done in the previous step. This step will discuss in detail about the analysis of choosing the best vendor along with the performance evaluation on each vendor of the company. This analysis is based on the result of each method, starting from ANP to TOPSIS. The best vendor analysis can be decided from the weight of the score, in ANP it’s the highest, while in TOPSIS is the smallest difference on negative value and the biggest difference on the positive value.

4. RESULTS

In this section, the results and analysis of the research that has been conducted will be explained. The results of this study are divided into several parts: identification of criteria and sub-criteria, identification of the relationship between criteria and sub-criteria with DEMATEL, preparation of the ANP network structure, and determination of the best alternative using TOPSIS. This data collection was conducted using a questionnaire on 4 people who were directly involved in the evaluation and determination of vendors. Then the data from the respondents are processed in accordance with the order mentioned above.

Identification of Criteria and Sub-Criteria

In this section, an explanation of the criteria and sub-criteria identified in this study will be explained. These criteria and sub-criteria are taken based on the company's vision and mission which are then confirmed by the respondents. This company has several visions which are as follows: (1) Becoming a Leading Energy Logistics Company in Indonesia (2) Becoming a national energy logistics company supported by digital services (IT Infrastructure) (3) Placing our company as the leading energy logistics player in the National arena (Quality Assurance) (4) Playing a role as a Leader in the Energy Logistics sector which can be used as a role model for the National Oil and Gas industry (5) Advancing the National logistics sector by becoming a leading National Energy Logistics Company and encouraging the creation of a competitive and efficient supply chain flow (Efficiency – Cost, Time, Quality) (6) To become a national energy logistics market leader (7) to become a national energy logistics and supply chain market leader.

Table 1. Visions and Vendor Breakdown

Visions	Vendor Criteria
Becoming a national energy logistics company supported by digital services (IT Infrastructure)	IT Infrastructure
Placing our company as the leading energy logistics player in the National arena (Quality Assurance)	Quality
Advancing the National logistics sector by becoming a leading National Energy Logistics Company and encouraging the creation of a competitive and efficient supply chain flow (Efficiency – Cost, Time, Quality)	Cost, Time, Quality, Delivery
Playing a role as a Leader in the Energy Logistics sector which can be used as a role model for the National Oil and Gas industry	Flexibility, Delivery, Relationships

After obtaining vendor criteria from the vision that has been given, these criteria are then further elaborated and relevant according to the criteria needed in logistics, as shown in the following table below.

Criteria	Notation	Subcriteria
Quality	A1	The suitability of the goods sent (amount and type)
	A2	Defect rate
	A3	Quality consistency
Price	B1	Affordable price
	B2	Insurance Cost
	B3	Payment Term Flexibility
Delivery	C1	On-Time Delivery
	C2	Faster Lead Time Offer
	C3	Guarantee that the goods will be delivered in good condition
Technology	D1	IT Infrastructure
	D2	Appropriate use of technology
Flexibility	E1	Response Speed
	E2	Ease of Order Change
	E3	Ease of Schedule Change
Relationships	F1	Professionality
	F2	Reputation and Integrity
	F3	Cooperation Transparency
Warranty	G1	Compaint Service
	G2	Guarantee of damage to goods
	G3	Easy warranty claim

The criteria and sub-criteria listed in the table above will be used as evaluation criteria in the selection and assessment of vendors. These criteria and sub-criteria were also used in questionnaires involving the evaluation and selection of vendors to respondents.

Identification Of The Relationship Between Criteria And Sub-Criteria with DEMATEL

The relationship between the criteria and sub-criteria is conducted using the DEMATEL method which is divided into several stages, namely matrix normalization, reducing the identity matrix to the normalized matrix, calculating the total matrix and calculating (D+R) and (D-R). The determination of the values (D+R) and (D-R) aims to determine which criteria are the cause, and effect categories as well as a reference in making causal diagrams. The following below is the result of the matrix processing that has been done. The value of D or dispatcher is obtained by summing each row, while the value of R or receiver is obtained from the sum of the results in each column.

Table 2. Total Matrix

Criteria	Quality	Price	Delivery	Flexibility	Technology	Warranty	Relationship
Quality	0,88	1,05	1,04	0,98	1,07	0,87	0,94
Price	0,99	0,83	0,97	0,91	1,01	0,82	0,87
Delivery	1,00	1,00	0,85	0,94	1,04	0,87	0,93
Flexibility	0,87	0,89	0,89	0,73	0,93	0,81	0,83
Technology	0,84	0,84	0,82	0,80	0,74	0,70	0,76
Warranty	0,59	0,60	0,60	0,58	0,63	0,45	0,57
Relationship	0,89	0,86	0,87	0,82	0,93	0,74	0,69

From this total matrix processing, the values of D, R, (D+R) and (D-R) are calculated through the sum of rows and columns.

Table 3. D and R-value

Criteria	D	R	(D+R)	(D-R)
Quality	6,83	6,06	12,90	0,77
Price	6,40	6,06	12,46	0,34
Delivery	6,62	6,04	12,67	0,58
Flexibility	5,96	5,76	11,71	0,20
Technology	5,50	6,34	11,83	-0,84
Warranty	4,01	5,27	9,28	-1,25
Relationship	5,80	5,59	11,39	0,21

Based on the results of the D and R calculations above, it can be seen that the criteria included in the cause category are quality, price, delivery, flexibility, technology, warranty, relationship. This is because these criteria have a positive D-R value. Meanwhile, technology and warranty criteria are included in the effect category because the D-R value is negative. The values of D and R are then made in a causal diagram to show the position of each criterion.

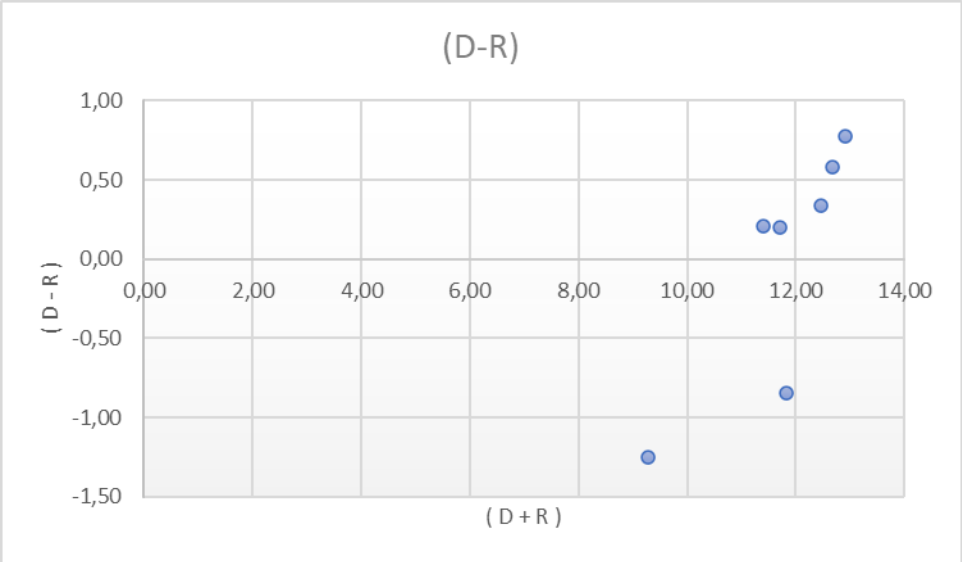


Figure 1. D and R Value for Criteria

This calculation process is also carried out on the sub-criteria matrix with the following results.

Sub-Criteria	D	R	(D+R)	(D-R)
A1	7,842484	9,967994	17,81048	-2,12551
A2	8,047921	10,15451	18,20243	-2,10659
A3	8,561063	10,77029	19,33136	-2,20923
B1	8,87443	8,413126	17,28756	0,461304
B2	8,199004	8,200644	16,39965	-0,00164
B3	7,317272	7,118684	14,43596	0,198588
C1	7,987084	8,376314	16,3634	-0,38923
C2	7,644979	7,628361	15,27334	0,016618

Sub-Criteria	D	R	(D+R)	(D-R)
C3	8,56546	8,592779	17,15824	-0,02732
D1	8,527863	7,788409	16,31627	0,739454
D2	7,63766	7,57925	15,21691	0,058411
E1	7,825858	8,10002	15,92588	-0,27416
E2	7,802876	7,445382	15,24826	0,357494
E3	7,627705	7,440118	15,06782	0,187586
F1	8,339363	6,943373	15,28274	1,39599
F2	7,280823	6,770847	14,05167	0,509976
F3	7,327875	6,388851	13,71673	0,939025
G1	9,04458	7,727563	16,77214	1,317018
G2	8,18341	7,570662	15,75407	0,612748
G3	8,718485	8,379013	17,0975	0,339472

Based on the results of the D and R calculations above, it can be seen that the sub-criteria included in the effect category are A1, A2, A3, B2, C1, C3, and E1 because the D-R value is negative. The values of D and R are then made in a causal diagram to show the position of each criterion.

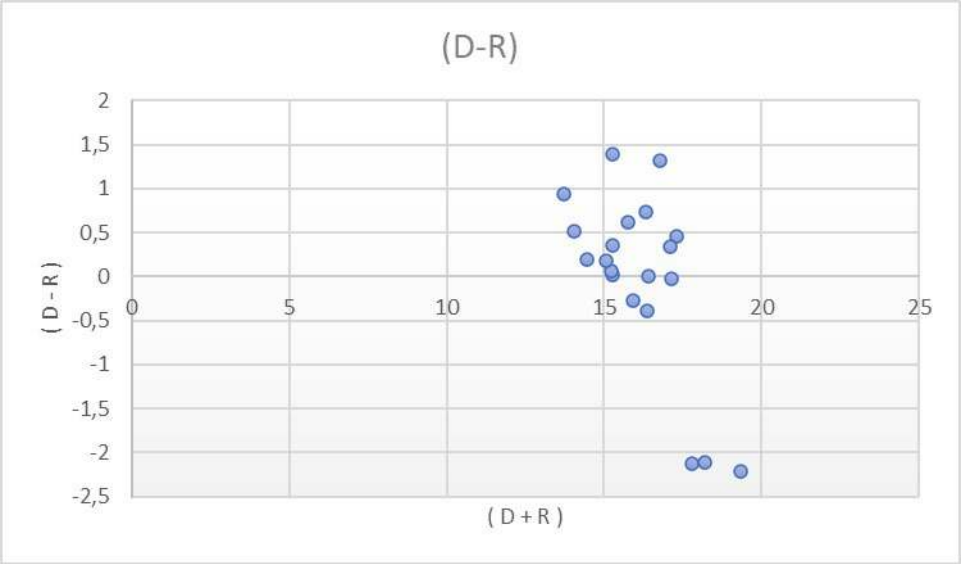


Figure 2. D and R value for Sub-Criteria

Identification Of The Relationship Between Criteria And Sub-Criteria with DEMATEL

After identifying the relationship between criteria and sub-criteria with DEMATEL, the results of the above process are then carried out to create an ANP network to show the relationship and its relationship. The following below is the result of making the ANP network.

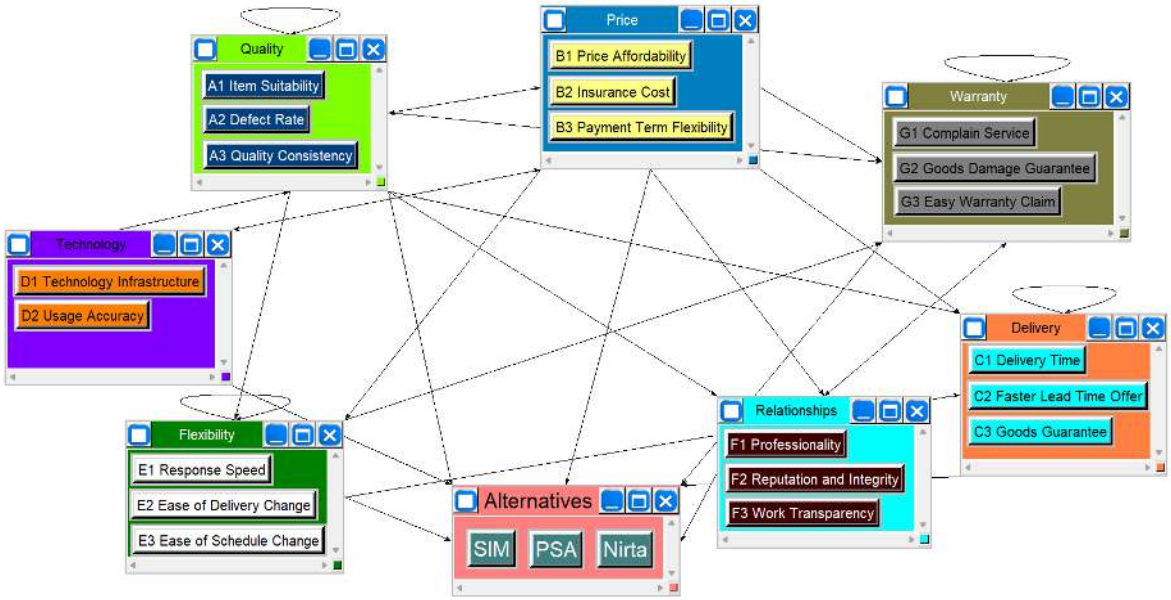


Figure 3. ANP Network

The design of the ANP network structure is conducted by considering the relationship between criteria in different clusters or outer dependence and also the relationship between criteria in the same cluster or inner dependence. Based on Figure 3 above, it can be seen that the quality criteria have an outer dependence relationship with other criteria and have a two-way relationship with the price criteria and warranty criteria. The same thing also happened to the price criteria which had an outer dependence relationship with the other four criteria. Likewise with the delivery, flexibility, and warranty criteria which also have an outer dependence relationship with other criteria. However, not all criteria have an inner dependence relationship. There are only 4 criteria that have an inner dependence relationship, namely the criteria for quality, delivery, warranty and flexibility.

Determination of The Best Alternative using TOPSIS

In this section, we will explain about determining the best alternative using TOPSIS. This data processing is taken from a different questionnaire with ANP and DEMATEL in the previous process. At this stage, several processes are passed, namely matrix normalization, making a weighted normalization matrix, and determining the best alternative. The following below is the result of the calculation process.

	Sub-criteria																		
Vendor Alternative	**A1**	**A2**	**A3**	**B1**	**B2**	**B3**	**C1**	**C2**	**C3**	**D1**	**D2**	**E1**	**E2**	**E3**	**F1**	**F2**	**F3**	**G1**	**G2**	**G3**
X (SIM)	0,06	0,06	0,06	0,03	0,03	0,05	0,06	0,06	0,06	0,05	0,04	0,05	0,05	0,05	0,05	0,05	0,05	0,05	0,05	0,04
Y (PSA)	0,06	0,05	0,06	0,04	0,04	0,05	0,05	0,04	0,05	0,05	0,04	0,06	0,04	0,05	0,05	0,05	0,04	0,05	0,04	0,05
Z (Nirta)	0,05	0,05	0,05	0,03	0,04	0,05	0,06	0,05	0,05	0,04	0,05	0,05	0,05	0,05	0,05	0,05	0,05	0,05	0,05	0,04

5. CONCLUSIONS

Based on the results of the research above, there are several conclusions drawn, namely (1) it can be seen that the criteria included in the cause category are quality, price, delivery, flexibility, technology, warranty, relationship. This is because these criteria have a positive D-R value. Meanwhile, technology and warranty criteria are included in the effect category because the D-R

value is negative. The values of D and R are then made in a causal diagram to show the position of each criterion. (2) it can be seen that the quality criteria have an outer dependence relationship with other criteria and have a two-way relationship with the price criteria and warranty criteria. The same thing also happened to the price criteria which had an outer dependence relationship with the other four criteria.

REFERENCES

Agrawal, V., Seth, N., & Dixit, J. K. (2020). A combined AHP–TOPSIS–DEMATEL approach for evaluating success factors of e-service quality: *an experience from Indian banking industry*. Electronic Commerce Research, 1-33.

Alfianti Permatasari, A. A. (2016). *Operational Risk and Mitigation Strategy*. Semarang.

Azimifard, A., Moosavirad, S. H., & Ariafar, S. (2018). Selecting sustainable supplier countries for Iran's steel industry at three levels by using AHP and TOPSIS methods. Resources Policy, 57, 30-44.

Büyüközkan, G., & Güleryüz, S. (2016). An integrated DEMATEL-ANP approach for renewable energy resources selection in Turkey. International journal of production economics, 182, 435-448.

Büyüközkan, G., & Çifçi, G. (2012). A novel hybrid MCDM approach based on fuzzy DEMATEL, fuzzy ANP and fuzzy TOPSIS to evaluate green suppliers. Expert Systems with Applications, 39(3), 3000-3011.

dos Santos, B. M., Godoy, L. P., & Campos, L. M. (2019). Performance evaluation of green suppliers using entropy-TOPSIS-F. Journal of cleaner production, 207, 498-509.

Fendi, A.2012. Analytical Strategy Risk Mitigation of Supply Chain PT. PAL Indonesia (Persero). Final Thesis. Institut Adhi Tama. Surabaya

Javad, M. O. M., Darvishi, M., & Javad, A. O. M. (2020). Green supplier selection for the steel industry using BWM and fuzzy TOPSIS: a case study of Khouzestan steel company. Sustainable Futures, 2, 100012.

Li, Y., Diabat, A., & Lu, C. C. (2020). Leagile supplier selection in Chinese textile industries: a DEMATEL approach. Annals of Operations Research, 287(1), 303-322.

Mohammed, A., Naghshineh, B., Spiegler, V., & Carvalho, H. (2021). Conceptualising a supply and demand resilience methodology: A hybrid DEMATEL-TOPSIS-possibilistic multi-objective optimization approach. Computers & Industrial Engineering, 160, 107589.

Ocampo, L., Deiparine, C. B., & Go, A. L. (2020). Mapping strategy to best practices for sustainable food manufacturing using fuzzy DEMATEL-ANP-TOPSIS. Engineering Management Journal, 32(2), 130-150.

Oztaysi, B. (2014). A decision model for information technology selection using AHP integrated TOPSIS-Grey: The case of content management systems. Knowledge-Based Systems, 70, 44-54.

Pujawan, I. N., & Geraldin, L. (2009). House of risk: a model for proactive supply chain risk management. Business Process Management Journal, Vol. 15, No.6, pp.953-967

Saaty, T. L. (2003). Decision making—the analytic hierarchy and network processes (AHP/ANP). Journal of systems science and systems engineering, 13(1), 1-35.

THE DEVELOPMENT OF REFRIGERATED-CONTAINER LOADING PROBLEM MODEL FOR VENTILATED CARGO

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ABSTRACT

Product transportation system from producer to consumer is very important in logistic management. Perishable products, such as fruit need special mode of transportation to maintain product quality, such as reefer. Controlling the temperature inside the reefer is not easy. Cargo should be placed in an area within the reefer where the temperature is close to the optimal temperature for each product. This research will develop a Refrigerated-Container Loading Problem (R-CLP) model ventilated cargo by considering internal temperature distribution of the reefer. Ventilation holes facilitate air circulation in and out of the cargo. So that air circulation does not only move around the cargo, but also enters through the cargo. We conducted a Computational Fluid Dynamics simulation to get the internal temperature distribution data on the reefer. Based on experimental results, by using ventilated cargo to load fruit products, distributors can save costs. The purpose of this research is to produce a decision support tools to optimize the yield of agricultural and reduce food loss due to the distribution process.

Keywords: container loading problem, refrigerated container, perishable products, ventilated cargos, computational fluid dynamics.

1. INTRODUCTION

Product transportation system from producer to consumer is very important in logistic management. Especially for perishable products, such as fruits that need a special mode of transportation to maintain product quality, namely refrigerated containers or reefer.

Perishable products have a limited shelf life. Storing perishable products for a long time without proper facilities will worsen the quality and safety of the product, so that it cannot be consumed and caused food loss.

Food loss is a decrease in the quantity and quality of food when the product is still in the supply chain (Rezaei & Liu, 2017). The distribution and marketing stages have a high contribution to food loss in Indonesia, which is around 3,2 – 7,6 million (Ministry of National Development Planning, 2021).

Cold chain management is a solution to optimize the quality of perishable products. Cold chain is a series of activities to keep products at a safe temperature (Kim et al., 2015). Perishable

products need an environment with the right temperature to slow down the ripening process and destroy microbes (Berry et al., 2015).

Reefer is the main segment in the cold chain which keeps the product at a low temperature during the shipping process (Getahun et al., 2017). Reefer will distribute different temperatures in each area (Mercier et al., 2017). The further away from the cooler, the higher the temperature in that area. Cargo should be placed in a reefer areas where the temperature is close to the optimal product temperature, so that the quality does not decrease too much.

Air circulation is one of the factors that can affect the temperature of the reefer. Circulation will be different for different types of products. Chilled products, such as fruits and vegetables, give off heat that must be removed to maintain the required temperature. Therefore cargo needs ventilation holes so that air circulation can move through the cargo. Figure 1a shows the air circulation in the reefer containing chilled products. Pre-cooled/frozen products, such as fish and meat must be refrigerated prior to shipment. Air circulation will move around the cargo because there are no ventilation holes in the cargo hold as shown in Figure 1b.

(a) (b)



Figure 1. Air circulation in the reefer (a) chilled products, (b) pre-cooled / frozen products (GDV, 2021)

Air circulation in reefers containing chilled products will also be different for each cargo design. Different sizes and air vents have different air circulation on the reefer. Cargo with larger ventilation holes at the bottom of the cargo will have higher vertical air circulation (Getahun et al., 2017).

This research is the development of Rusdiansyah et al. (2022) research. Rusdiansyah et al. (2022) developed the R-CLP model for fish products. In this study, the researcher developed an R-CLP model for ventilated cargo containing fruit products by considering the internal temperature distribution inside the reefer so as to minimize the quality loss and cost. The costs calculated in this study consist of penalty costs, quality loss costs, cooling costs, and reefer fixed costs.

The R-CLP model was developed as a decision support tool for the agricultural industry. This model also gives users more insight unto the problem of packing cargo inside the reefer, which the helps users in choosing a more appropriate strategy.

2. LITERATURE REVIEW

2.1 Quality degradation model for perishable products

Based on the quality degradation model, perishable products are divided into two categories, namely zero-order reaction and first-order reaction (Rong et al., 2011). Zero-order reaction occurs in perishable products with a chemical reaction rate that does not change with increasing or decreasing reactant concentration, such as fresh fruit and vegetables (Figure 2 line

A). First-order reaction occurs in perishable products with chemical reaction rate that varies based on changes in the concentration of the reactants, such as fresh meat and fish (Figure 2 line B).

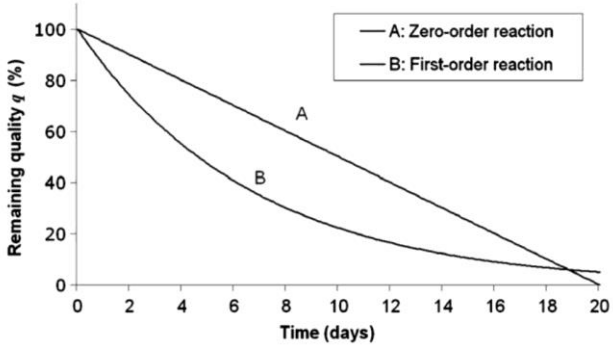


Figure 2. Quality degradation of perishable products (Rong et al., 2011)

2.2 Cold chain

The cold chain system is a series of control fresh products or perishable products to keep them in a safe temperature (Kim et al., 2015). A good cold chain can apply optimal temperatures to its logistics process so as to keep products in good condition. In cold chain, several infrastructures along the supply chain are needed to keep the products at their optimal temperature, as shown in Figure 3.

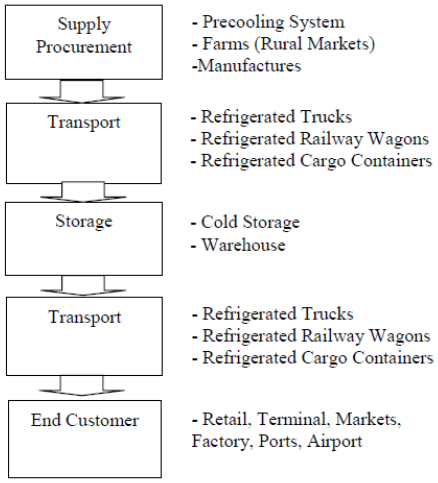


Figure 3. Cold chain infrastructures (Brzozowska, 2016)

2.3. Computational Fluid Dynamics (CFD)

CFD is a fluid flow analysis to find out how fluid flow affects heat transfer processes and chemical reactions in combustion streams (Tu et al., 2018). CFD can be used in several industries, such as aviation, automotive, medical, chemical and mineral processing, civil and environmental engineering, and metallurgy. Figure 4 is an example of CFD visualization showing the temperature difference on the reefer for three different types of cargo and at different times.

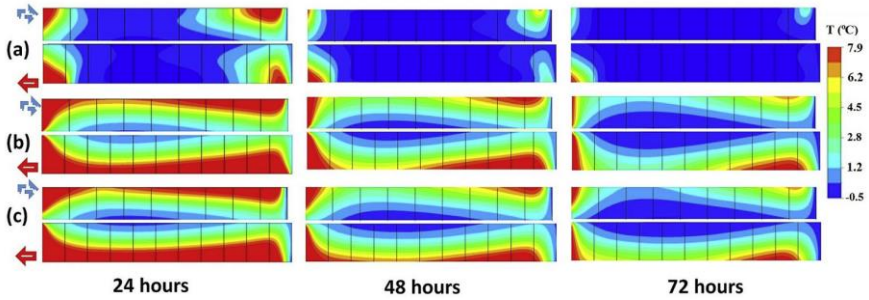


Figure 4. Visualization of temperature different on the reefer for cargo (a) Mk6, (b) Mk9, and (c) Econo-D (Getahun et al., 2017)

2.4 Fruit cargo

Cargo or packaging cargos will keep the product safe until it reaches the consumer. The shape of the cargo affects the post-harvest handling process, use of storage space and transportation facilities (Ambaw et al., 2022). Cargo for fruit products need ventilation holes as airflow paths. Ventilation holes facilitate the flow od cold air into the cargo during the product cooling process and remove heat due to respiration from the product as visualized in Figure 5 (Pathare & Opara, 2014). Mukama et al. (2020) recommend that the ventilation hole size is at least 5% of the surface area and misalignment of the buildup that causes blockage of the ventilation openings should be avoided to facilitate air flow.

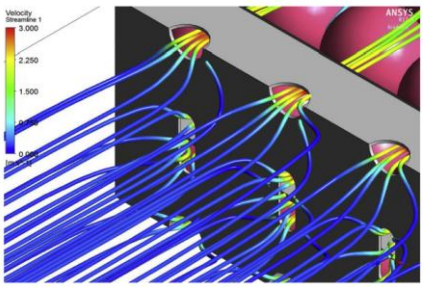


Figure 5. Ventilation holes visualization (Mukama et al., 2020)

2.5 Container Loading Problem (CLP)

CLP is the process of packing boxes into containers. There are two types of cargo loading problems, namely input minimization and output maximization. Input minimization applies when there are enough containers to hold all cargo. Output maximization applies when only a portion of the cargo can be packed due to limited container availability.

There are three basic geometric constraints that must be applied in CLP, namely (i) all boxes must be entirely inside the container, (ii) all boxes must only be placed parallel to the walls of the container, and (iii) boxes do not overlap each other. CLP must also consider several constraints that are practically relevant, including matters related to the type of goods, cargo size, position, and load.

There are several studies that have developed the CLP model, such as Rusdiansyah et al. (2022); Junior et al. (2019); Li et al. (2022); Zhang et al. (2022); Gadja et al. (2022); and Alonso et al. (2019). Rusdiansyah et al. (2022) developed an R-CLP model for loading fishery products by taking into account the internal temperature distribution. Junior et al. (2022) developed the Multi-Compartment Container Loading Problem (MC-CLP) model for loading beverage products for multiple consumers. Alonso et al. (2019) developed a CLP model using a palette and layer

concept. Gadja et al. (2022) developed a CLP model by grouping cargo by customer location. Li et al. (2022) developed a CLP model for strongly heterogeneous charges. And Zhang et al. (2022) developed a CLP model for weakly heterogeneous charges. Researchers have not found a study using the R-CLP model for ventilated cargo that will be developed in this study.

3. METHODS

The model developed in this study is the R-CLP model for ventilated cargo containing fruit products by considering the internal temperature distribution. R-CLP model will be developed through mathematical models. This study develops a mathematical models from Rusdiansyah et al. (2022). The difference is in the type of product and cargo used. Rusdiansyah et al. (2022) use closed cargo to load fishery product. This study uses ventilated cargo to load fruit product. This difference will make a difference in the quality degradation model and internal temperature distribution of reefer.

After compiling the model, the researcher conducted a numerical experiment to find out how to apply R-CLP to the delivery of fruit products using ventilated cargo. The data used in numerical experiment is data from previous research. The internal temperature distribution data considered in this research were obtain from simulation using ANSYS FLUENT software.

4. RESULTS

4.1 Mathematical model

The objective function of R-CLP model is to minimize the total cost, which consists of penalty, quality degradation, refrigeration, and reefer fixed costs (Formula 1). Formula (2) – (5) ensure the total weight and size of the cargo does not exceed the reefer capacity. Formula (6) – (11) ensure that each cargo does not overlap each others. Formula (12) – (19) ensure that the cargo rotation is orthogonal to the x, y, and z axes. Formula (20) ensures that heavy cargo is not on top of lighter cargo. Formula (21) – (29) is the vertical stability constraint. Formula (30) ensures that the product quality is not less that the quality requirements. Formula (31) – (33) is the domain of the variables used.

Notation:

I = Set of products or cargos = {1, 2, 3, …, i}
A = Set of axes = {1, 2, 3}
B = Set of cargo sides = {1, 2, 3}
V = Set of cargo vertices = {1, 2, 3, 4}
FC = Reefer fixed cost per unit
RC = Refrigeration cost per kcal per hour
n = Amount to be packed of cargo i
w_i = Width of cargo i
h_i = Height of cargo i
d_i = Depth of cargo i
b_i = Weight of cargo i
v_i = Value of cargo i
W = Width of the reefer
H = Height of the reefer
D = Depth of the reefer
B = Weight capacity of the reefer
T_0 = Neutral temperature (0°C)

T_{ext} = External temperature or environment temperature (°C)
T_{int} = Internal temperature of the reefer or temperature setting (°C)
T_{ref} = Reference temperature (K)
TR_i = Temperature inside the reefer received by product i (°C)
TS_i^+ = Maximum temperature in the safe temperature range of product i (°C)
SL_i = Initial shelf life of product i
QR_i = Quality requirement of product i (%)
k_0 = Deterioration rate constant
e = Euler number (e = 2.71828)
E_a = Activation energy (Joule/mole)
R = Gas constant (Joule/mole K)
TT = Shipping time
s = Surface thickness of the reefer (m)
k = Coefficient of insulting material
A = Surface area of the reefer (m^2)
Δt^* = Temperature difference between two surface sides of the reefer (°C)
C = Specific heat (kcal)
Cl = Latent heat (kcal)

Decision variables:

$p_i = \begin{cases} 1 & \text{If cargo } i \text{ is placed in the reefer} \\ 0 & \text{Otherwise} \end{cases}$

(x_i, y_i, z_i) Coordinate location of the left-bottom-back corner of cargo i

(x_i', y_i', z_i') Coordinate location of the right-top-front corner of cargo i

$r_{iab} = \begin{cases} 1 & \text{If the side } b \text{ of cargo } i \text{ is along the } a \text{ axis} \\ 0 & \text{Otherwise} \end{cases}$

$x_{ik}^p = \begin{cases} 1 & \text{If cargo } i \text{ is on the right of cargo } k \ (x_k' \le x_i) \\ 0 & \text{Otherwise } (x_i < x_k') \end{cases}$

$y_{ik}^p = \begin{cases} 1 & \text{If cargo } i \text{ is above of cargo } k \ (y_k' \le y_i) \\ 0 & \text{Otherwise } (y_i < y_k') \end{cases}$

$z_{ik}^p = \begin{cases} 1 & \text{If cargo } i \text{ is behind of cargo } k \ (z_k' \le z_i) \\ 0 & \text{Otherwise } (z_i < z_k') \end{cases}$

$w_i^+ = \begin{cases} 1 & \text{If the width of cargo } i \text{ can be in a vertical position} \\ 0 & \text{Otherwise} \end{cases}$

$h_i^+ = \begin{cases} 1 & \text{If the height of cargo } i \text{ can be in a vertical position} \\ 0 & \text{Otherwise} \end{cases}$

$d_i^+ = \begin{cases} 1 & \text{If the depth of cargo } i \text{ can be in a vertical position} \\ 0 & \text{Otherwise} \end{cases}$

$g_i = \begin{cases} 1 & \text{If cargo } i \text{ is on the ground } (y_i = 0) \\ 0 & \text{Otherwise} \end{cases}$

$\eta_{ik}^1 = \begin{cases} 0 & \text{If } z_k \le z_i \\ 1 & \text{Otherwise} \end{cases}$

$$\eta_{ik}^{2} = \begin{cases} 0 & \text{If } x_k \le x_i \\ 1 & \text{Otherwise} \end{cases}$$

$$\eta_{ik}^{3} = \begin{cases} 0 & \text{If } z_i' \le z_k' \\ 1 & \text{Otherwise} \end{cases}$$

$$\eta_{ik}^{4} = \begin{cases} 0 & \text{If } x_i' \le x_k' \\ 1 & \text{Otherwise} \end{cases}$$

$$\beta_{ik}^{v} = \begin{cases} 0 & \text{If vertex } v \text{ of cargo } i \text{ is supported by cargo } k \\ 1 & \text{Otherwise} \end{cases}$$

$$N_i = \begin{cases} 1 & \text{If } TR_i > TS_i^{+} \\ 0 & \text{If } TR_i \le TS_i^{+} \end{cases}$$

Objective function:

$$MIN\left[[(n-\sum p_i)V_i] + \left[\sum \frac{TT+N_i\left(k_0 TT_e^{-\left[\frac{E_a}{R}\left(\frac{1}{T}-\frac{1}{T_{ref}}\right)\right]}\right)}{SL_i} V_i p_i\right] + \left[\left(\left(\frac{1}{s}kA\Delta t^{*}\right) + \frac{1}{TT}\left(\left(\sum b_i p_i \times C \times (T_{ext}-T_0)\right) + \left(\sum b_i p_i \times Cl\right) + \left(\sum b_i p_i \times C \times (T_0 - T_{int})\right)\right)\right) \times RC\right] + [FC]\right] \quad (1)$$

Constraints:

$$\sum_{i=1}^{n} b_i p_i \le B \quad (2)$$

$$x_i' \le W \quad (3)$$

$$y_i' \le H \quad (4)$$

$$z_i' \le D \quad (5)$$

$$x_{ik}^{p} + x_{ki}^{p} + y_{ik}^{p} + y_{ki}^{p} + z_{ik}^{p} + z_{ki}^{p} \ge (p_i + p_k) - 1 \quad (6)$$

$$x_k' \le x_i + \left(1 - x_{ik}^{p}\right)W \quad (7)$$

$$x_i + 1 \le x_k' + x_{ik}^{p} W \quad (8)$$

$$y_k' \le y_i + \left(1 - y_{ik}^{p}\right)H \quad (9)$$

$$z_k' \le z_i + \left(1 - z_{ik}^{p}\right)D \quad (10)$$

$$z_i + 1 \le z_k' + z_{ik}^{p} D \quad (11)$$

$$x_i' - x_i = r_{i11}w_i + r_{i12}h_i + r_{i13}d_i \quad (12)$$

$$y_i' - y_i = r_{i21}w_i + r_{i22}h_i + r_{i23}d_i \quad (13)$$

$$z_i' - z_i = r_{i31}w_i + r_{i32}h_i + r_{i33}d_i \quad (14)$$

$$\sum_{a} r_{iab} = 1 \quad (15)$$

$$\sum_{b} r_{iab} = 1 \quad (16)$$

$$r_{i21} \le w_i^{+} \quad (17)$$

$$r_{i22} \leq h_i^+ \tag{18}$$
$$r_{i23} \leq d_i^+ \tag{19}$$
$$b_i \leq b_k y_{ik}^p \tag{20}$$
$$\sum_{v=1}^{4}\sum_{k=1}^{n} \beta_{ik}^v \geq 4(1-g_i) \tag{21}$$
$$y_i \leq (1-g_i)H \tag{22}$$
$$\eta_{ik}^1 + \eta_{ik}^2 \leq 2(1-\beta_{ik}^1) \tag{23}$$
$$\eta_{ik}^3 + \eta_{ik}^4 \leq 2(1-\beta_{ik}^3) \tag{24}$$
$$\eta_{ik}^4 + \eta_{ik}^4 \leq 2(1-\beta_{ik}^4) \tag{25}$$
$$x_k \leq x_i + \eta_{ik}^1 W \tag{26}$$
$$z_k \leq z_i + \eta_{ik}^2 D \tag{27}$$
$$x_k \leq x_i + \eta_{ik}^3 W \tag{28}$$
$$z_k \leq z_i + \eta_{ik}^4 D \tag{29}$$
$$\frac{SL_i - \left(TT + N_i\left(k_0 TT_e^{-\left[\frac{E_a}{R}\left(\frac{1}{T}-\frac{1}{T_{ref}}\right)\right]}\right)\right)}{SL_i} \geq QR_i \tag{30}$$
$$i, k \in \{1, \ldots, n\} \tag{31}$$
$$a, b \in \{1, 2, 3\} \tag{32}$$
$$v \in \{1, \ldots, 4\} \tag{33}$$

4.2 Experiment - Comparison between closed cargo and ventilated cargo

Numerical experiments were conducted to compare the use of closed and ventilated cargos in the R-CLP model. Ventilated holes facilitate vertical and horizontal airflow through the cargo. Table 1 shows the product specification for the experiment. This experiment uses one type of cargo with dimensions of 40 x 27 x 30.

Table 1. Product specification

No	Product	Quantity (cargo)	Temperature (°C)		Shelf life (hours)	Weight per cargo	Value
			Min	Max			
1	Apple	300	-1	4	720	19	665,000
2	Kiwi	300	0	3	1344	19	1,121,000
3	Cherry	300	0	3	240	11	2,805,000

In this research, we performs simulation using ANSYS FLUENT software to know the temperature distribution in the reefer. Figure 6 shows the temperature distribution in a reefer that containing closed and ventilated cargo. This visualization is the result of a simulation with temperature setting -5°C and velocity 2m/s. In reefer that containing ventilated cargo, the temperature is distributed more evenly. In more detail, the vertical distribution of temperature on the reefer that containing ventilated cargo is more evenly distributed. The temperature in the bottom row of closed cargo is relatively higher than on the ventilated cargo. This temperature data will be used for numerical experiment.

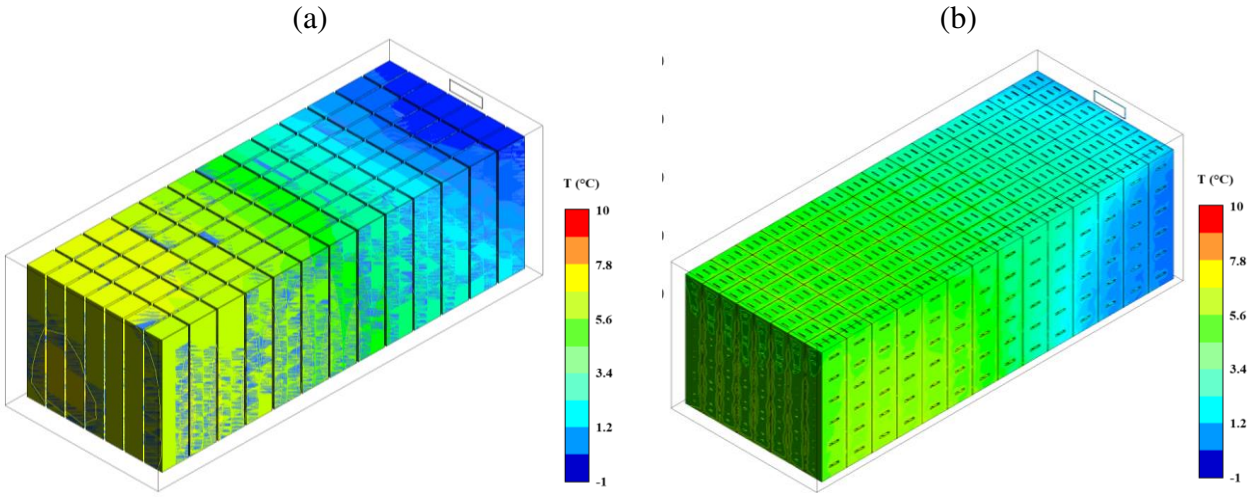


Figure 6. Visualization of internal temperature distribution in reefer that containing (a) ventilated cargo and (b) closed cargo

Table 2. Experimental results

	Closed cargo	**Ventilated cargo**
Cargo to Load	900	900
Cargo Loaded	500	672
Cargo Left Out	400	228
Penalty Cost	616,800,000	206,340,000
Quality Loss Cost	13,072,916	23,365,689
Refrigeration Cost	171,075	307,921
Reefer Fixed Cost	5,000,000	5,000,000
Total Loading Cost	635,043,992	235,013,610

Table 2 shows the results of numerical experiments. From the internal temperature distribution data, when using closed cargo, there are some area that have higher temperature than the other. There is no cargo can be loaded on these area because the temperature on these area is higher than the optimal temperature of each product. That's make the container is unable to be fully loaded when using closed cargo. The container can only load 500 cargos. So, the penalty cost when using closed cargo will be higher than using ventilated cargo. And it also affects the refrigeration cost. The refrigeration cost is considered by the amount of cargo loaded. Because the amount of closed cargo loaded is smaller than ventilated cargo, the refrigeration cost will be less too. And for the total loading cost, using closed cargo will need a larger total cost than using ventilated cargo. The total cost when using closed cargo is 270% compared to using ventilated cargo. It is because a significance differences on the penalty cost generated.

5. CONCLUSIONS

Product transportation system is very important in logistic management. Especially for perishable products that need a special mode of transportation to maintain product quality, namely refrigerated containers or reefer. Reefer will keep the product at a low temperature during the shipping process. This study developed a R-CLP model for ventilated cargo containing fruit

products. From the experimental results, it is shown that the total cost of ventilated cargo for fruit products is less that that of closed cargo.

The model developed in this study can be used by distributors in arranging ventilated cargo in reefer. There are many things that can be developed in further research, such as using pallets. Pallet is one of the material handling tools that can be speed up the loading process. Further research can also use the other types of ventilated cargo, so that it can provide variations in loading results.

REFERENCES

Alonso, M. T., Alvarez-Valdes, R., Iori, M., & Parreno, F. (2019). Mathematical models for Multi Container Loading Problems with practical constraints. *Computers & Industrial Engineering, 127*, 722-733.

Ambaw, A., Mukama, M., Fadiji, T., & Opara, U. L. (2022). Fresh fruit packaging design verification through virtual prototyping technique. *Food Packaging and Shelf Life, 32*, 1-11.

Berry, T., Griessel, H., Delele, M., & Opara, U. L. (2015). Geometric design characterisation of ventilated multi-scale packaging used in the South African pome fruit industry. Agricultural Mechanization in Asia, Africa, and Latic America, 46(3), 34-42.

Brzozowska, A., Brezeszczak, A., Imiolcyzk, J., & Szymczyk, K. (2016). Managing cold supply chain. *5th International Conference on Advanced Logistics and Transport.* Krakow, Poland: IEEE.

Gadja, M., Trivella, A., Mansini, R., & Pisinger, D. (2022). An optimization approach for a complex real-life container loading problem. *Omega, 107*.

GDV. (2021). Container Handbook: Cargo loss prevention information from German marine insurers. Retrieved March 11, 2022, from www.containerhandbuch.de

Getahun, S., Ambaw, A., Delele, M., Meyer, C. J., & Opara, U. L. (2017). Analysis of airflow and heat transfer inside fruit packed refrigerated shipping container: Part II - Evaluation of apple packaging design and vertical flow resistance. Journal of Food Engineering, 203, 83-94.

Junior, R. R., Yanasse, H. H., Morabito, R., & Junqueira, L. (2019). A hybrid approach for a multi-compartment container loading problem. *Expert Systems With Applications, 137*, 471-492.

Kim, W. R., Aung, M. M., Chang, Y. S., & Makatsoris, C. (2015). Freshness gauge based cold storage management: A ethod for adjusting temperature and humidity levels for food quality. *Food Control, 47*, 510-519.

Li, Y., Chen, M., & Huo, J. (2022). A hybrid adaptive large neighborhood search algorithm for the large-scale heterogeneous container loading problem. *Expert Systems With Applications, 189*.

Mercier, S., Villeneuve, S., Mondor, M., & Uysal, I. (2017). Time temperature management along the food cold chain: A review of recent developments. Comprehensive Reviews in Food Science and Food Safety, 1-21.

Ministry of National Development Planning. (2021) Laporan kajian: Food loss and waste di Indonesia. Jakarta: Kementerian Perencanaan Pembangunan Nasional.

Mukama, M., Ambaw, A., & Opara, U. L. (2020). Advances in design and performance evaluation of fresh fruit ventilated distribution packaging: A review. *Food Packaging and Shelf Life, 24*.

Pathare, P. B., & Opara, U. L. (2014). Structural design of corrugated boxes for horticultural produce: A review. *Biosystems Engineering*, 128-140.

Rezaei, M. & Liu, B. (2017) Food loss and waste in the food supply chain. [Online]. Available: http://www.fao.org/3/a-bt300e.pdf. [Accessed on 13 Februari 2022].

Rong, A., Akkerman, R., & Grunow, M. (2011). An optimization approach for managing fresh food quality throughout the supply chain. *International Journal Production Economics, 131*, 421-429.

Rusdiansyah, A., Adetio, I. R., & Dewi, R. S. (2022). The development of the refrigerated-container loading problem model for perishable fishery products considering internal temperature distribution. *International Journal of Systems Science: Operations & Logistics*, 1-16.

Tu, J., Yeoh, G.-H., & Liu, C. (2018). *Computational Fluid Dynamics: A Practical Approach* (3rd ed.). United States: Butterworth-Heinemann.

Zhang, D., Gu, C., Fang, H., Ji, C., & Zhang, X. (2022). Multi-strategy hybrid heuristic algorithm for single container weakly heterogeneous loading problem. *Computers & Industrial Engineering, 170*.

THE IMPLEMENTATION OF ENTROPY AND TOPSIS METHOD FOR RANK PROJECTS AND PRIORITIZING BUDGET ALLOCATION : A CASE STUDY AT PT.VALE INDONESIA

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ABSTRACT

Executing project is more difficult when the projects in interaction with current line of production as it becomes a hard constraint in term of timeline and work duration. Common problems are missing deadline, delay and under-perform in financial. Project selection plays an important role to choose the best projects. New several important criteria: risk reduction, procurement planning and production fitness; are added on top of existing safety and financial criteria of project selection. Project's annual budget contains three main scopes i.e., engineering, procurement and construction. There are 12 distinction projects in term of risk, budget, and technical complexity as a case study. Shannon's Entropy determines criteria's weight and TOPSIS ranks the projects. Annual Budget allocation is based on deterministic. Spearman's rank correlation is used to see project rank sensitivity. The result shows, financial is the most influencing criteria. Changing criteria's weight referring to DM's preference weight result project's rank with strong rank correlation coefficient. This method within this study achieves its robustness. Budget allocation per year is gradually increasing aligned with project's life cycle. The simplicity implementation of Shannon's entropy and TOPSIS reduces complexity and saves time; safety, financial, and maturity indicate a proper combination criterion to select the best projects.

Keywords: Entropy, TOPSIS, Risk Reduction, Procurement Planning, Production Fitness

1. INTRODUCTION

Project selection is a very complicated process. It involves a number of expected objectives, assessment criteria, decision makers used to in the form of a committee, the site situation in which the project will be implemented, etc. Good project selection will contribute greatly to the overall successful implementation of the project. This study is about sustaining project selection in a mining company. Sustaining project has objective to maintain existing asset and will interact with existing line of production. Common problem used to arise are delay in engineering/design work, material or equipment procurement, construction work, and/or even construction's duration longer than plan. Those kinds of delays will impact on financial performance, both project and company, and under achievement of company goal. Project selection plays an important role and as a process to evaluate

each project idea and choose several projects to achieve company objective. Project selection needs to consider several important criteria. In this study, new criteria (risk reduction, technical maturity, procurement planning and production fitness) are added to existing safety and financial criteria. This is in line with company objective to reduce risk (safety) into acceptable level and achieving financial benefit. Meanwhile, a new criterion i.e., maturity consisting of technical maturity, procurement plan, and production fitness are to consider the uniqueness of site location in which projects will be implemented. It represents engineering work complexity, lead time of material, and availability time for construction in the production plan. It is to ensure an alignment between project and production plan. These maturities criteria are considered as the newness of this study. Financial evaluation is based on cost and benefit. Safety is based on risk assessment following company risk matrix and maturity is based on expertise judgment (project owner) assessment using linguistic scale (Xu 2011). There are 12 distinction projects in term of risk, budget, and technical complexity as a case study. Projects and criteria are shown in Table 1, with Budget, NPV, EAB are in thousand USD.

The remaining of this study is organized as follows. Section 2, present a literature review, similar study about project selection and usage of MCDM. Section 3 presenting the proposed approach on project selection, section 4 result, and section 5 conclusion.

Table 1. Project and Criteria

No	Proj. Code	Safety		Financial					Maturity		
		Risk	Delta Risk	Budget	NPV	EAB	IRR	PP	Tech	Proc	Prod
		1	2	3	4	5	6	7	8	9	10
1	A	24	8	2,780	3,304	555	30.6%	4.08	8	5	7
2	B	16	8	1,700	1,559	249	20.0%	5.28	6	5	3
3	C	52	20	2,398	325	56	10.4%	6.11	6	3	7
4	D	20	8	1,000	985	169	23.4%	3.90	6	1	1
5	E	16	8	894	231	39	11.2%	7.29	6	1	1
6	F	24	8	386	650	109	43.2%	3.38	8	3	3
7	G	16	8	427	1,632	325	92.4%	3.69	7	5	1
8	H	32	12	554	333	57	11.9%	9.40	7	5	3
9	I	10	4	939	1,990	329	42.7%	3.84	8	3	7
10	J	12	4	906	1,202	199	46.6%	1.91	9	5	7
11	K	10	4	997	1,127	225	43.2%	3.58	6	3	5
12	L	12	4	702	960	164	23.1%	5.07	8	3	7

2. LITERATURE REVIEW

Multi-criteria decision making (MCDM) methods have been applied widely to project selection problems. There are a lot of studies using different method and different criteria as summarize by (Lee & Chang 2018) and (Mojtaba Ranjbar 2021), depending on uniqueness and interest. Study (Vijaykumar, et al. 2021) used fuzzy AHP and financial criteria for projects selection; (Lee & Chang 2018) uses four MCDM method with financial technology and environment criteria of evaluation for ranking renewable energy; (J. Ma, et al. 2020) uses criteria base on KPI performance (economic, environment, and social) with fuzzy TOPSIS; other criteria e.g.: competitive advantage, strategic adaption, optical and social risk, and technical risk are used by (Mojtaba Ranjbar 2021) for project portfolio selection and scheduling using fuzzing AHP and fuzzy TOPSIS.

In this study, Shannon's entropy will be used to weight criteria and TOPSIS to rank the projects. The concept of entropy in the field of information was introduced by (Shannon 1948) that

stated the amount of information will depend on the level of probability how easy/difficult the information to be obtained or predicted. The easier (high probability) information is obtained, it means smaller data variant, and vice versa (Vajapeyam 2014). This method is suitable for use when DM and direct experimentation to weigh criteria are not possible (Lotfi and Fallahnejad 2010). Typical application is study by (Alao, et al. 2020), (Feng, Xu and Li 2021), (Hwan & Yoon 1981), and (Poongavanam and Sivalingam 2021). Meanwhile, (Hwan & Yoon 1981) developed the Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) method based on the concept that the best alternative is those has the shortest distance from the positive ideal solution (PIS) and has the farthest distance from the negative ideal solution (NIS).

3. METHODS

In general, the methodology of this study will follow sequence: taking all data from projects business case, defining criteria, Shannon's entropy calculates criteria weight, TOPSIS ranks the projects, carrying sensitivity analysis by changing criteria weight scenario to see project rank: Low medium high weighting, mean weighting, CRITIC method, and DM preference weight; TOPSIS is compared to EDAS and MOORA method; then those scenarios compare to original weight and measure its correlation using Spearman's rank correlation. The next is examining budget allocation plan deterministically based on expertise experience and project prioritization based on approved budget through cut-off procedure.

3.1 Determine criteria

Three categories are used i.e., safety, financial and maturity. Safety consists of criteria (1) risk score, (2) risk reduction (delta risk). Financial consists of criteria (3) total budget, (4) NPV, (5) equivalent annual benefit (EAB), (6) IRR, (7) payback period (PP). Maturity consists of (8) technical/engineering complexity, (9) procurement planning, and (10) production fitness. There are 10 criteria in total used for evaluation, as shown in Table 1.

3.2 Calculate criteria's weight based on Shannon's Entropy

Following is a systematic procedure for entropy weight method (Alao, et al. 2020), (Feng, Xu and Li 2021), (Hwan & Yoon 1981):

Step 1: Make a decision matrix comprising of m projects and n criteria given as $(x_{ij})_{m\times n,}$ as shown in Table 1.

Step 2: Normalization of the arrays of a decision matrix to obtain project outcome Pij

$$P_{ij} = \frac{x_{ij}}{\sum_{i=1}^{m} x_{ij}} \quad (1)$$

Step 3: Computation of the entropy measure of project outcomes

$$E_j = -k \sum_{i=1}^{m} P_{ij}\, x \ln P_{ij} \quad (2)$$

$$k = \frac{1}{ln(m)}$$

Step 4: Defining the criteria weight, *wj* - weighted values

$$W_j = \frac{1-E_j}{\sum_{j=1}^{n}(1-E_j)} \quad (3)$$

i = 1, 2, ..., 5; j = 1, 2, ...,12

3.3 Rank the projects based on TOPSIS

Following step to rank project based on TOPSIS (Ma, Harstvedt and Smith 2020):

Step 1: Make a decision matrix comprising of m projects and n criteria given as $(x_{ij})_{m\times n,}$ as shown in Table 1.

Step 2: Normalized decision matrix (z_{ij})

$$z_{ij} = \frac{x_{ij}}{\sqrt{\sum_{i=1}^{n} x_{ij}^2}} \quad (4)$$

Step 3: Aggregate criteria weights to the decision matrix by

$$V_{ij} = w_j z_{ij} \quad (5)$$

where: w_j is the weight for criteria j calculated by Shannon's entropy (3)

Step 4: Locate PIS (S^+) and NIS (S^-).

For benefit criteria, $v_j^+ = \max \{v_{1j}, v_{2j}, \ldots, v_{mj}\}$, $vj = \min \{v_{1j}, v_{2j}, \ldots, v_{mj}\}$ (6)

For non-benefit criteria, $v_j^+ = \min \{v_{1j}, v_{2j}, \ldots, v_{mj}\}$, $vj = \max \{v_{1j}, v_{2j}, \ldots, v_{mj}\}$ (7)

Step 5: Calculate the distance between PIS (S^+) and NIS (S^-) of each project.

$$S_i^+ = \sqrt{\sum_{i=1}^{n} \left(v_{ij} - v_j^+\right)^2} \quad (8)$$

$$S_i^- = \sqrt{\sum_{j=1}^{n} \left(v_{ij} - v_j^-\right)^2}$$

Step 6: Calculate the closeness coefficients to the ideal solution for each project

$$C_i = \frac{S_i^-}{S_i^+ + S_i^-} \quad (9)$$

Step 7: Rank the projects based on Ci, as shown in Table 3 and 4.

3.4 Budget Plan Distribution

There are 3 main scopes of work: engineering, procurement, and construction. The budget distribution follows deterministic pattern from historical experience data and formulated backward from construction work target, Figure 1. In general, construction work is allocated 80% in the same year of construction, unless urgent, simple, or very mature project. The output of this budget plan distribution is a 5-years plan project list and subject for budget approval.

Project Type	Construction Year					Remarks
Project Type #1	1	2	3	4	5	
Engineering	100%					Simple, mature, Urgent
Procurement	100%					
Construction	100%					
Project Type #2	1	2	3	4	5	
Engineering	50%	50%				Simple, mature, normal
Procurement	45%	55%				
Construction	20%	80%				
Project Type #3	1	2	3	4	5	
Engineering	33%	33%	33%			Medium, Mature, Normal
Procurement	10%	35%	55%			
Construction		20%	80%			
Project Type #4	1	2	3	4	5	
Engineering	25%	25%	25%	25%		High/complex, less mature, multiple years
Procurement		10%	35%	55%		
Construction			20%	80%		
Project Type #5	1	2	3	4	5	
Engineering	20%	20%	20%	20%	20%	Complex, less mature, multiple years
Procurement			10%	35%	55%	
Construction				20%	80%	

Figure 1. Budget Plan Distribution

3.5 Sensitivity Analysis

Sensitivity analysis is carried out in order to see projects rank change, by modifying criteria's weight from low (5%), medium (10%), and high (>10%) as scenario 2-7; Critic weight as scenario 8, mean weight (uniform distributed) as scenario 9, and DM's preferences as scenario 10. Number of scenarios is same as number of criteria (Ghorabaee, Amiri and Zavadskas 2017). Spearman's rank correlation coefficient is used to measure the strength relationship between two variables: scenario 1 with original weight and each of scenario #2-#10. Original weight (#1) reflects the actual competition among projects, meanwhile, DM's preference weight represents intuitive actual approach that all criteria have the same importance. Additional comparison is ranked using EDAS and MOORA method. The interpretation of the value of the Spearman's rank correlation coefficient is presented in Figure 2.

Range of the Coefficient	Interpretation of Relationship
$\rho \geq 0.8$	The relationship is very strong
$0.6 \leq \rho < 0.8$	The relationship is strong
$0.4 \leq \rho < 0.6$	The relationship is moderate
$0.2 \leq \rho < 0.4$	The relationship is weak
$\rho < 0.2$	The relationship is very weak

Figure 2. Interpretation of Spearman's correlation coefficient, by (Poongavanam and Sivalingam 2021)

3.6 Project Prioritization

Project's rank is the best result of project selection using multiple criteria. Budget plan allocation represents the need of a certain amount of money each year. After the total budget is approved, then, the next is allocating budget under a simple procedure i.e., fully assign budget as its plan starting from the highest rank. There will be a cut-off, some project will not get assigned budget and will be re-submit next year, and if there is a remaining budget, there is two possibilities, assign partially to next project and/or readjust all allocations based on DM's preference.

4. RESULTS

4.1 MCDM Result.

Using Shannon's entropy to calculate criteria weight, financial has the highest weight, as shown in Table 2. Meanwhile both of safety criteria has nearly similar weight, and production fitness has relatively significant weight. It is in line with data that financial has spreading value comparing safety and maturity. Project rank is shown in Table 3. Comparing two highest TOPSIS ranks (project G and A) to the lowest two (C and E), based on project owner, project G and A are much easier than the lowest two. It indicates criteria used resulting feasible project's as final decision.

Table 2. Criteria weight

Safety		Financial						Maturity	
Risk	Delta Risk	Budget	NPV	EAB	IRR	PP	Tech	Proc	Prod
9.14%	8.62%	12.43%	15.56%	15.41%	13.36%	5.22%	0.73%	6.67%	12.87%

4.2 Sensitivity

Financial is the most influencing criteria base on scenario #2 to #7, however, changing criteria's weight to CRITIC's weight (#8) and referring to DM's preference weight (#10) result project's rank with strong rank coefficient, as shown in Table 3 and Figure 4. Comparing with EDAS

and MOORA, the rank is very consistent, strong relationship, Table 4. It indicates combination entropy and TOPSIS is robust to determine project's rank.

Table 3. Sensitivity analysis, Spearman Rank correlation

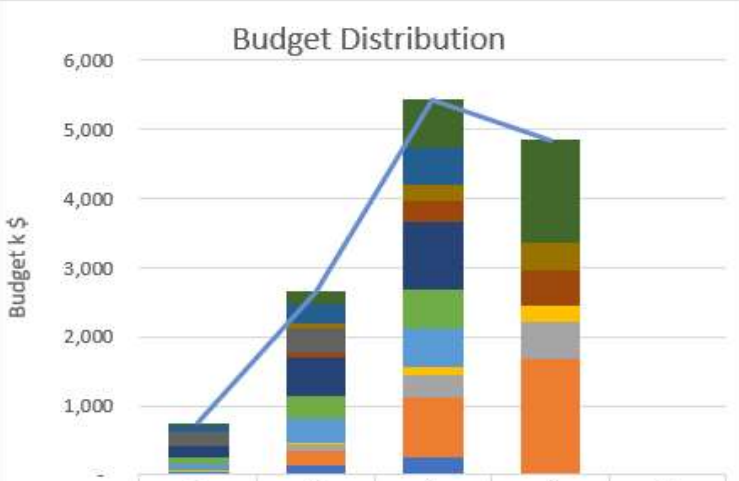
		#1	#2	#3	#4	#5	#6	#7	#8	#9	#10
1	A	2	2	9	3	2	2	7	2	2	2
2	B	7	9	7	8	10	9	8	10	10	10
3	C	12	12	4	1	5	12	1	9	5	7
4	D	5	5	1	7	8	4	2	3	6	6
5	E	11	8	2	9	12	8	4	7	8	9
6	F	4	4	5	5	6	5	6	5	7	5
7	G	1	1	3	2	1	1	5	1	1	1
8	H	9	7	6	4	4	7	3	6	3	4
9	I	3	3	10	6	3	3	10	4	4	3
10	J	8	10	12	11	9	10	12	12	11	11
11	K	6	6	8	10	7	6	9	8	9	8
12	L	10	11	11	12	11	11	11	11	12	12
	Coefficient Correlation	0.930	-0.03	0.32	0.66	0.92	-0.18	0.76	0.53	0.72	0.930

Table 4. Project Rank by TOPSIS, EDAS, MOOR

No	Project Code	TOPSIS	EDAS	MOORA
1	A	2	3	2
2	B	7	5	6
3	C	12	12	12
4	D	5	2	4
5	E	11	7	9
6	F	4	4	5
7	G	1	1	1
8	H	9	10	8
9	I	3	6	3
10	J	8	11	10
11	K	6	8	7
12	L	10	9	11
Spearman's correlation Coefficient			0.81 Very Strong	0.95 Very Strong

4.3 Budget Allocation

Budget allocation per year is gradually increasing aligned with project's life cycle. 5.5% allocation in first year is rationally fair due to mostly for engineering scope of work. 5-year distribution is as shown in Figure 3.



	1	2	3	4	5
C	38	176	694	1,491	-
E	77	291	526	-	-
L	4	69	239	391	-
H	215	339	-	-	-
J	5	84	301	517	-
B	165	550	985	-	-
K	94	334	570	-	-
D	96	340	564	-	-
F	7	29	112	239	-
I	3	93	323	521	-
A	11	216	866	1,687	-
G	38	137	252	-	-
Total	751	2,656	5,431	4,845	

Figure 3. 5-year Budget allocation

Prioritization projects is carried out under simulation. If approved budget is USD 700 thousand, meanwhile the budget plan year 1 required USD 751 thousand, there are two scenarios: (1) apply directly as project's rank, and (2) apply with tuning adjustment, as shown in Table 5. For those projects is partially allocated, the remaining will be added into year 2 budget plan.

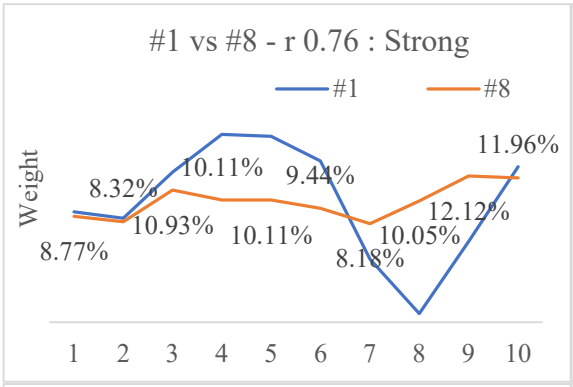
6. CONCLUSIONS

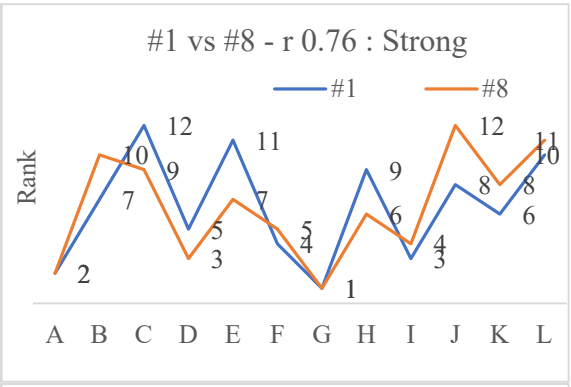
The simplicity usage of Shannon's and TOPSIS to rank projects, and deterministic budget allocation for prioritization, the results expose following points:

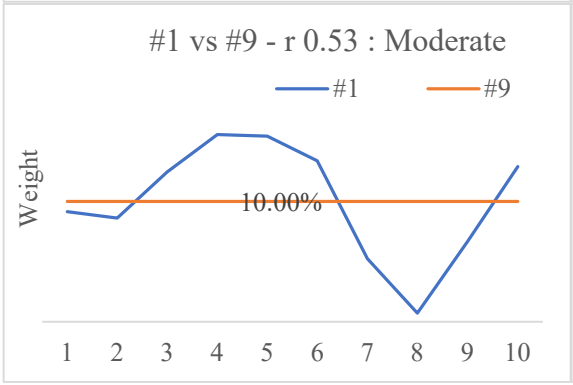
1. The use of the Shannon's and TOPSIS methods very suitable for the situation project selection with large number of projects, various types and complexity, and various project owners. It reduces complexity and saves time.
2. Project ranking is strongly influenced by the weight of the financial category. However, based on results, introducing maturity category as an assessment criterion, will help decision makers see the level of confidence to implement project so that achieve company objective. Safety, financial, and maturity indicate a proper combination criterion to select the best projects.
3. Allocation budget plan will help DM to prioritize projects based on its rank.

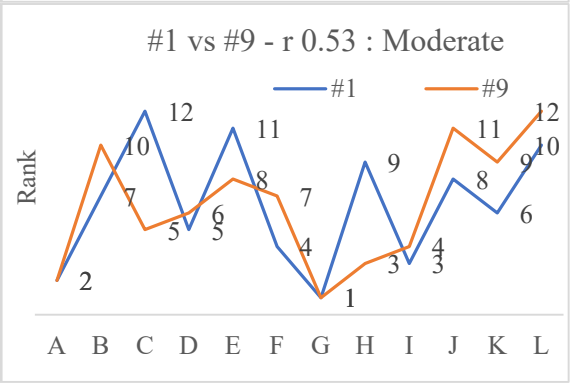
Table 5. Prioritizing Budget Simulation

No	Proj	Plan	Budget Allocated - 1	Budget Remaining	Remarks	Budget Allocated -2	Budget Remaining	Remarks
				700	Available Budget		700	Approved Budget
1	G	38	38	662		38	662	
2	A	11	11	651		11	651	
3	I	3	3	649		3	649	
4	F	7	7	642		7	642	
5	D	96	96	546		96	546	
6	K	94	94	453		94	453	
7	B	165	165	287		165	287	
8	J	5	5	282		5	282	
9	H	215	215	67		215	67	
10	L	4	4	64		4	64	
11	E	77	64		Partially allocated	26	0	Partially Alocated
12	C	38	-		Reschedule	38	26	
		751	700			700		









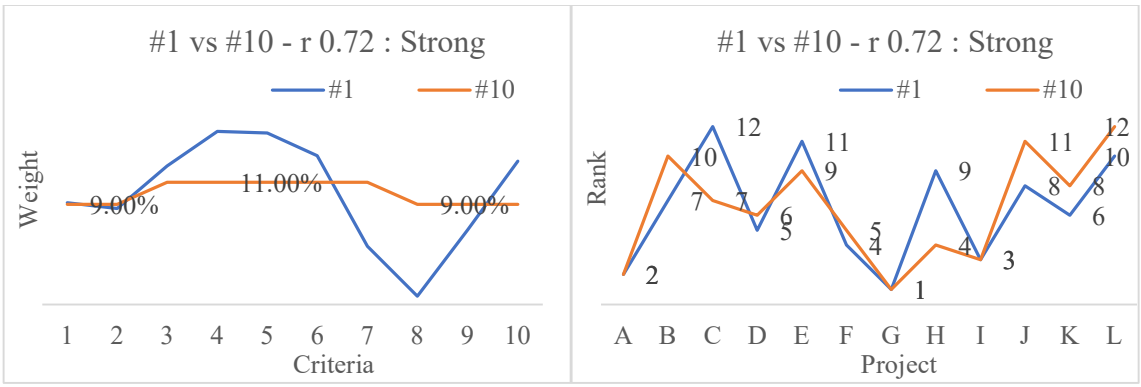


Figure 4. Sensitivity analysis scenario 8,9,10

REFERENCES

Alao, M.A, T.R Ayodele, A.S.O Ogunjuyibe, and O.M Popoola. 2020. "Multi-criteria decision based waste to energy technology selection using entropy-weighted TOPSIS techniques: The case study of Lagos, Nigeria." *Energy* (Elsevier).

Cheng & Chen. 2009. "A comprehensive model for selecting information system project under fuzzy environment." *International Journal of Project Management, 27* 389-399.

Feng, Jianghong, Su Xiu Xu, and Ming Li. 2021. "A Novel multi-criteria decision-making method for selecting the site of an electric-vehicle charging station from a sustainable perspective." *Sustainable Cities and Society* (Elsevier).

Ghorabaee, Mehdi Keshavarz, Maghsoud Amiri, and Kazimieras Edmundas Zavadskas. 2017. "Stochastic EDAS method for multi-criteria decision making with normally distributed data." *Jurnal of Intellegent and Fuzzy System 33* (IOS Press).

Hwan & Yoon. 1981. "Multiattribute decision making methods and applications." *Springer-Verlag, New York.*

Iamratanakul dkk. 2008. "Project portofolio selection : From past to present." *Proceeding of the 4th IEEE international conference on management of innovation and technology* 287-292.

Lee & Chang. 2018. "Comparative analysis of MCDM methods for ranking renewable energy source in Taiwan." *elseiver.*

Liberatore, MJ. 1987. "An extension of the analytic hiererchy process for industrial R&D project selection and resources allocation." *IEEE Transaction on Engineering Management 34* (IEEE Transaction on Engineering Management) 12-18.

Lotfi, Farhad Hosseinzadeh, and Reza Fallahnejad. 2010. "Imprecise Shannon's entropy and multi attibute decision making." *Entropy.*

M. Shakhsi-Niaei, Torabi, Iranmanesh. 2011. "A Comprehensive framework for project selection problem under uncertainty and real-world constraints." *Elsevier.*

Ma, Junfeng, James D. Harstvedt, Raed Jaradat, and Brian Smith. 2020. "Sustainability driven multi-criteria project portofolio selection under uncertain decision making environment." *Computer & Industrial Engineering.*

Ma, Jungfeng, James D. Harstvedt, and Brain Smith. 2020. "Sustainability driven multi-criteria project portofolio selection under uncertain decision-making environment." *Computer & Industrial Engineering 140.*

Mojtaba Ranjbar, Mohammad Mahadi Nasiri, S. Ali Torabi. 2021. “Multi-mode project portofolio selection and schedulling in a build-operate-transfer environment.” *Elsevier.*

Poongavanam, Ganeshkumar, and Vinothkumar Sivalingam. 2021. "Selection of the best refrigerant for replacing R134a in automobile air conditioning system using different MCDM methods: A comparative study." *Elsivier.*

Sadi. 2017. “A state of art survey on project selectin using MCDM techniques.”

Shannon, Claude E. 1948. "A Mathematical Theory of Communication." *The Bell System Technical Journal* Vol. 27: 379-423, 623-656.

Vajapeyam, Sriram. 2014. "Understanding Shannon's Entropy metric for Information."

Vijaykumar, S.R., P. Suresh, K. Sasikumar, K. Pasupathi, T. Yuvaraj, and D. Velmurugan. 2021. "Evaluation and selection of projects using hybrid MCDM technique under fuzzy environment based on financia factors." *Material Today : Proceedings.*

Xu, Zeshui. 2011. *Linguistic Decision Making : Theory and Methods.* Science Press Beijing; Springer.

Yazdani, Mortexa Yazdani, Ali Ebadi Torkayesh, and Ernesto Gonzxalez. 2020. "Evaluation of renewable energy resources using integrated Shannon Entorpy - EDAS model." *Elsevier.*

ANALYSIS REDUCTION NON REVENUE WATER (NRW) FOR MITIGATION WATER LOSSES USING ROOT CAUSE ANALYSIS METHOD

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ABSTRACT

Based on the technical data of Perumda Air Minum Tirta Sewakadarma in 2021, the level of Non Revenue Water (NRW) reached 40,43 %. It was recorded that in December 2021 the total production of Perumda Air Minum Tirta Sewakadarma reached 38,604,472 m3. Meanwhile, the recorded capacity distributed only reached 24,122,562.47 m3. This study will discuss the factors causing the level of Non-Revenue Water (NRW) and can be used as a reference for Perumda Air Minum Tirta Sewakadarma in policy making and planning programs to reduce the level of NRW in accordance with BPPSPAM instructions that every water treatment provider is obligated to secure SPAM with NRW levels below 25%. In connection with the above, research will be conducted to reduce the level of NRW to mitigate water loss using the Root Cause Analysis method.Based on the results of the analysis and discussion for the reduction of Non Revenue Water for mitigating water loss in Perumda Air Minum Tirta Sewakadarma Denpasar City, the conclusion obtained is that the main focus in reducing Non Revenue Water (NRW) is on physical water loss which is more dominant than non-revenue water loss. physical water loss as the biggest contributor to water loss in Perumda Airminum Tirta Sewakadarma with the contributors to water loss sequentially being physical water loss (21.83%), unbilled consumption (7.64%), unofficial consumption (6%), water meter inaccuracy and incorrect data input (4.09%), and unbilled metered consumption (0.03%).

Keywords: Water Treatment, Non Revenue Water (NRW), Root Cause Analysis

1. INTRODUCTION

Perumda Air Minum Tirta Sewakadarma as the operator of drinking water supply in the city of Denpasar, in addition to the conditions described above, also faces various challenges, such as limited raw water sources and leakage of drinking water distribution networks. In addition, the infrastructure also experienced a decline in function and equipment aging. In addition to age, pipe length also has the greatest influence on the level of pipe damage (Wang & Tarek, 2009). In

addition, pipe material, environmental conditions, as well as internal and external loads are the main factors causing pipe damage which results in leakage in the distribution network (Rezai, Bernadette, & Ivan, 2015), otherwise known as Non Revenue Water (NRW). The high value of Non Revenue Water (NRW), will result in losses, both for drinking water supply companies, and for the community as consumers (Directorate General of Human Settlements, 2018). And of course, this also has a larger economic and social impact (Shin, Choongnam, & Jayong, 2016).

Water loss can be divided into 2, namely physical and non-physical losses. Physical water loss is the loss of pressurized water, starting from the transmission and distribution process to the point of the water meter at the customer, or the loss of water contained in the distribution system which includes leaks of pipes, joints, fittings, or other accessories, leaks in the reservoir tank, overflowing water coming out of the reservoir or over flow, and inadequate open-drain or blow-offs systems. This water loss can be referred to as real losses. while non-physical loss is water loss that will result in loss of income for the water treatment system, including inaccurate water meters to unauthorized water use or illegal connection, so it is referred to as apparent losses, or calculations for all types of inaccuracies including meters production water and water meters to customers, plus illegal consumption or illegal of water.

Based on the Technical Data of Perumda Air Minum Tirta Sewakadarma in 2021, the level of Non Revenue Water (NRW) reached 40.43% according to the results of the BPKP audit. It was recorded that in December 2021 the total production of Perumda Air Minum Tirta Sewakadarma reached 38,604,472 m3. Meanwhile, the recorded capacity distributed only reached 24,122,562.47 m3. The service coverage of Perumda Air Minum Tirta Sewakadarma in every sub-district in Denpasar City has not exceeded 80%. Services in North Denpasar District only reached 79.07%, in West Denpasar it only reached 65.86%, in South Denpasar it only reached 57.05%, and in East Denpasar it only reached 76.94% (as of December 2021).

Therefore, the researcher views the importance of conducting research on the factors causing the high level of Non Revenue Water (NRW), where according to BPPSPAM instructions, that every drinking water provider is obliged to secure SPAM with an NRW level below 25%. Thus reducing NRW becomes a very important thing to do. NRW reduction can be done through reducing the level of water loss, and the main causes of water loss need to be known with certainty. The Root Cause Analysis (RCA) method is a structured evaluation method to identify the root cause of unexpected events and the steps needed to prevent the recurrence of unexpected events. So the Root Cause Analysis method is used to help find the cause of the high rate of water loss, so that the most effective strategy can be determined to overcome the existing problems to reduce NRW while increasing company efficiency.

2. LITERATURE REVIEW

A water treatment distribution system is a system built with the aim of delivering water from the source to the user (Walski, 2001). Sources of water or raw water can come from water in the ground or ground surface (rivers, lakes, reservoirs). To move water from the source to the user, a network of piping, pumps, valves and other equipment is needed. Storing water to meet fluctuations in water demand, fire fighting, and other storage facilities such as tanks or reservoirs are required. Piping systems, usually categorized into transmission and distribution systems. Transmission systems are usually used to move large amounts of water over long distances while distribution systems are used to deliver water to users.

Initially, the term used was Unaccounted for Water (UFW). The term Unaccounted for Water (UFW) has been widely used in the past. Simply put, UFW is also defined as Water Loss. No one has defined UFW in detail so that the understanding of drinking water actors regarding UFW is very broad and varied. The term UFW was later replaced by NRW, which is Non-Revenue Water or can be translated in Indonesian as Loss of Water. The definition of water loss is the difference between the amount of water supplied to the water pipe network and the amount of water consumed.

Loss of water in the distribution system (physical water loss), including leaks in pipes, joints, fittings, leaks in tanks and reservoirs, water spilling out of reservoirs, and inadequate open-drain or blow-off systems. These losses are referred to as real losses (Thornton, et al., 2008) or referred to as technical losses. Technical loss is understood as the physical loss of water from a pressurized system, up to the point of the customer's water meter. The annual loss volume based on all types of leaks, pipe breaks and overflows depends on the frequency, flowrate, and average duration of individual leaks. With a note, although the physical water loss that occurs after the customer's water meter is not included in the calculation of technical water loss, it is still significant, so it needs to be considered in managing water needs.

Non-physical losses, which result in loss of revenue for water management, including inaccurate metering to unauthorized or illegal use of water, this loss is referred to as apparent losses (Thornton et al., 2008) or commercial water losses. Commercial water loss is understood as a calculation for all types of inaccuracies including production water meters and customer water meters, plus unauthorized consumption (theft or illegal use of water). With a note, that the recording on the production water meter is lower than the actual one, and the recording on the customer's water meter is higher than the actual one, causing the calculation of water loss to be lower than the actual one. On the other hand, the recording on the production water meter is higher than the actual one, and the recording on the customer water meter is lower than the actual one, causing the calculation of water loss to be higher than the actual one.

Root Cause Analysis (RCA) is used to identify the root cause of the problem. RCA is a structured evaluation method to identify the root cause of unexpected events and the steps needed to prevent the recurrence of unexpected events. There are various structured evaluation methods to identify the root cause of a problem. Five popular methods for identifying the root cause of a problem (Jing, 2008), namely Is/Is Not Comparative, 5 Why Method, Fishbone Diagram, Cause and effect diagram, Root Cause Tree.

5 Why's is a problem solving technique used to get to the root of the problem. This technique has been applied to the Toyota Production System since the 1970s. According to Wedgwood (2006), this technique is used by asking questions about what causes a problem 5 times / class. Pareto chart is a tool used to identify and prioritize based on the order of the number of problems or causes that exist in the form of a bar graph. The Pareto diagram uses a main principle which reveals that eighty percent of problems that arise are caused by twenty percent of existing causes, so that by addressing only a few causes, most of the problems have been solved (Montgomery, 2005). Cause and effect diagrams are used to analyze problems and the factors that cause these problems. Thus the diagram can be used to explain the causes of a problem (Pyzdek, 2002). Failure Mode and Effect Analysis (FMEA) is a systematic approach that applies a tabular method to assist the thought process used by engineers to identify potential failure modes and their effects. Failure Mode and Effect Analysis (FMEA) is an engineering technique used to identify, prioritize, and remove potential problems from a system, design or process before the failure is identified by consumers (Stamatis, 2003).

3. METHODS

Data collection in the analysis of Non-Revenue Water (NRW) reduction for mitigating water loss using Root Cause Analysis is as follows: Reports from the Transmission & Distribution Section related to NRW and TKA starting from how many times there have been leaks, leaking pipe diameters, DMA monitoring reports, minimum night flow data, step test data for 4 months. Data on the use of 0-10 m3 in the Meter Reader Sub-Section regarding the number of damaged water meters, illegal connections and the use of drilled wells other than the use of water from Perumda Air Minum Water Tirta Sewakadarma for the last 4 months. Distributed water discharge data starting from the inlet of the transmission process until it is distributed for 4 months. From this data, the level of Non Revenue Water (NRW) is calculated at the Perumda Air Minum Tirta Sewakadarma. Next, make a water balance at Perumda Air Minum Tirta Sewakadarma.

At the data processing stage, the dominant cause of the problem was obtained from the high Non-Revenue Water in Perumda Air Minum Tirta Sewakadarma. This stage is a process of further analysis of results to find alternative solutions to existing problems. The method used is Cause and Effect diagram and Failure Mode & Effect Analysis (FMEA). The dominant cause of the problem of the high Non Revenue Water in Perumda Air Minum Tirta Sewakadarma was searched for the root cause by using the cause and effect diagram method. Identification of root causes is done through Focus Group Discussion (FGD). Conclusions and suggestions are the last stage of this research. At this stage, conclusions and suggestions are drawn from the results of data analysis and interpretation using the cause and effect diagram and FMEA methods. The conclusions drawn are in accordance with the objectives of this study, namely analyzing the factors that cause the high level of Non Revenue Water (NRW) at Perumda Air Minum Tirta Sewakadarma, analyzing solutions to reduce Non Revenue Water (NRW) at Perumda Air Minum Tirta Sewakadarma.

4. RESULTS

4.1 WATER BALANCE

From the data collection process, the data obtained are as follows: Non-physical water losses (commercial losses) are unofficial consumption plus meter inaccuracies and data handling. So the calculation of non-physical water loss in January-April 2022 for Perumda Air Minum Tirta Sewakadarma is 175,709 + 119,742 = 295,451 m3 / month. If it is converted into a percentage, it is 10.09%.

Physical water losses are the volume of water lost through all types of leaks, explosions, and overflows in pipes, service reservoirs, and so on. Calculation of physical water loss is water loss minus non-physical water loss. So the calculation of physical water loss in January-April 2022 for Perumda Air Minum Tirta Sewakadarma is 932,780 – 295,451 = 637,828 m3 / month. If it is converted into a percentage, it is 21.83%. The results of the calculation of the water balance of Perumda Air Minum Water Company Tirta Sewakadarma for the months of January-April 2022 are the starting point of reference in calculating the decrease in the percentage of water loss. The

current condition is the percentage of water loss is 39.59% with the composition of physical water loss is 21.83% and non-physical water loss is 17.76%.

Table 1. Water balance Perumda Air MinumTirta Sewakdarma

<table>
<tr><td rowspan="6">Volume Input Sistem</td><td rowspan="4">Konsumsi Resmi (68,08%)</td><td rowspan="2">Konsumsi resmi berekening (60,41%)</td><td>Konsumsi bermeter berekening (60,4%)</td><td>Air berekening (60,41%)</td></tr>
<tr><td>Konsumsi tak bermeter berekening (0,01%)</td></tr>
<tr><td rowspan="2">Konsumsi resmi tak berekening (7,67%)</td><td>Konsumsi bermeter tak berekening (0,03%)</td><td rowspan="4">Air tak berekening (39,59%)</td></tr>
<tr><td>Konsumsi tak bermeter tak berekening (7,64%)</td></tr>
<tr><td rowspan="3">Kehilangan Air (31,92%)</td><td rowspan="2">Kehilangan air non fisik (10,09%)</td><td>Konsumsi tak resmi (6%)</td></tr>
<tr><td>Ketidak akuratan meter dan salah input data (4,09%)</td></tr>
<tr><td colspan="2">Kehilangan air fisik (21,83%)</td></tr>
</table>

4.2 RATE OF DEFECT

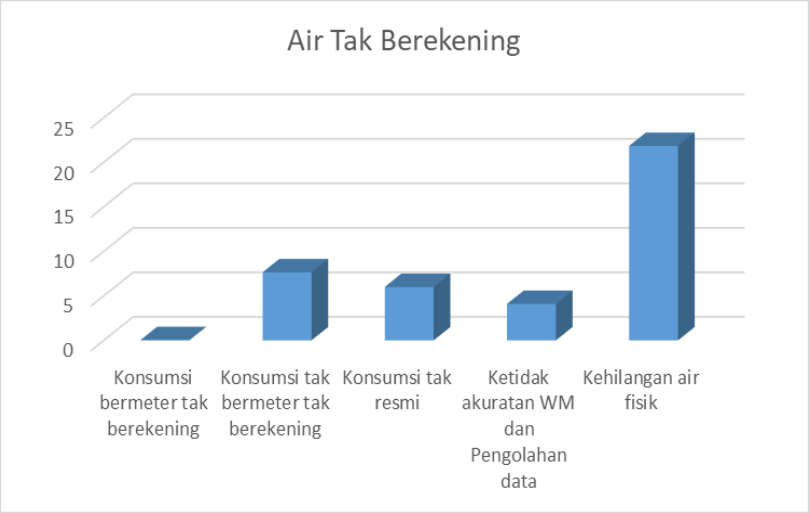


Figure 1. Rate Of Defect

Figure 1 show that the average defect in the distribution process, respectively, is physical water loss with a defect of 21.83%, for unmetered consumption without an account, the defect is

7.64%, for unofficial consumption there are defect is 6%, inaccuracy of WM and data processing is 4.09% and non-accounted metered consumption has defect of 0.03%.

4.3 PARETO CHART

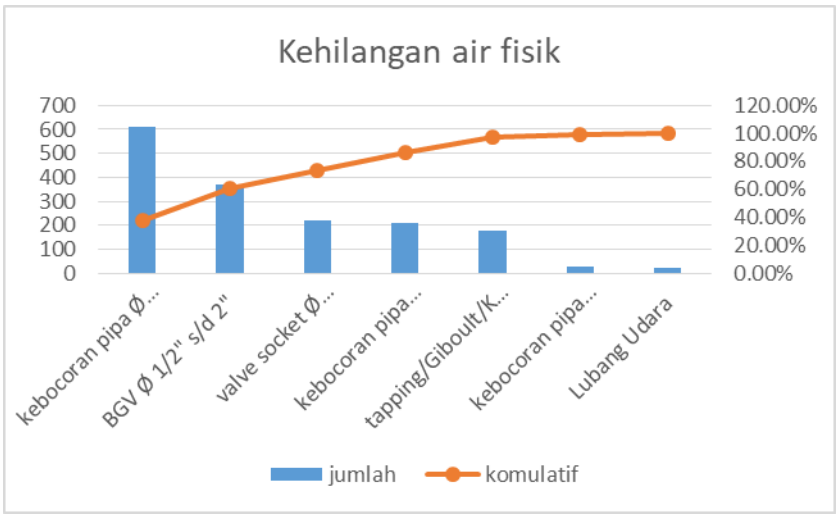


Figure 2. Pareto Chart Physical Losses

In Figure 2 above, it can be seen that the first dominant factor for physical water loss is pipe leakage 1/2" to 3/4" with a percentage value of 37.45%, the second factor is leakage caused by BGV 1/2" up to 2" with a percentage value of 22.77%, and the third is a leak in the valve socket 1/2" to 3" with a percentage value of 13.46%.

4.4 FISH BONE DIAGRAM

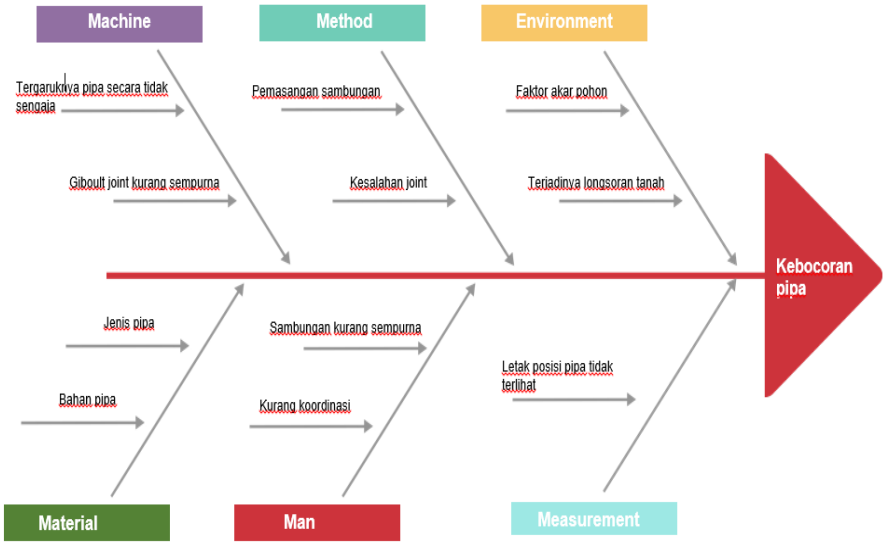


Figure 3. Fish Bone Diagram Pipe Leakage

The cause and effect diagram shown in the figure above shows that there are six main factors causing leakage in the pipe. The causes of leakage in the pipe if viewed from the material side are first, the type of pipe, the age of the pipe and the pipe material whether the pipe used is pipe ACP, GI, PVC or HDPE. According to the data in the field, it is stated that the pipes that often leak are ACP pipes that are old because they tend to break more quickly when high pressure is applied. Then the age of the pipe is also very influential because the old pipe breaks faster than the new pipe. For environmental factors that influence is the presence of tree roots and the occurrence of sudden or unpredictable landslides that can cause leaks in the pipes belonging to Perumda. The method factors that influence are errors or deviance in the installation of pipe connections such as imperfect joints or welding and the lack of sand bags on the bottom bearing of the pipe so that the pipe is easily broken due to the presence of rocks under the pipe. For measurement factors, one of the causes is the accidental scratching of the Perumda pipe due to the unknown location or position of the pipe because it is in the ground and it cannot be predicted. Meanwhile, the human factor is the lack of accuracy at the time of pipe installation, connection, and lack of coordination with third parties when it has to do with other city infrastructure works. Next is the engine factor that causes leakage is the pump setting or inline pump whose pressure is not in accordance with the type and material of the pipe because if it exceeds the threshold it can cause the pipe to burst.

4.5 FAILURE MODE AND EFFECT ANALYSIS

After the process of distributing water and the factors of water loss in Perumda Air Minum Tirta Sewakadarma mapped in the previous sub-chapter, the next step is to identify the factors that reduce water loss. The water loss identification process is carried out using Failure Mode Effect Analysis (FMEA). In this FMEA, the types of defects that occur will be identified and an assessment will be made of each form of defects that occur. The assessment given is based on pre-determined values and criteria. The assessment will result in the value of the Risk Potential Number (RPN). RPN is the product of severity, occurrence and detection. Severity is how big the impact on the system, occurrence is how often the activity occurs and detection is the probability of detecting a failure. In identifying failures in this process, it is done by conducting interviews with resource persons, direct observations and brainstorming. After getting the RPN value for each failure mode that occurs, then the RPN value will be sorted from the highest value to the lowest value. The RPN calculation shows the seriousness of a failure mode. This sorting is done to find out the sequence of the most serious failure modes, as a priority for making improvements. The following table 2 is a sequence of RPN values starting from the highest to the lowest.

Table 2. Table of RPN

No	Faktor Penyebab	RPN
1	Jenis, umur dan bahan pipa	448
2	Jenis, umur dan bahan fitting	448
3	disebabkan oleh akar pohon	392
4	tergaruknya pipa Perumda secara tidak sengaja	336

5	Fitting pipa ada yang berkerak atau mengkarat	192
6	Kurangnya koordinasi dengan pihak ketiga dalam pengembangan infrastruktur Kota	180
7	pasir masuk akibat kebocoran yang tidak terdeteksi	168
8	adanya longsoran tanah secara tidak terduga	144
9	pengakalan pemasangan sambungan atau joint	144
10	fluktuasi tekanan akibat jaringan tidak ideal	144

6. CONCLUSIONS

Based on the results of the analysis and discussion for the reduction of Non-Revenue Water for mitigating water loss in Perumda Air Minum Tirta Sewakadarma Denpasar City, the following conclusions are obtained:

The main focus in decreasing Non Revenue Water (NRW) is on physical water loss which is more dominant than non-physical water loss as the biggest contributor to water loss in Perumda Air Minum Tirta Sewakadarma.

Sequentially the contributors to water loss in sequence are physical water loss (21.83%), unbilled consumption (7.64%), unauthorized consumption (6%), inaccurate water meter and incorrect data input (4, 09%), and unbilled metered consumption (0.03%).

Overall from the analysis of water loss at Perumda Air Minum Tirta Sewakadarma Denpasar City caused by: Personnel/Man: deception carried out due to too many types and materials, both pipes and fittings and accessories so that joints, welding cannot be done perfectly due to differences in pipe types and accessories.

Material: the technical age of pipes, accessories and fittings has an impact on the level of water loss.

Methods: still using the manual method in terms of reading customers so that human error may occur as well as being a contributor to the level of water loss.

Machine: a water meter that is no longer functioning properly also results in the level of water loss for the Perumda Air Minum Tirta Sewakadarma.

Measurement: Infrequently calibrated tools lead to errors in readings and setting doses.

Environment: the presence of unexpected natural factors can also result in a level of water loss that is difficult to detect.

REFERENCES

Lim Jen Nee Jones, Daniel Kong, Boon Thong Tan and Puspavathy Rassiah (2021) *Non-Revenue Water in Malaysia: Influence of Water Distribution Pipe Types*

Upendo Paul,Shushu Hans,Charles Komakech, David Dodoo,Arhin David Ferras Mitthan LalKansal (2021). *Managing non-revenue water in Mwanza, Tanzania: A fast-growing sub-Saharan African city*

Rezai, H., Bernadette, R., & Ivan, S. (2015). *Pipe Faiure Analysis and Impact of Dynamic Hydraulic Condition in Water Supply Networks. Elsevier*

Shin, H., Choongnam, J., & Jayong, K. (2016). *Optimal Rehabilitation Model for Water Pipeline Systems With Generic Algorithm. Elsevier.*

Wang, Y., & Tarek, Z. (2009). *Prediction Model For ANnual Break Rates of Water Mains. Journal of Performance of Constructe Facilities*.

Farley, M., Wyeth, G., Ghazali, Z., Istandar, A., Singh, S. 2008. *The Managers Non Revenue Water Handbook: A Guide To Understanding Water Losses. USAID*

Ardiansyah, Juwono, P., & Ismoyo, M. (2012). *Analisa Kinerja Sistem Distribusi Air Bersih Pada PERUMDA Di Kota Ternate. Jurnal Teknik Pengairan 2*

Denik Sri Krisnayanti, I Made Udiana, dan Henry Jefrison Benu (2013). *Studi Perencanaan Pengembangan Penyediaan Air Bersih*

Sarungallo, Goberth Atto, & Wardhani, E. K. A. (2016). *Evaluasi Sistem Jaringan Distribusi Air Bersih di Kecamatan Pontianak Selatan Kota Pontianak Provinsi Kalimantan Barat. Jurnal Rekayasa Lingkungan, Jurnal Online Institut Teknologi Nasional*

Muhammad Rizky Syabani. (2016). *Penerapan Jaringan Distribusi Sistem District Meter Area (DMA) Dalam Optimalisasi Penurunan Kehilangan Air Fisik Ditinjau Dari Aspek Teknis Dan Finansial (Studi Kasus: Wilayah Layanan IPA Bengkuring PERUMDA Tirta Kencana Kota Samarinda)*

BPPSPAM (2021) *Laporan Kinerja Perumda Air Minum*

Perumda Air Minum Tirta Sewakadarma Kota Denpasar (2021*) Laporan Bagian Distribusi*

Perumda Air Minum Tirta Sewakadarma Kota Denpasar (2021*) Laporan Bagian Perencanaan Teknik*

Perumda Air Minum Tirta Sewakadarma Kota Denpasar (2021*) Laporan Bagian Hubungan Langganan*

Perumda Air Minum Tirta Sewakadarma Kota Denpasar (2019*) Rencana Bisnis Perumda Air Minum Tirta Sewakadarma Tahun 2019-2024*

ERP MODULE DESIGN AND IMPLEMENTATION OF INVENTORY AND WAREHOUSE IN THE MEDICAL INDUSTRY TO IMPROVE INVENTORY ACCURACY

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ABSTRACT

Enterprise Resource Planning (ERP) is an information system for companies in managing business processes. Manufacturing companies have various interrelated business processes, including manufacturing companies in the health sector. PT X as one of the medical device companies has problems in recording and processing data on inventory and warehouses, so the inventory accuracy value was low. In this study, a design and trial will be carried out to implement an ERP system in a medical device company. The research was conducted using the Rapid Application Deployment (RAD) method. The ERP system that will be used is Odoo 15 with a focus on inventory and warehouse modules and related modules, namely manufacturing, purchasing, and sales. There are many research designs and trials of ERP systems with Odoo, but with a focus on inventory and warehouse parts in the medical device industry, it is still very limited. It is hoped that this research can be used as a reference for medical device companies in increasing inventory accuracy and as a means of conducting discussions on the development of research on ERP systems using Odoo on the inventory and warehouse module in the medical device industry.

Keywords: Enterprise Resource Planning (ERP), Inventory, Medical Device, Odoo, Rapid Application Deployment (RAD), Warehouse

1. INTRODUCTION

Prayodya et al, (2017) suggested that Enterprise Resource Planning or what is usually abbreviated as ERP is a software needed by companies in managing business processes. Business process management is carried out by managing each input data into output in the form of information used by other related departments, one of which is used by management in making decisions. ERP systems can perform data integration starting from the purchase of raw materials to the delivery of finished goods to customers and various other processes. With ERP in a company, it will produce significant benefits for the company.

PT X is a company engaged in manufacturing, this company produces various kinds of medical equipment and facilities. This company has a business process that has been running since 1995 until now. Company X uses information systems, Microsoft Excel, and traditional methods in recording, inputting and processing its data. Traditional recording and using Microsoft Excel is the longest system used by company X, and each section also has data using its own Microsoft

Excel so that it can be linked to one another. This relationship makes users feel more understandable and comfortable using Microsoft Excel and traditional note-taking methods.

The available data between physical and recorded data, both traditional recording, Microsoft Excel, and using Information Systems have significant differences. Inaccurate inventory data resulted in the concerned department getting invalid information and affecting the manufacturing process and other processes. The assembly schedule that has been prepared by PPIC cannot be completed according to the schedule and also the predetermined plan, as presented in Table 1 which explains the differences in plans and realization of the assembly schedule from 2019 to 2021. The data in Table 1.1 shows that every year there is a gap between the plan (RC) and realization (RL) of the assembly schedule that has been prepared.

Table 1. Delays and Deviations in the 2019-2021 Assembly Schedule

No	Product	Assembly Plan And Realization					
		2019		2020		2021	
		RC	RL	RC	RL	RC	RL
1	Oxygen Concentrator	83	42	148	82	241	113
2	Pulse Oximeter	955	1.555	18.182	11.039	24.908	13.681
3	Electrocardiograph	936	616	823	660	3.221	331
4	Antropometri	3.238	2.851	1.872	1.142	13.049	15.959
5	Safety Goggle	0	0	500	732	25.034	29.838

In 2009 there was a study that showed ERP system design using Odoo 9. The research sector is the livestock industry using the ASAP (Accelerated SAP) method. The modules used in this research are Purchasing and Inventory modules. The results of the research conducted are that there is data integration that improves the management of inventory management (Hidayat et al, 2009).

Previous research has also been conducted in 2017, using Odoo 8 to implement it in the Garment manufacturing sector. The module used in this study is the warehouse module, with the research results obtained increasing work efficiency and data integration so that the company's business processes run more effectively (Prayodya et al, 2017). In addition, in 2019 there was also research in the chicken food management sector to model halal internal traceability using the Odoo ERP system. In this study, researchers used several modules in Odoo, including the inventory, warehouse, manufacturing, and purchase modules. The research was carried out in two stages, namely starting with modeling and continuing with trials. The results of this study indicate that the function and design of the system being tested can provide them with problem solving and is in accordance with the research objectives (Vanny, 2019).

The existence of integrated technology in the industry can increase the efficiency and effectiveness of employee performance twenty to fifty percent higher than before using technology (Minister of Industry, 2019). PT X requires an integrated system and can improve inventory accuracy, ERP can be a solution to PT X's problems, ERP implementation can make it easier to carry out material management in inventory and warehouse processes. Thus, this study will discuss the design and testing of an ERP system using Odoo 15 in the medical device manufacturing industry sector. The modules that will be used in this research are the inventory, manufacture, purchase, and sales modules. The method that will be used in this research is using the RAD (Rapid Application Deployment) method. It is hoped that this research can improve the

accuracy of PT X's inventory and be useful for filling the gaps in ERP system planning research using Odoo.

2. LITERATURE REVIEW

2.1 Inventory

The definition of inventory according to the Indonesian Institute of Accountants (IAI), inventory is (PSAK No. 14.1:2009):

1. Available for sale in the normal course of business
2. In production process or in transit
3. In the form of materials or equipment for use in the production process or in providing services

Inventory is also known as inventor, inventory has inventory control. Inventory control is an activity that has a close relationship with each other in every production process/operation of the company in accordance with the planned earlier time, quantity, quality, and cost. The purpose of inventory control is as an effort from the company to satisfy consumers by meeting needs quickly, maintaining the continuity of the production process so that the production process does not stop due to running out of inventory, and increasing company profits and sales. Inventory also has several types of inventory management classifications. the following is the inventory classification used by the company, among others (Lahu et al, 2017):

1. Raw material inventory
2. Maintenance/repair/operations supply inventory (MRO Inventory)
3. Inventory of semi-finished goods (work in process inventory)
4. Finished goods inventory

2.2 Warehouse

Warehouses have types that are grouped into several types. The division of the type of warehouse depends on the needs of a company (Inayanti, 2020). The following are the types of warehouses, namely:

1. Operational Warehouse
   Operational warehouse is a warehouse that has a close relationship with the production department. This warehouse performs storage for the needs of the production process. Storage carried out by this warehouse is raw material.
2. Equipment Warehouse
   Equipment warehouse is the same as operational warehouse, where this warehouse has a close relationship with the production department and the location of this warehouse is not far from the production location. The equipment warehouse stores work tools that help the process of running production activities. The contents of the equipment warehouse will not enter the finished goods product, because the goods stored are work tools. Borrowing of work tools is carried out when carrying out production activities, and is returned after production activities end.
3. Departure Warehouse
   The departure warehouse can also be referred to as the finished goods warehouse. In this warehouse there is a process of receiving goods from the assembly. Storage is done that is storing every finished goods received from the production. In this warehouse delivery can be made to customers in accordance with the order information obtained from the sale.
4. Seasonal Warehouse

Seasonal warehouses do the same job as all other warehouses, depending on conditions. This warehouse is a warehouse that is not always available, where this warehouse is not owned by the company, but is the result of rent. Seasonal warehouses exist when the company's warehouse is full and there is no place to store materials or goods.

2.3 Information System

Management Information Systems can also be referred to as MIS, where the word system here means the relationship between one unit and other units that are interconnected and cannot be separated. The units in the system have the same purpose, so that if one unit is disturbed, it will affect the work of the other units. In running the system, it is necessary to first understand unanimously about the integrity of the system, namely the input (input), the process of the system (process), and the output produced from the system (output) (Sugeng, 2008).

MIS has a main purpose in an organization, namely, as feedback or feedback. MIS acts as a monitoring tool, completing plans, and comparing the results of the plans that have been prepared for implementation. Organizations can provide feedback back based on the results of the feedback received from MIS. The understanding of the system indicates integration, but not all MISs show integration. Stand-Alone system shows a system that stands alone and has no connection or relationship with other parts or systems (Tyoso, 2016).

2.4 Enterprise Resource Planning

ERP has various kinds of software that can make it easier for companies to implement it. ERP software is available and widely circulated, so companies can easily use ERP. Although in practice there are still some companies who want to establish their own ERP software, according to the needs and business processes of the company. Each ERP software available has its own advantages and disadvantages, there are paid ERP software and some are open-source, here is a list of ERP software that is often used (Sumner, 2007):

1. Paid
    a. System Applications and Products in Data Processing (SAP)
    b. Oracle E-Business Suite (EBS)
    c. Maximo
    d. Microsoft Dynamics/Axapta
2. Open-Source
    a. Odoo/OpenERP
    b. Adempiere
    c. Idempiere
    d. Salesforce

MIS and ERP have significant differences in several aspects, visible differences in the system before using ERP (MIS) and after using ERP. There are nine aspects that affect MIS and ERP, namely information systems, coordination, databases, maintenance, display, information, system architecture, processes, and applications. Each aspect listed describes the implementation of MIS and ERP (Monk, 2013). Nine aspects that influence the difference between MIS and ERP are located in table 2.

Table 2. Difference between MIS and ERP

No	Aspect	MIS	ERP
1	Information Systems	Stand-Alone Systems	Integrated system

2	Coordination	Lack of coordination between related departments.	Supports inter-departmental and cross-sectional coordination.
3	Database	Data is not integrated, where each data has a different meaning and purpose.	Data are integrated with each other and have the same meaning and meaning in several functions and parts.
4	Maintenance	System maintenance is carried out bit by bit, the results received are inconsistent, and maintenance costs are expensive because it needs to be done repeatedly.	Maintenance is carried out as a whole, changes made have an impact on all parts of the system.
3	Appearance	Difficulty in managing display consistency across different systems.	The appearance is generally the same in every part of the system.
4	Information	Information redundant (repetitive) and inconsistent.	Have consistent and real-time information.
5	System Architecture	Unsophisticated system architecture.	Relying on the client server model.
6	Process	The processes that are executed are not in accordance with the business processes and may change or be inconsistent.	Consistent with business processes based on information models.
7	Application	Multiple separate applications.	One application for all business processes

2.9 Object Oriented Design Analysis

Object-oriented design analysis can use a model known as the Unified Modeling Language or also known as UML, which is a diagram that describes the process in the system. This diagram will be a visualization of the running of the system, the purpose of this diagram is to facilitate the design and documentation of a system. The system referred to here is the development of a software system based on Object Oriented Programming (OOP) (Agustin, 2020). The results of the UML diagrams used can be in the form of Use Case Diagrams (UCD) and activity diagrams.

2.9.1 Use Case Diagram (UCD)

Use Case Diagram or can also be referred to as UCD is a design that describes the visualization of interactions between actors or users with the system. This design will also show the access rights contained in the system. In UCD there are two important elements that must always be present, namely actor notation and Use Case (UC) notation. Each element has relations and interactions, relations can also occur between elements such as fellow actors and fellow UC. Actor is anything that interacts with the system, actors are described with the notation of a stickman. While UC is a system that interacts with actors, UC is described by ellipse notation. Each actor can interact with more than one UC, and vice versa one UC can be run by more than one actor (Kurniawan, 2018).

2.9.2 Activity Diagram

Activity Diagram is a technique that can describe business processes and workflows from various cases. Activity diagrams are different from flowcharts, where activity diagrams can run processes in parallel while flowcharts cannot be in parallel. This design does not describe the interaction between subsystems but only describes the flow of activities. The difference with the Use Case Diagram (UCD) is that the activity diagram designs the running process, while the UCD describes how the actors run the system (Hasugian et al, 2012).

2.9.3 Class Diagram

Class diagram is a model that is important in UML. Class diagram is a technique that can show how the schema of the architecture of the system is being designed. The content of the class diagram is that each class contains attributes and methods, each class will be connected according to the interactions it describes, thus the class diagram can describe the relationship between classes. The relationship between each class is depicted using a line without direction (arrow) which is called an association. The function of the class diagram is to create logical models of the system, making it easier for programmers to read in making programs or implementing systems that are already available (Aliman, 2021).

3. METHODS

The flow of this research is shown in Figure 1, the research flow starts from determining the theme to the conclusions obtained

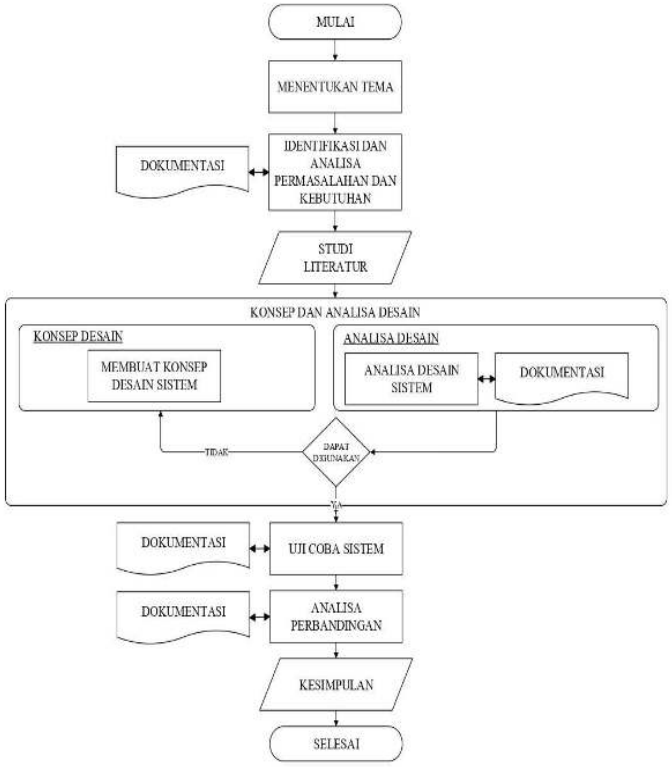


Figure 1. Research flow

The research method used in this study is the Rapid Application Deployment (RAD) method. Because this method is done by merging processes, then here what is done is the merging of the analysis and design processes. Researchers will develop a system design concept that will be applied during system testing. The system design concept that is compiled is adjusted to the results of data collection that has been done previously. The following are the stages of the system design process:

1. Use Case Diagrams (UCD)
   The first design stage is to design a UCD, in this design the researcher will describe the user's interaction with the system.
2. Activity Diagrams

At this stage, it will contain a functional description of the system that will explain each logical process and function process.

3. Class Diagram
4. At this stage, a design will be carried out that will explain the structure of the data required for the use of the system. In addition, this design also contains attributes, methods, and relationships or interactions that occur within the system. System design analysis

At the same time the researcher gives the results of the design by making a presentation at PT X. The results of this analysis will be used as material for application to the system to be tested. If the design results have been approved and can be used it will be applied to the system. The design that has been applied to the system at this stage is tested by the user directly by being observed by the relevant section managers and company leaders. And the last stage is the stage where the researcher compares the results of the system that has been designed with the previous process.

4. RESULTS

4.1 Analysis Current Process

In Figure 2 it can be seen that the inventory and warehouse recording process occurs in the inventory/storage of material goods and finished goods, where in that section each item will be entered to be recorded and stored and issued as well. The entry of material goods into the warehouse and inventory through the purchasing department who makes purchases from suppliers. Production carries out the assembly process based on the assembly schedule that has been prepared by PPIC and based on the Bill of Materials (BOM) that has been made by the technique. The results of the production are submitted to the finished goods warehouse for storage and recording of finished goods inventory. Sales ship units to customers through the finished goods warehouse. From the existing business processes, it shows that the modules that need to be designed and tested are processes that have a direct relationship with inventory recording. This study will design and test the inventory, manufacture, purchase, and sales modules to improve inventory accuracy.

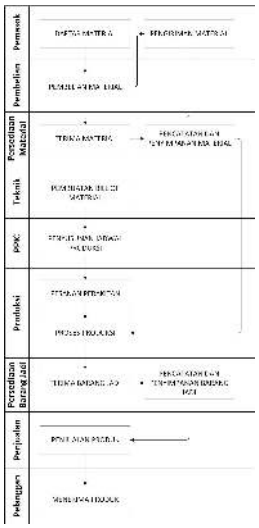


Figure 2. Business Process

4.2 ERP module Customization Design

The system design compiled in this study uses the UML model, namely Use Case Diagrams, Activity Diagrams, and Class Diagrams. Each model will be explained in detail. The current business processes have not been changed, but have been designed and tested on the Odoo ERP module to improve inventory accuracy.

The UCD design in Figure 3 depicts a number of inputs from six actors as direct users of PT X, namely as administrators, inventory admins, purchasing admins, productive admins, engineering admins, and sales admins. There are also actors who are the output, here there are actors from PT X, namely PPIC and apart from PT X, one actor as a supplier and another actor as a customer.

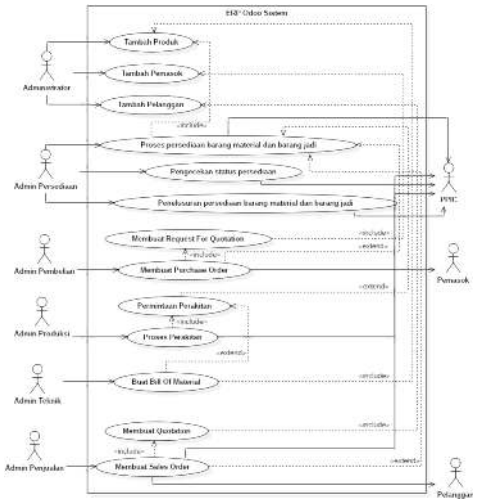


Figure 3. Use Case Diagram (UCD)

The ERP system flow design in this study is described using the UML model, namely the activity diagram. Figure 4 shows the activity diagram design from the beginning to the end of the process. The flow starts from inputting the product first, the inputted product can be a product that has a quantity or a product that is only limited to a catalog. The inventory and warehouse department will carry out inspections and records for each product inputted by the administrator.

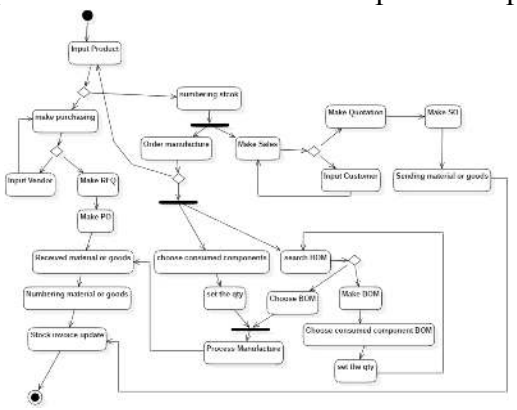


Figure 4. Activity Diagram

In this design, it can be seen that each process is integrated with each other and the identity of the product data becomes centralized so that it does not have a different identity and changes in reports or data that are not directly or in real time.

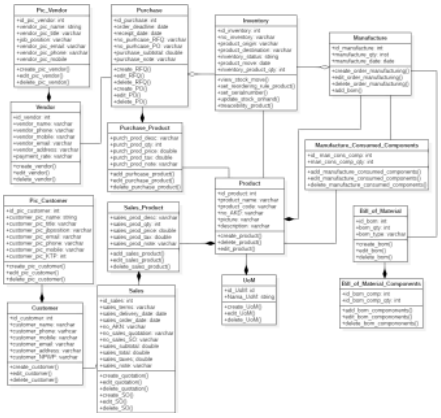


Figure 5. Class Diagram

The next design is displayed using a UML model, namely a class diagram. The class diagram displays every attribute, model, and relationship between classes in the system that is designed, namely in Figure 5. There are as many as 15 classes complete with attributes, models, and relationships between classes which are shown in Figure 5. The various classes start from product, sales, customer, purchasing, supplier, production, inventory, and other support classes. Each class has a different purpose and function so it cannot be combined into one with other classes.

4.3 Testing

Based on the flow design that has been prepared, there are three transaction processes that are related to the recording and accuracy of warehouse and inventory data. The related transaction processes are buying, assembling, and selling. In the process of purchasing the product name has been registered as shown in Figure 6 and it is confirmed by the administrator that there are no similar products and have the same product name.



Figure 6. Product List

The manufacturing process can run when using BOM or other additional materials, but in the process of selecting materials it is also necessary to have registered and not add their own data without going through verification from the administrator, as shown in Figure 7.

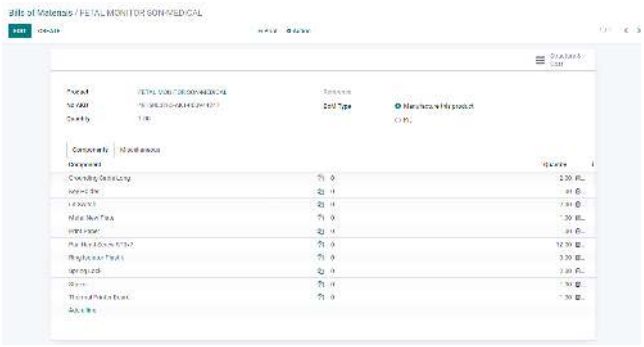


Figure 7. Bill Of Material

If the sales admin fills in the sales product that does not match the available data, it will get a display as shown in Figure 8. In the picture, a test is carried out to fill in the name of an unregistered product, namely "ASDASD", the user fails and cannot add the product.

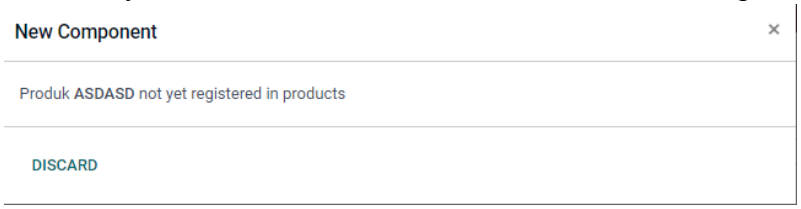


Figure 7. Failed to add data as admin

4.4 Comparative Analysis

Comparative analysis is needed to know the acceptable impact, in this study a comparative analysis was carried out on the conditions before testing the Odoo 15 ERP system based on the results of interviews and field observations with the conditions after testing the Odoo 15 ERP system based on the results of trials and interviews with test users. try the Odoo 15 ERP system, managers and company leaders.

Table 3. Comparative analysis before and after system testingTitle of table 1

Indicator	Before	After
System Integration	(-) There is no system that can perform data integration. (-) Each section still uses a different system so that the data needed is not integrated.	(+) The process of buying to selling has been integrated, especially in product inventory. (-) Not all departments use this system, so there are sections that have to do more and more work at once because they input as much as the system used.
Reliability	(+) Every feature in each system works well, but there are more limitations.	(+) Every feature used can function well, even exceeding the imagined expectations.
Ease of use	(+) Very easy to use because it does not require a variety of processes.	(+) Easy to use and the rules are appropriate so there is no need to understand the new system, just move the process.

		(-) For initial use, assistance needs to be done many times, especially in the inventory, product, and production sections.
Security	(-) There is no data security on any data user.	(+) Core data can only be accessed by users who have been assigned tasks, so data cannot be added, changed, and deleted by other parties.
Information accuracy	(-) is not accurate and cannot be used as material for making decisions.	(+) The existing data in the system has a high level of accuracy because data processing is only allowed for available data, the possibility of duplicate or incorrect data is reduced.
Complete Information	(-) Information is incomplete because it is fragmentary and inaccurate.	(+) The information provided is complete, where each module is interconnected and completes the required information automatically from the system.
Decision making	(-) could not make a decision due to inaccurate data.	(+) Can make decisions quickly and precisely because the data is accurate and there are further calculations (forecasting).

6. CONCLUSIONS

Based on the research results listed in the previous chapter, the conclusion that can be drawn from this research is "The Odoo 15 ERP system on the inventory and warehouse module can improve inventory accuracy". In achieving problem solving and research objectives, there are several notes obtained, including:

1. The design of the business processes that are currently running in the company can be applied to the Odoo ERP system.
2. In testing the ERP system to improve inventory accuracy, it requires the involvement and relationships of other modules besides the inventory module. The modules used in this research are inventory, manufacture, purchase, and sales.
3. By using the Odoo 15 ERP system, data between inventory and other related parts is integrated with each other, transaction processing is faster, and the data available on the system physically does not have gaps.

REFERENCES

Agustin, C. and Yusuf, F.R. (2020), Web-Based Human Resource Development Information System Using the ODOO Framework at PT, Nuro Intelia Prospera Jakarta, *Journal of Informatics and Computers (INFOKOM)*, Piksi Ganesha Polytechnic, Bandung, 13-24.

Aliman, W. (2021), Software Design for Drawing Diagrams Based on Android, *Syntax Literate: Indonesian Scientific Journal*, Bandung, 6(6), 3091-3098.

Hidayat, A.S., Saedudin, RD. R. and Witjaksono, W. (2016), Design ERP System With Purchasing and Inventory Module Based Odoo 9 Using ASAP Method At PT Aretha Nusantara Farm, *e-proceeding of engineering*, Bandung, 3483-3490.

Inayanti, A. (2020), The Process of Receiving and Storing Imported CKD (Completely Knock Down) Component Parts in the Warehouse Section at PT. Astra Honda Motor, *Final Thesis Report*, Indonesian College of Economics, Jakarta.

Kurniawan, T.A. (2018), Use Case Modeling (UML): Evaluation of Some Errors in Practice, *Journal of Information Technology and Computer Science (JTIIK)*, Universitas Brawijaya, Malang, 5(1), 77-86.

Lahu, E.P. and Sumarauw, J.S.B. (2017), Analysis of Raw Material Inventory Control to Minimize Inventory Cost On Dunkin Donuts Manado, *EMBA Journal*, Manado, 5(3), 4175-4184.

Monk, E., and Wagner, B. (2013), *Concepts in enterprise resource planning (4th ed.)*, Course Technology: Thomson Learning, Australia.

Prayodya, A.C. and Rinawati, D.I (2017), Implementation of Odoo 8 ERP Software at Warehouse PT Apparel One Indonesia Semarang, *Industrial Engineering Online Journal*, 6(2).

Sugeng, A.P. and Gaol, C.J.L. (2008), *Management Information Systems: Understanding and Application*, Jakarta: Grasindo, 2008, Indonesia.

Sumner. M. (2007), *Enterprise resource planning (1 ed.)*, Pearson Education, United States of America.

Tyoso, J.S.P. (2016), *Management Information System*, Depublish, Jl Rajawali, Yogyakarta, Indonesia.

Vanany, I., Maftuhah, D.I., Soeprijanto, A., Sukoso., and Zulhafizh. (2019), Modelling Halal Internal Traceability in Open Source ERP System for Chicken Meat Processing Company, *2019 IEEE International Conference on Industrial Engineering and Engineering Management (IEEM)*, 1017-1021.

FACTORS ANALYSIS FOR PREVENTING THE SPREAD OF COVID-19 EXPOSURE ON CONSTRUCTION WORKERS

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ABSTRACT

The construction sector involves many workers who are at risk of being exposed to Covid-19. The mobility of construction workers moving from one project to another is very dynamic, making them vulnerable to the health risk of being infected with Covid-19. Construction workers exposed to COVID-19 during the construction of the Vocational Faculty Building in Yogyakarta totaled 4 people who were handled according to the Covid-19 protocol. the effect of Covid-19 on the exposure of construction workers. The research design is a literature review that critically reviews the knowledge, ideas or findings contained in the body of academically oriented literature, and formulates its theoretical and methodological contributions to the exposure of construction workers consisting of Project Owners, Construction Companies and OHS Supervisory Consultants. Based on the results of the analysis, there are factors to prevent the spread of Covid-19, namely knowledge factors, compliance factors, awareness factors, personal protective equipment factors, control factors to exposure factors.

Keywords: Covid-19, Protocol, Construction, Control, Exposure

1. INTRODUCTION

The construction sector involves many workers who are at risk of being exposed to Covid-19. The mobility of construction workers moving from one project to another is very dynamic, making them vulnerable to the health risk of being infected with Covid-19. Since 2020, the Ministry of Health and the Ministry of Public Works and Public Housing have issued protocol policies to prevent the spread of the Covid-19 pandemic in the construction sector. Construction workers exposed to COVID-19 during the construction of the Vocational Faculty Building in Yogyakarta totaled 4 people who were handled according to the Covid-19 protocol. Everyone is facing tremendous difficulties due to the Covid-19 coronavirus outbreak. The virus pandemic is causing a big catastrophe today, not because of death, but related to social, economic, cultural, political and other aspects Anies (2021). WHO declared Covid-19 a pandemic on March 11, 2020. The President of Indonesia officially announced that two residents had contracted the Corona virus on March 2, 2020 at Jakarta CNBC (2020). The Large-Scale Social Restriction Policy (PSBB) has changed people's daily lives, because all activities that are usually carried out outside the home become at home. The impact of the Covid-19 pandemic can be divided into 3 construction phases, namely the planning phase, the implementation phase and the operational phase. Where the construction implementation phase is the most impactful, which is 55% Sihombing (2020). According to Araya (2020), workers in a construction project can experience Covid-19 transmission by 30% to 90%. The simulation that has been carried out by Araya, it also provides

information that the mobility of construction workers from one project to another is very dynamic so they are vulnerable to health risks of being infected with Covid-19. The implications of Covid-19 on construction are twofold, namely, on the one hand, work is stopped or changed and new projects are temporarily suspended, then construction practices begin to adapt to new ways of carrying out work Stiles et al. (2021).

The current state of Indonesia's construction services based on the Indonesian Construction Indicators BPS (2022) that the Permanent Worker Index for the fourth quarter of 2021 grew by 1.55 percent compared to the fourth quarter of 2020 and quarterly growth in the Permanent Worker Index also accelerated from 0.16 percent in the fourth quarter in 2020 to 0.30 percent in the fourth quarter of 2021. The index of Permanent Workers in the fourth quarter of 2020 is 106.63 and in 2021 it is 108.28. The People's Day Index for the fourth quarter of 2021 grew by 3.63 percent compared to the same period last year. There was also acceleration in growth from 0.97 percent (Quarter IV-2020) to 1.80 percent (Quarter IV-2021). The People's Day Index for the fourth quarter of 2020 is 119.10 and 123.43 in 2021. So the construction services sector is experiencing positive growth even though this sector involves many construction workers who are at risk of Covid-19. The government made a policy that construction work in supporting the country's economy must continue to run side by side with the Covid-19 pandemic, from this until now the construction sector has become an exception to the rules of Large-Scale Social Restrictions (PSBB). The influence of effectiveness of the implementation of the applicable health protocols in the construction sector by implementing the Instruction of the Minister of PUPR No. 2 of 2020, it is necessary to know the number of construction workers exposed to Covid-19 related to danger of not complying with health protocol Fuad (2021). The occurrence of wider spread, increasing severity, mortality, transmission modalities, diagnostics, treatment and management, and lack of self-awareness to administer vaccines greatly affect the risk of disease occurrence in construction projects during a pandemic Covid-19. Thus, the successful implementation of the protocol to prevent the spread of Covid 19, it is necessary to conduct research on the analysis of factors that influence the implementation of the protocol to prevent the spread of Covid-19 in the construction sector on the exposure of workers in the construction sector.

2. LITERATURE REVIEW

Covid-19 (Corona Virus Disease-2019) is the name of the disease caused by the corona virus and is officially approved by the WHO (World Health Organization). Covid-19 is caused by the corona virus attacking the respiratory tract which causes fever, flu, high fever, cough, shortness of breath and sore throat Anand et al. (2020). Corona viruses are a large family of viruses that cause disease in both animals and humans. Diseases arising from COVID-19, which are more severe, such as Middle East Respiratory Syndrome (MERS), and Severe Acute Respiratory Syndrome (SARS). This virus causes people to lose their lives so that WHO has made the status of this corona virus a pandemic Logunov et al. (2020). The health protocol policy that applies in the construction sector is regulated in the Instruction of the Minister of Public Works and Housing Number 02/IN/M/2020. The policy regulates the Protocol Mechanism for the Prevention of the Spread of Covid19 in the Implementation of Construction Services as shown in figure 1 as follows.



Figure 1. Mechanism of the Covid-19 Protocol
Source: Instruction of the Minister of Public Works and Housing Number 02/IN/M/2020.

Covid 19 Health Protocol

The community must be able to carry out activities in the COVID-19 pandemic situation by adapting to new habits that are healthier, cleaner, and more obedient, which are carried out by all components in the community and empower all existing resources. The role of the community in being able to break the chain of transmission of COVID-19 (risk of contracting and transmitting) must be carried out by implementing Health protocols. To increase the effectiveness of the implementation of the Covid 19 Protocol in the construction sector, it is influenced by factors. Information can be provided through brochures/posters, outreach and training. Research conducted by Adiwibowo (2020) proves that K3 (Construction Occupational Safety and Health) communication through posters and brochures is effective in preventing the transmission of COVID-19. Socialization is one way to increase the knowledge of construction workers for occupational safety and health Suryan et al. (2020). Labor compliance in using personal protective equipment (PPE) in the workplace Luthfiyah (2019). Factors that affect compliance with the use of infrastructure is convenience. Workers need to be aware of the dangers of COVID-19 with new approaches and methods that are more intensive and comprehensive considering there is a tendency for many people in Indonesia to think that this pandemic has subsided. Adaptation of new habits to prevent virus transmission needs to be socialized, facilitated, and implemented in an effective and sustainable manner Mardiasmo (2020).

New adaptation of work in the construction work environment Nugraheni (2021) that the technical engineering supervision at a high risk level with an important/emergency nature of work, extra control measures are needed, administrative control, educating workers to be aware of the dangers of exposure to the COVID-19 virus is very necessary to use More protective Personal Protective Equipment. New adaptation of work in the construction work environment Nugraheni, (2021) technical engineering supervision at a high risk level with an important/emergency nature of work, extra control measures are needed, administrative control, educating workers to be aware of the dangers of exposure to the COVID-19 virus is very necessary to use More protective Personal Protective Equipment. Therefore, the factors that influence the implementation of the Covid 19 Protocol are as follows:

2.1 Knowledge

The analysis showed that the delivery of the discussion was running effectively as indicated by a positive and significant increase in knowledge on the variables of masks, social distancing and washing hands with soap. As Pawitra (2021) states that it can be concluded that by

providing intensive information and through light discussions, workers will better understand the pandemic conditions and will play a role in breaking the chain of transmission of COVID-19. Information can be provided through brochures/posters, outreach and training as a research conducted by Adi wibowo (2020) proves that K3 communication through posters and brochures is effective in preventing the transmission of COVID-19. Socialization is one way to increase the understanding of construction workers for occupational safety and health Suryan et al. (2020). This is also supported by research conducted by Pattisinai et al. (2020) socialization and education from the company greatly affect worker discipline in implementing K3 and implementing health protocols in the midst of the COVID-19 outbreak. Training needs to be done for safety measures in construction programs. Research conducted by Othman et al. (2019) explains that training is a factor that influences success in implementing safety on construction projects. This is in accordance with the research conducted by Fertilia (2020) which also proves that the awareness of the workforce towards work safety affects the implementation of K3 management.

2.2 Compliance

Labor compliance in using personal protective equipment (PPE) in the workplace is the comfort of PPE Luthfiyah (2019). Factors that affect compliance with the use of infrastructure is convenience. Research conducted by Saputri & Paskarini (2014) says that the factors that influence the compliance of construction workers in the use of PPE are age, knowledge, sanctions and encouragement from coworkers. This is also supported by research conducted by Dyanita (2017) which says that knowledge and communication are important factors that affect compliance with the use of PPE. Service providers need to raise awareness of the workforce so that they always use infrastructure while working through an individual approach by K3 officers and companies need to implement a reward policy for the use of personal protective infrastructure, so that workers are motivated to use personal protective equipment. Improving compliance with health protocols through more effective risk communication is to convey information widely with evidence, friendly to the diversity of society and improving the critical thinking and involve role models and communicate risks effectively. Improve community-based education and campaigns by involving community leaders and experts with examples of non-discriminatory actions and attitudes of workers. It is delivering a message against COVID-19 is a joint effort in a collective unity that depends on the compliance of the workers themselves.

2.3 Awareness

Workers need to be made aware of the dangers of COVID-19 with new approaches and methods that are more intensive and comprehensive considering there is a tendency for many people in Indonesia to think that this pandemic has subsided. Adaptation of new habits to prevent virus transmission needs to be socialized, facilitated, and implemented in an effective and sustainable manner Mardiasmo (2020). Research conducted by Buniya et al. (2021) prove that a lack of safety awareness is a barrier to the implementation of safety programs in construction projects. Research conducted by Fertilia (2020) also proves that workforce awareness of work safety affects the implementation of K3 (Construction Occupational Safety and Health) management.

2.4 Personal Protective Equipment

The new adaptation of work in the construction work environment according to Nugraheni (2021) that engineering engineering supervision at a high risk level with an important/emergency nature of work, extra control measures are needed, administrative control, educating workers to be

self-reliant with the danger of exposure to the COVID-19 virus is very necessary use of more protective Personal Protective Equipment (PPE). In addition to the use of PPE, management is also encouraged to pay attention to the health and immunity of workers. This can be done by providing the construction workers with nutritious food or multivitamins at least once a week. So protein and worker nutrition must be considered.

2.5 Control

All work leaders must go down to supervise the field to ensure that preventive facilities and infrastructure for personal protective equipment (thermal scanners, masks, gloves, sanitizers, and others) are met for workers. For the purposes of facilities and infrastructure to prevent the spread of COVID-19 such as masks, hand-sanitizers, gloves, thermal scanners, vitamins/supplements, it is important that the leadership optimizes the existing budget in each work unit, namely the procurement account for medicines and immune boosters. If there is no budget available in the account, please revise the operational instructions for activities from other operational expenditure accounts that are not absorbed according to the 'let the manager manage' principle while still paying attention to accountability. Service providers mostly bear the additional costs of implementing the COVID-19 protocol. Contractors have the highest responsibility and role in preventing the spread of the Corona virus in the field. Therefore, to answer the challenges required a reliable human resources and finance. in accordance with the knowledge, compliance, and awareness of the need for the COVID-19 Prevention Task Force to ensure that health protocols can be implemented properly so that construction projects do not become clusters of the spread of the Corona virus. On the other hand, for the cost of handling the COVID-19 protocol, a contract addendum can be made through the minutes of agreeing on additional costs for handling the COVID-19 protocol.

2.6 Exposure

Based on a scientific study by Ashley, et. al. (2021) that workers have a three times greater risk of being infected with Covid-19 even though they are in a country with a good Covid-19 control process. According to the Data Monitoring and Evaluation Sub-Sector Team (Covid-19 Task Force National Disaster Management Agency (BNPB), the factors that affect health workers so that they are easily infected with Covid-19 can even lead to death including : excessive/long working hours and excessive workload with the number of patients who tend to continue to increase (working overload), have a history of comorbid or comorbid diseases, stress, and obesity.

3. METHODS

The design of this research is literature review, which is research that examines or critically reviews knowledge, ideas, or findings contained in the body of academically oriented literature, and formulates theoretical and methodological contributions to certain topics Cooper (2010). This research will be done by literature review regarding on the factors that can prevent the covid-19 spread specificly in construction project. The literature review will be done based on previous research that have been conducted by other researcher.

4. RESULTS

Knowledge is information that has been combined with understanding and the potential to act which then sticks in one's mind. In general, knowledge has the predictive ability of something as a result of recognizing a pattern. While information and information data are only capable of

informing or even causing confusion, then knowledge is capable of directing action. This is called the potential to act and knowledge increases the will of the workforce.

Table 1. Indicators of Knowledge Variables

Variable	Indicators	Sources
Knowledge	Workers understand that COVID-19 is a respiratory tract infection that can spread through droplets from the mouth or nose.	Pawira (2021) Adiwibowo (2020); Pattisuari (2020); Instruction of the Minister of Public Works and Housing Number 02/IN/M/2020.
	Workers understand the health protocol procedures, namely the rules & regulations to maintain normal activities during the COVID-19 pandemic.	
	Workers understand the importance of maintaining health protocols that aim to reduce the transmission rate of COVID-19.	
	Workers carry out the recommendations of the COVID-19 Task Force in the form of maintaining distance, wearing masks & washing hands.	
	Workers apply health protocols both inside and outside the work environment.	

Compliance to health protocols, namely wearing masks, washing hands, using hand sanitizer, maintaining physical distance, and avoiding crowds are the keys to preventing the pandemic situation from worsening. However Sekarasih (2020), factually, it appears that many community members ignore health protocols, especially when restrictions are starting to be relaxed and the adaptation of new habits is increasingly being campaigned.

Table 2. Indicators of Compliance Variables

Variable	Indicators	Sources
Compliance	Carry out spraying disinfectant for construction workers when entering/exiting the project area.	Saputri (2014); Luthfiyah (2019); Tim Tanggap UI (2020); Instruction of the Minister of Public Works and Housing Number 02/IN/M/2020
	Carrying out spraying disinfectants on project workers' belongings from outside the project area.	
	Carry out periodic SWAB/ANTIGEN tests for project workers.	
	Carry out body temperature measurements to all project workers every morning, afternoon, and evening.	
	Prohibit project workers and guests from entering the project area if indicated to have a body temperature of 38 degrees Celsius.	
	Medical officers assisted by the Security Unit have sprayed disinfectant on every project facility and work equipment.	
	Has a special room for project guests.	
	Spraying on new equipment that will enter the area proyek.	
	There is a Task Force for Preventing the Spread of COVID-19 in the project area.	
	There are at least 5 personnel of the COVID-19 Prevention Task Force in the project area.	
	The COVID-19 Prevention Task Force conducts periodic socialization about COVID-19.	
	The COVID-19 Prevention Task Force regularly identifies potential COVID-19 hazards in the area.	
	The COVID-19 Prevention Task Force conducts tracing and inspections of project workers departing/returning from overseas.	

Variable	Indicators	Sources
	The COVID-19 Prevention Task Force applies emergency procedures to project workers who are indicated to be positive for COVID-19.	
	The COVID-19 Prevention Task Force implements emergency procedures in the project area when there are project workers who are indicated to be positive for COVID-19.	
	The Project Party disinfects according to protocol for guests who come to the project	
	The project party cooperates with service providers for operational health protection and prevention of COVID-19 in case of force majeure.	
	The COVID-19 Prevention Task Force together with medical officers conduct socialization of COVID-19 prevention techniques in every morning K3 (Construction Occupational Safety and Health) counseling activity (safety morning talk).	
	The Project provides PPE for guests who come to work sites both in the Office and in the Field	

Awareness Research conducted by Al Shabbani et al. (2020) proves that increasing awareness of occupational safety and health can be done by providing knowledge before starting to do work. The policy recommendation is to improve risk communication that is more effective and friendly to the diversity of the community in order to increase the critical awareness of the community through the involvement of leaders at various levels. And also increase community-based counseling and education that prioritizes local wisdom and strengthens the capacity of health workers to provide education through testimonials from stories and experiences of colleagues on the front lines as COVID-19 survivors.

Table 3. Indicators of Awareness Variables

Variable	Indicators	Sources
Awareness	All workers apply 3M (Wearing masks, Washing hands, Keeping distance).	Bumiya (2021); Fertiha (2020); Al Shabani(2020); Instruction of the Minister of Public Works and Housing Number 02/IN/M/2020
	Workers who do not comply with health protocols have an effect on other workers not to comply as well.	
	The conditions and types of work carried out affect the desire not to use masks or other personal protective equipment.	
	Workers are accustomed to providing information to the K3 if there are workers who do not apply health protocols.	
	Project workers provide information to K3 parties if there are workers who do not apply health protocols.	

The research also suggests that construction service providers are required to provide infrastructure to prevent the transmission of COVID-19 to workers, namely vaccines, vitamins and additional nutrients to increase work immunity Sari (2021). Although most construction projects are still running in the era of the COVID-19 pandemic, it has a significant impact on the implementation of construction contracts Larasati (2021).

Table 4. Indicators of Personal Protective Equipment Variables

Variable	Indicators	Sources
	Personal Protective Equipment is equipment to minimize exposure to serious accidents and prevent occupational diseases	

Variable	Indicators	Sources
Personal Protective Equipment	If there are workers who are exposed to COVID-19, the company conducts a swab test on the people who interact with the workers.	Nugraha (2021); Tim Tanggap UI (2020); Instruction of the Minister of Public Works and Housing Number 02/IN/M/2020
	The company provides a special room for guests from outside the project.	
	The installation of digital and physical posters about COVID-19 prevention recommendations can affect workers' habits in complying with health protocols.	
	The company provides health facilities in the form of hand washing facilities, hand sanitizers, vaccines, and vitamins for project workers.	
	Personal Protective Equipment as a barrier between construction workers and the work environment.	
	The Head of Construction Works is the most valuable asset and deserves the best protection	
	Personal protective equipment that acts as a barrier between the skin and the exposure agent can be considered a skin protector.	
	Hearing protection should be used to prevent construction workers from being exposed to excessive noise	
	Isolation rooms are needed for newly arrived workers so that new workers are free from the Covid-19 virus	
	Personal Protective Equipment used must be identified according to the results of the risk assessment in accordance with the basic principles of the needs assessment	
	The company conducts periodic inspections for workers.	
	The company where you work is required to provide adequate protection against the risk of accidents or injuries as well as the health of the workers.	
	Masks protect workers and function as respirators to filter material from the Covid-19 virus and dirty air particles.	
	Companies carry out spraying disinfectants if workers are found to be positive for COVID-19.	
	Cleanliness of work facilities in the project environment is well maintained.	
	The company provides PPE according to the Covid-19 protocol handling budget that has been agreed with the Covid-19 Handling Task Force	
	The COVID-19 Prevention Task Force issued a policy for workers in closed room conditions in accordance with the policies on the new normal order and the COVID-19 Protocol policy in the construction environment.	

Supervision Thematic analytical approach involving individual interviews with 20 contracting companies conducted by Zamani et al. (2021) that in supervision resulted in findings that COVID-19 caused operational and financial problems, while financial assistance and complete information were needed to overcome these impacts.

Table 5. Indicators of Control Variables

Variable	Indicators	Sources
	Workers are always under the supervision of the foreman/ K3 inspector.	
	Supervision of the foreman / K3 inspector does not interfere with my concentration while working.	
	The foreman/ K3 inspector periodically urges workers to always wear PPE in the work area.	

Control	The foreman/ K3 inspector periodically reminds workers to always be careful at work.	Larasati (2021); Zamani (2021); Instruction of the Minister of Public Works and Housing Number 02/IN/M/2020
	There is supervision on the feasibility of a light fire extinguisher (APAR), machines, and human factors (eg use of PPE, attitude or way of working).	
	There is a procedure for checking work tools before use.	
	Supervisors check K3 equipment regularly for us.	
	Enforcement of regulations and imposition of sanctions in carrying out supervision of hazardous materials.	
	Supervisors remind workers to be careful in using hazardous materials.	
	The company warns the foreman/K3 inspector for the obligation to use personal protective equipment.	
	The company has occupational health and safety (K3) regulations in conducting supervision.	
	The company facilitates the implementation of the Covid-19 vaccine for project workers	

In addition, other factors that can also trigger exposure to Covid-19 in the workforce are: the threat of mutation of the Covid-19 virus, sleep disturbances, work and life imbalances, mental dilemmas between demands for safety at work and family safety, abandoned families, lack of accurate information, burnout, and miss leadership in hospitals and other health facilities Raudenská, et. al. (2020).

Table 6. Indicators of Exposure Variables

Variable	Indicators	Sources
Exposure	There are workers who are exposed to Covid-19 outside the project area	Ashley (2021); Raudenska (2020); Tim BNPB (2020); Instruction of the Minister of Public Works and Housing Number 02/IN/M/2020
	There are workers who are infected with Covid-19 in the project area	
	Workers infected with COVID-19 are being treated in hospital.	
	Project work was temporarily suspended because there were workers who were exposed to Covid-19.	
	There are workers who are sick for more than 10 days due to exposure to Covid-19.	
	There are workers who died due to exposure to Covid-19.	
	There are workers who have recovered from Covid-19.	

The following figure is a model concept in the form of variables that affect COVID-19 exposure to construction workers.

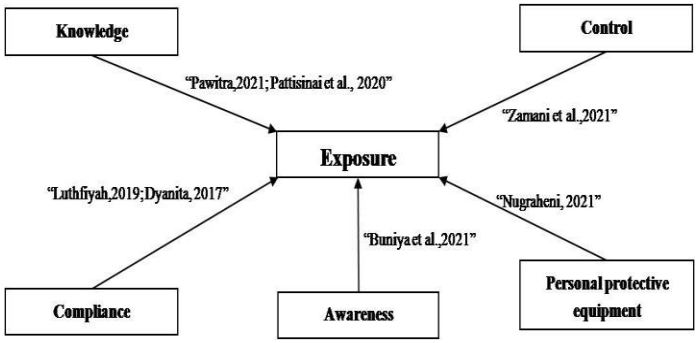


Figure 2. Model concept

6. CONCLUSIONS

The conclusion in the analysis there are factors to prevent the spread of Covid-19, namely the knowledge factor consisting of 5 (five) indicators, the compliance factor consisting of 19 (nineteen) indicators, the awareness factor consisting of 5 (five) indicators, the personal protective equipment factor consisting of 18 (eighteen) indicators, the control factor consists of 11 (eleven) indicators on the exposure factor consisting of 7 (seven) indicators.

REFERENCES

Adiwibowo, Tri Sakti.(2020). *Efektifitas Komunikasi Keselamatan dan Kesehatan Kerja (K3) dalam Mencegah Penularan Covid-19 di PLN UPDL Semarang*. Vol 12 No 2 (2020): Energi dan Kelistrikan: Jurnal Ilmiah, STT PLN.

Anand, S., Montez-Rath, M., Han, J., Bozeman, J., Kerschmann, R., Beyer, P., Parsonnet, J., & Chertow, G. M. (2020). *Prevalence of SARS-CoV-2 antibodies in a large nationwide sample of patients on dialysis in the USA*: a cross-sectional study. *The Lancet*, *396*(10259),

Anies (2021). *Covid-19, Tinjauan Covid-19 dari Aspek Kesehatan, Ekonomi dan Hukum*, Gosyen Publishing.

Araya, F. (2020). *Modeling the spread of COVID-19 on construction workers : An agent-based approach. October*. https://doi.org/10.1016/j.ssci.2020.105022

Ashley, et. al. (2021).*Mental health, safety and support during COVID-19: A cross-sectional study of primary health care nurses*.Journal of Nursing Management. https://doi.org/10.1111/jonm.13534

Buniya (2021). Critical Success Factors of Safety Program Implementation in Construction Projects in Iraq

Construction Leadership Council and Construction Industry Taskforce, Coronavirus Update: Site Operating Procedures Protecting Your Workforce, 2020, in: https://www.building.co.uk/focus/coronavirus-update-site-operating-procedure s-protecting-your-workforce/5105128.article.

Fuad.(2021) *Analisis Risiko Pelaksanaan Proyek Konstruksi Di Masa Pandemi Covid 19 Di Kota Semarang*, Universitas Diponegoro Semarang.

Luthfiyah,FI,(2019), Kepatuhan Tenaga Kerja Dalam Menggunakan Apd di Tempat Kerja, *MTPH Journal, Volume 3, No. 1, March 2019 Medical Technology and Public Health Journal (MTPH Journal)* Universitas Airlangga.

Logunov, D. Y., Dolzhikova, I. V., Zubkova, O. V., Tukhvatullin, A. I., Shcheblyakov, D. V., Dzharullaeva, A. S., Grousova, D. M., Erokhova, A. S., Kovyrshina, A. V., Botikov, A. G., Izhaeva, F. M., Popova, O., Ozharovskaya, T. A., Esmagambetov, I. B., Favorskaya, I. A., (2020). *Safety and immunogenicity of an rAd26 and rAd5 vector-based heterologous prime-boost COVID-19 vaccine in two formulations: two open, non-randomised phase 1/2 studies from Russia. The Lancet*, *396*(10255), 887–897. https://doi.org/10.1016/S0140-6736(20)31866-3

Pawitra (2021). Pawitra,2020, Online Classes To Improve The Implementation Of Health Protocol In The Community During Pandemic COVID19 Departemen Kesehatan Lingkungan, Fakultas Kesehatan Masyarakat, Universitas Airlangga.

Sihombing, Lucas.(2020).*Dampak Covid-19 pada Industri konstruksi dan tantangannya Pasca COVID-19 di Indonesia: Tinjauan dari sisi Manajemen Keuangan Proyek, Program dan Portofolio.* Conference: Seminar IAMPI dan IPMA-Indonesia 2020

Stiles, S., Golightly, D., & Ryan, B. (2020). Impact of COVID-19 on health and safety in the construction sektor. In *Human Factors and Ergonomics In Manufacturing*. https://doi.org/10.1002/hfm.20882

World Health Organization, WHO Director-General's Remarks at the Media Briefing on 2019-ncov on 11 February 2020, 2020. https://www.who.int/dg/speeches/detail/who-director-general-s-remarks-at-the-media-briefing-on-2019-nco v-on-11-february-2020.

Zamani et al.(2021).*Effect of COVID-19 on building construction projects: Impact and response mechanisms*.IOP Conference Series: Earth and Environmental Science.

INVESMENT FINANCING ANALYSIS OF PT JASAMARGA TOLLROAD MAINTENANCE

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ABSTRACT

PT Jasamarga Tollroad Maintenance (JMTM) is a subsidiary of PT Jasa Marga (Persero) Tbk (JM), JMTM is engaged in toll road maintenance to support Jasa Marga's main business lines, especially in terms of meeting the Minimum Service Standards (SPM) for toll roads. In 2021 the value of the maintenance management contract has increased almost 2 times compared to 2020. The impact of the Covid-19 pandemic greatly affected JM's financial performance in 2020. With the large value of work and the impact of the Covid-19 pandemic which resulted in JM's financial performance being negative, This resulted in limited capital from JM. Therefore, JMTM was asked to find other financing solutions apart from its own capital. It is planned that in 2021 JMTM will carry out financing solutions other than own capital in the form of bank loans and shares, but do not yet know the method that will be used to find the most optimal financing structure. By using a theoretical mapping of leading journals, 8 journals were obtained from 2013-2020 with the results that there are various methods, both in a project, company, and investment in determining the financing structure. From the results of the theoretical mapping analysis, the method for finding the most optimal financing structure is WACC and Leverage. The method used to calculate the lightest cost of capital financing structure is to use the WACC method and to find out the lightest rate of return using the Leverage method.

Keywords: Financing Analysis, Sensitivity Analysis, Cost of Capital, Toll Road, Maintenance.

1. INTRODUCTION

PT Jasamarga Tollroad Maintenance (JMTM) is a subsidiary of PT Jasa Marga (Persero) Tbk (JM), the largest freeway provider in Indonesia, where 99.82% of its ownership belongs to Jasa Marga as the parent company. Well known as engaged in toll road maintenance to support Jasa Marga's main business lines, especially in case of fulfilling the Minimum Service Standards (SPM) for toll roads. In 2019, JMTM assumed greater trust from PT Jasa Marga (Persero) Tbk. to carry out toll road maintenance with the concept of total maintenance solutions (Management Contracts) on toll road sections operated by JM.

In 2021 the value of maintenance management contracts increased by almost two times compared to 2020. The impact of the Covid-19 pandemic greatly affected JM's financial performance in 2020. Based on JM's financial report, in 2020 operating revenues from JM decreased compared to 2019, from 10.984 billion to 9.588 billion, the most noticeable is that JM

in 2020 experienced a loss of 42 billion and compared to 2019 previously experienced a profit of 2,074 billion.

With the magnitude value of work and the impact of the Covid-19 pandemic, which resulted in JM's financial performance becoming negative, this resulted in limited capital from JM. Therefore, JMTM asked to find other financing solutions apart from its capital.

It's planned that in 2021 JMTM will carry out financing solutions other than its capital in the form of Bank and Share loans but didn't know yet the method that will be used to find the most optimal financing structure.

2. LITERATURE REVIEW

2.1 Toll Road Financing

Funding for toll road construction projects in Indonesia can come from the government, foreign aid, or other sources. Business Entities can participate in building and operating toll roads within a certain period and have the right to collect service usage fees from users to return investment capital, operating and maintenance costs, as well as reasonable profits (Karsaman, Rodhiatun, Al Rasyid, & Santoso, 2015).

2.2 Project Financing

Financing is the provision of money or bills that can be equated with it, based on an agreement or agreement between the bank and another party that obliges the financed party to return the money or bill after a certain period in exchange for profit-sharing (Kasmir, 2001).

Noor (2007) stated that project financing is the fulfillment of the need for funds for business development which is usually calculated in feasibility studies. These fundraisers include fixed capital and working capital. Fixed capital is an investment for the needs of capital goods, while working capital is capital to start operations that are exhausted in one production.

According to Miles, Berens, Eppli, & Weiss (2007), the source of project financing comes from own capital, loans, and a combination of the two.

2.3 Capital Structure

According to Dare & Sola (2010), there are various alternative ratios of debt and capital, including 100% equity, 100% debt, and the composition of X% equity and Y% debt (in Akeem, et al., 2014).

Sirait's research (2017) suggested that there is an optimal range of capital structures, although there is no methodology that companies use in determining their optimal capital structure.

2.4 Debt Policy Theory

1. Trade off theory

The Trade-Off Theory was first introduced in 1958 by Modigliani and Miller. Trade-Off Theory has considered various factors such as corporate tax, bankruptcy costs, and personal tax in explaining why a company chooses a specific capital structure (Husnan, 2000).

2. Pecking Order Theory

The Pecking Order Theory was developed by Myers and Majluf (1984). This theory explains that Company Managers like internal financing (e.g., retained earnings). Gitman and Zutter (2015) illustrate: "If the manager of a company has an investment opportunity with high profitability and

needs funding, then the manager will tell the investor about this opportunity, but the investor does not believe it..

3. Market Timing Theory

The Market Timing Theory states that companies will issue equity at times of high market value and will repurchase equity at a time when market value is low (Baker and Wurgler, 2002). In research conducted by (Baker & Wurgler, 2002), it was found that market timing affects the capital structure and market price fluctuations have a great influence on the capital structure for at least a decade

2.5 Cash Flow Concept

According to Noor (2007), investment cash flow is the amount or volume of net cash generated from investment activities that are presented in a cash flow to be easily understood, controlled, and evaluated.

2.6 Cost of Capital

According to Suharto (2002) consider that projects require large amounts of funds. This funding generally involves more than one source with a different capital cost. The cost of capital can be calculate based on the cost for each source of funds or so-called individual costs of capital. Individual capital costs are calculated for each type of capital. However, if the company uses several source of equity, the calculated cost of equity is the weighted average cost of capital (WACC) of all equity used.

2.7 *Leverage*

According to Noor (2011), Leverage is an opportunity or opportunity to magnify profits either through increased operations, the addition of outside funds, or a combination of both.

According to Miles (2000), there are several advantages and disadvantages of using loans in project financing with an effect on cash flow, including :

1. The use of debit/loans can increase or decrease the percentage of return to equity (return on capital).
2. The use of debt can increase the diversity of cash flows to capital.

In loan reviews, it's known that there is a terms of positive leverage and negative leverage in this case. Leverage said to be positive if the investor's capital increases the return on capital by using the loan. Conversely, negative leverage occurs when the return on capital decreases due to using a loan.

3. METHODS

The studies used in theoretical mapping are research obtained from reputable journals. That was to ensure the academic standards of the literature analyzed in the paper. In this literature review, there are eight publications from 2013-2020. Next, theoretical mapping of the collected literature was carried out, the results of which there are various methods in a project, company, and investment in determining the financing structure. Table 1 will present the results of the explanation of the theoretical mapping.

Table 1. Theoretical mapping from previous research

No.	Author/Year	Title	Method	Result
1	Putra, Utomo, & Nurcahyo, 2013	Investment Enrichment Analysis of Puncak Kertajaya Apartment Project	NPV and WACC (*Weighted Averaged Cost of Capital*)	The best financing is with 30% of own capital and 70% of loans that have the lightest cost of capital of 10.98% at positive leverage.
2	Wibisono & Utomo, 2013	Financing Analysis of the Gresik Petrochemical Hospital Development Project	IRR (Internal Rate of Return), NPV (Net Present Value), PI (Profitability Index), and Payback Period	Alternatives with the highest cost of the capital value of 11.4%, the shortest Payback period of 6.57 years, NPV with a value of Rp 17,872,629,730.00, the highest IRR of 18.55%, the highest PI of 1,707, which is a combination of 30% debt with a loan interest rate of 10% per year and 70% of own capital.
3	Ningsih & Utomo, 2014	Investment Financing Analysis of Puri Park View Tower E Kebon Jeruk Apartment – West Jakarta	*Discounted Cash Flow* (DCF), WACC (*Weighted Averaged Cost of Capital*) and *leverage method.*	The result of the composition of alternative financing that has the smallest cost of capital is 30% of own capital and 70% of loans with a value of 10.98% on positive leverage.
4	Maulanasari & Utomo, 2015	Analysis of Office Property Investment Financing in South Jakarta	*Discounted Cash Flow* (DCF), WACC (*Weighted Averaged Cost of Capital*) and metode *leverage*	The result of the composition of alternative financing that has the smallest cost of capital is 40% of own capital and 60% of loans with a value of 11.69% on positive leverage.
5	Bean, Blazquez, & Nezamuddin, 2017	*Assessing the cost of renewable energy policy options e A Spanish wind case study*	WACC and NPV	Projects with higher factor capacity tend to be more to be financed with debt than with equity, thus having a lower average cost of capital
6	Savolainen,	*The trade-off between*	*Monte carlo* and	The decision to use debt

No.	Author/Year	Title	Method	Result
	Collan, Kyl€aheiko, & Luukka, 2017	*the leverage effect and real options thinking: A simulation-based model on metal mining investment*	system dynamic model	financing has a significant influence on the value of the project and the wealth of equity holders and the selection of the financial structure has an important role for investment profitability
7	Lai et al, 2019	A *financial model for lithium-ion storage in a photovoltaic and biogas energy system*	DCF, NPV, and IRR	The profitability of the EES is difficult to ascertain due to the uncertainty of two aspects, namely the technical aspects such as the decrease in EES and the operating life. Then economic aspects such as the cost of EES capital and the retail price of electricity.
8	Sakka, Bilionis, Vanvatsikos, & Gantes, 2020	*Onshore wind farm siting prioritization based on investment profitability for Greece*	NPV, IRR, dan WACC	

4. RESULTS

Based on the theoretical mapping in part 3 above, the method used to find the most optimal financing structure is with WACC and Leverage. WACC method for finding the lightest cost of capital in a financing structure. Then Leverage is a method to find out the lightest loan return rate. In Table 2 and Table 3, it will be explained how the variables will be used and how to measure it..

Table 2. Conceptualization of Variables

Variabel	Source	Information
Investment costs, financing, income, Cost of Capital (WACC), NPV, IRR, ROA, ROE	Maulanasari and Utomo (2015), Ningsih and Utomo (2014), Putra, Utomo and Nurcahyo (2013), Sakka, dkk (2020), Wibisono and Utomo (2013)	Investment and financing analysis: • Cash flow analysis using Discounted Cash Flow method • Analysis of financing costs with Cost of Capital (WACC) • Debt analysis using the leverage method

Variabel	Source	Information
Investment costs, financing, income, NPV	Savolainen, dkk (2017)	Analysis of the effect of debt financing on the feasibility of a mining project investment.
Investment costs, financing, income,CBA, NPV	Bean, dkk (2017)	Cost-Benefit Analysis is used to determine the effect of debt on the sustainability of a project investment.
Investment costs, financing, income, profitability, NPV, IRR, Payback Period	Lai, dkk (2017)	Financial analysis is used to measure the financial performance of electrical energy storage projects (EES) and calculate the need for debt to its financial feasibility.

Source: Processed writers

Table 3. Variable Measurement

Variabel	Indicator	Type of Data	Source of Data	Reference
Investment costs	1. Construction Cost 2. HARI Cost 3. Administration Cost 4. Tax	Secondary	PT JMTM	Maulanasari and Utomo (2015), Ningsih and Utomo (2014), Putra, Utomo and Nurcahyo (2013), Sakka, dkk (2020), Wibisono and Utomo (2013)
Financing	1. Equity 2. Debt 3. Public subsidy	Secondary	The results of previous research	Maulanasari and Utomo (2015), Ningsih and Utomo (2014), Putra, Utomo and Nurcahyo (2013), Sakka, dkk (2020), Wibisono and Utomo (2013)
Income	Termyn payments	Secondary	PT JMTM	Maulanasari and Utomo (2015), Ningsih and Utomo (2014), Putra, Utomo and Nurcahyo (2013), Sakka, dkk (2020), Wibisono and Utomo (2013)
Cost of Capital (WACC)	1. Weight of Debt 2. Equitable Weight 3. Cost of Debt after Tax 4. Cost of Equitable after Tax	Secondary	The results of previous research	Maulanasari and Utomo (2015), Ningsih and Utomo (2014), Putra, Utomo and Nurcahyo (2013), Sakka, dkk (2020), Wibisono and Utomo (2013)
NPV	1. Net Cash Flow 2. Investment Cost	Secondary	The results of previous research	Maulanasari and Utomo (2015), Ningsih and Utomo (2014), Putra,

Variabel	Indicator	Type of Data	Source of Data	Reference
				Utomo and Nurcahyo (2013), Sakka, dkk (2020), Wibisono and Utomo (2013)
IRR	NPV	Secondary	The results of previous research	Maulanasari and Utomo (2015), Ningsih and Utomo (2014), Putra, Utomo and Nurcahyo (2013), Sakka, dkk (2020), Wibisono and Utomo (2013)
ROR	1. Net Income 2. Construction value	Secondary	The results of previous research	Maulanasari and Utomo (2015), Ningsih and Utomo (2014), Putra, Utomo and Nurcahyo (2013), Sakka, dkk (2020), Wibisono and Utomo (2013)
ROE	1. Cash Flow before Tax 2. First Capital Investment	Secondary	The results of previous research	Maulanasari and Utomo (2015), Ningsih and Utomo (2014), Putra, Utomo and Nurcahyo (2013), Sakka, dkk (2020), Wibisono and Utomo (2013)

Source: Processed writers

5. CONCLUSIONS

The method used to calculate the financing structure of the lightest cost of capital is to use the WACC method and to find out the lightest rate of return using the Leverage method.

REFERENCES

Baker, M., & Wurgler, J. (2002). Market timing and capital structure. *The Journal of Finance*, 57(1), 1e32.

Bean, P., Blazquez, J., & Nezamuddin, N. (2017). Assessing the cost of renewable energy policy options e A Spanish wind case study. *Renewable Energy*, 180 - 186.

Dare, F., & Sola, O. (2010). Capital Structure and Corporate Performance in Nigeria. *Panel Data Analysis Journal of Mathematics and Statistics 6(2)*, 168-173.

Gitman, L., & C.J, Z. (2015). *Principles of Managerial Finance. Fourteenth Edition.* California: Pearson.

Husnan, S. (2000). *Dasar-dasar Teori Portofolio dan Analisis Sekuritas.* Yogyakarta : UPP AMP YKPN.

Karsaman, R. H., Rodhiatun, Al Rasyid, H., & Santoso, I. (2015). Kajian Investasi Pembangunan Jalan Tol di Indonesia Berdasarkan Sistem Syariah: Studi Kasus Jalan Tol Cikampek-Palimanan. *Jurnal Perencanaan Wilayah dan Kota*, 86-99.

Kasmir. (2001). *Manajemen Perbankan.* Jakarta: PT Raja Grafindo Persada.

Kasmir. (2012). *Analisis Laporan Keuangan.* Jakarta: Rajawali Pers.

Lai, C. S., Locatellib, G., Pimm, A., Taoa, Y., Lia, X., & Laia, L. L. (2019). A financial model for lithium-ion storage in a photovoltaic and biogas energy system. *Applied Energy*, 1-16.

Maulanasari, A., & Utomo, C. (2015). Analisa Pembiayaan Investasi Properti Perkantoran di Jakarta Selatan. *JURNAL TEKNIK ITS*.

Miles. (2000). *Real Estate Development.* Washington: Urban Land Institute.

Miles, M., Berens, G., Eppli, M., & Weiss, M. (2007). *Real Estate Development Priciples and Process Fourth Edition.* USA: ULI.

Ningsih, M., & Utomo, C. (2014). Analisa Pembiayaan Investasi Apartemen Puri Park View Tower E Kebon Jeruk - Jakarta Barat. *JURNAL TEKNIK POMITS*.

Noor. (2011). *Ekonomi Manajerial.* Jakarta: PT Rajagrafindo Persada.

Noor, H. (2007). *Ekonomi Manajerial.* Jakarta: PT. Rajagrafindo Persada.

Putra, M., Utomo, C., & Nurcahyo, C. (2013). Analisa Pembeayaan Invesitasi Proyek Apartemen Puncak Kertajaya. *JURNAL TEKNIK POMITS*.

Sakka, E., Bilionis, D., Vanvatsikos, D., & Gantes, C. (2020). Onshore Wind Farm Siting Prioritization Based on Invesment Profitability for Greece. *Renewable Energy*.

Savolainen, J., Collan, M., Kyl€aheiko, K., & Luukka, P. (2017). On the trade-off between the leverage effect and real options thinking: A simulation-based model on metal mining investment. *International Journal of Production Economics*, 1-9.

Sirait, P. (2017). *Analisis Laporan Keuangan.* Yogyakarta: Ekuilibria.

Soeharto. (2002). *Manajemen Proyek Jilid 2: Konsep Studi Kelayakan dan Jarigan Kerja.* Jakarta: Erlangga.

Wibisono, G., & Utomo, C. (2013). Analisa Pembiayaan Proyek Pengembangan Rumah Sakit Petrokimia Gres. *JURNAL TEKNIK POMITS Vol. 1, No. 1*, 1-4.

Gitman, L., & C.J, Z. (2015). *Pr*

Dare, F., & Sola, O. (2010). Capital Structure and Corporate Performance in Nigeria. *Panel Data Analysis Journal of Mathematics and Statistics 6(2)*, 168-173.

Gitman, L., & C.J, Z. (2015). *Principles of Managerial Finance. Fourteenth Edition.* California: Pearson.

Karsaman, R. H., Rodhiatun, Al Rasyid, H., & Santoso, I. (2015). Kajian Investasi Pembangunan Jalan Tol di Indonesia Berdasarkan Sistem Syariah: Studi Kasus Jalan Tol Cikampek-Palimanan. *Jurnal Perencanaan Wilayah dan Kota*, 86-99.

Kasmir. (2001). *Manajemen Perbankan.* Jakarta: PT Raja Grafindo Persada.

Kasmir. (2012). *Analisis Laporan Keuangan.* Jakarta: Rajawali Pers.

Miles. (2000). *Real Estate Development.* Washington: Urban Land Institute.

Miles, M., Berens, G., Eppli, M., & Weiss, M. (2007). *Real Estate Development Priciples and Process Fourth Edition.* USA: ULI.

Noor. (2011). *Ekonomi Manajerial.* Jakarta: PT Rajagrafindo Persada.

Noor, H. (2007). *Ekonomi Manajerial.* Jakarta: PT. Rajagrafindo Persada.

inciples of Managerial Finance. Fourteenth Edition. California: Pearson.

Karsaman, R. H., Rodhiatun, Al Rasyid, H., & Santoso, I. (2015). Kajian Investasi Pembangunan Jalan Tol di Indonesia Berdasarkan Sistem Syariah: Studi Kasus Jalan Tol Cikampek-Palimanan. *Jurnal Perencanaan Wilayah dan Kota*, 86-99.

Kasmir. (2012). *Analisis Laporan Keuangan.* Jakarta: Rajawali Pers.

Miles. (2000). *Real Estate Development.* Washington: Urban Land Institute.

Noor. (2011). *Ekonomi Manajerial.* Jakarta: PT Rajagrafindo Persada.

DELAY RISK IDENTIFICATION FOR MAINTENANCE PROJECT IN GAS ENGINE POWER PLANT (PLTMG)

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ABSTRACT

Project risk is necessary to be identified for further assessment and development of risk response to minimize the project threats. Identification and assessment of causing factors and risks of project delay have attracted the interest of many researchers, especially in construction projects. Unfortunately, the publications on this topic for maintenance projects are limited. It is also at risk of experiencing delays given that it has high complexity of work and limited time to be completed. Therefore, this research aims to fill the existing research gap by developing delay risk identification for maintenance projects with a particular focus on the power plant in remote areas. A case study to represent this research topic was undertaken at three PLTMGs in Nusa Tenggara. Risks were identified through literature and work breakdown structure review. The search of the literature was not limited to maintenance projects but extended to other projects, e.g. construction, to discover more potential risks. These risks were selected based on their relevance to maintenance projects and synthesized based on expert judgment. The work breakdown structure of the major inspection was also used to validate the selected risk from the literature and evaluated to discover other possible risks which might be not mentioned in the literature. The population of this research was the project team at the site, while the sample, which also act as respondents, was the plant manager, maintenance manager, work planner, and maintenance engineer. Twenty-seven risks were identified and grouped into six categories, i.e. manpower, material, equipment, client, workplace, and contractor.

Keywords: Risk Identification, Project Delay, Maintenance, Power Plant

1. INTRODUCTION

Projects are subject to many unforeseen variables, i.e. risks, that may be occurred during the project planning and execution, and become project threats. Seventy percents of projects are unable to meet the expected completion date and experienced an average delay of ten to thirty percent over the desired duration (Assaf and Al-Hejji, 2005). Therefore, project risk is necessary to be identified for further assessment and development of risk response.

Identification and assessment of causing factors and risks of project delay have attracted the interest of many researchers, especially in construction projects. Delay risks for the infrastructure construction project were evaluated by El-Sayegh and Mansour (2015), Anggraini et al. (2019), Razi et al. (2019), and Andrić et al. (2019). While Shangea et al. (2020), Batool and Abbas (2017), Hossen et al. (2015), Islam and Skitmore (2019), Pall et al. (2016), Yau and Yang (2021), and Wu et al. (2019) studied delay factor and risks in the power systems. Unfortunately,

the publications on delay risk identification and assessment for maintenance project is limited. Even if there is a risk assessment for a maintenance project, it will mostly focus on determining the most suitable policy of maintenance for the particular object. Whereas, a maintenance project is also at risk of delays given that it has high complexity of work and limited completion time. Hence, this research aims to fill the existing research gap by developing a delay risk identification for preventive maintenance projects in the power plants located in remote areas because they have high urgency of plants availability and reliability due to the limited electricity sources and low quality for continuous access to electricity.

A case study to represent this research topic was undertaken at three PLTMGs in Nusa Tenggara which have limited accessibility and infrastructure, with only one main road leading to the site, no available jetty for ship berthing, and limited flight to those areas. These power plants are owned by an Indonesian state-owned enterprise with PT XYZ as an O&M contractor and have been commercially operated since 2019.

2. LITERATURE REVIEW

2.1 Project Delay

One of the critical constraints of a project is time, in which the project life span from the beginning to the end has been defined. A project shall deliver a product or services as stipulated in the scope of work until a specified date. The capability to complete the project on time may be considered a project efficiency indicator (Assaf and Al-Hejji, 2006). If the project is delayed, the owner will lose revenue, and the contractor will have overhead costs and poor credibility. The dispute among project parties may be also unavoidable.

Trauner (2009) classified a project delay into four categories, i.e. critical or non-critical, excusable or non-excusable, compensable or non-compensable, and concurrent or non-current. Delay is considered as critical or non-critical depending on its impact on the project completion time, delay that affects the project milestone will be categorized as a critical delay and vice versa. Then, a delay is divided into excusable and non-excusable based on its source, an excusable delay is caused by an unexpected incident beyond the control of the contractor, while a non-excusable delay is due to the contractor's error. Compensable and non-compensable delay is following the project contract. Delay will be classified into concurrent delay if two different delays are appearing simultaneously.

2.2 Preventive Maintenance

Preventive maintenance, also known as scheduled maintenance, is proactive maintenance to detect whether the equipment has critical wear or a tendency to break down to maintain its availability. Tabucanon and Dahanayaka (1990) divided preventive maintenance in power plants into routine maintenance and overhaul. Routine maintenance only conducts the inspection, lubrication, and adjusting of several parts, while overhaul requires the equipment to be out of operations for several weeks or months for cleaning, inspection, repairing, reconditioning, and/ or replacing items. This maintenance is carried out every certain operating hour defined by the manufacturers. Even though the equipment has the same type, it will have different maintenance policies if they are from different manufacturers.

2.3 Previous Researches

Interest in project management is increasing over time due to the demand growth for the project in various fields. One of the attractive topics in project management is causing delay factors and risk identification and assessment, especially in construction projects. El-Sayegh and

Mansour (2015) identified thirty-three risks associated with a highway construction project in the United Arab Emirates and grouped them into six categories, i.e. technical, site, commercial, environment, politics, and socio-economics. Anggraini et al. (2019) studied delay risk in the Batang-Kendal road construction project and discovered thirty-two risks within nine categories, i.e. manpower, material, equipment, financial, environment, scope and contract, control system and work evaluation, managerial and supervision, while the research of Razi et al. (2019) took place on the East Coast of Malaysia obtained twenty-two risks within seven categories, i.e. technical, natural hazards, economic and financial, contractual, socio-politics, organizational, and resources.

Shangea et al. (2020) identified delay factors in the Indian hydropower construction project, while Batool and Abbas (2017) also studied delay factors in hydropower projects in Pakistan and pointed out fifty identified factors. Pall et al. (2016) discovered eighty-two delay factors within power transmission projects through a literature review and classified them into nine main groups, i.e. owner, administrative, contractor, consultant, drawing, material, equipment, manpower, and external. Other research on identifying causing delay factors in the power systems was also investigated by Yau and Yang (2021) with a particular focus on the design schedule at the Taiwan power distribution substation projects. They found twenty-seven delay factors. Wu et al. (2019) conducted a risk assessment of offshore photovoltaic power generation projects in China and identified sixteen risks which were classified into four main categories, i.e. micro-economic, technical, environmental, and management.

Khan and Gul (2017) observed the potential risks in Islamabad and Rawalpindi construction projects through literature review and interviews with construction experts and found twenty-nine risks found within five main categories, i.e. design, financial, technical, manpower, and external risks. Kuo and Lu (2013) assessed twenty risks in a metropolitan construction project in Taipei city. El-Karim et al. (2017) identified four criteria of cost overrun and delay risks in Egyptian construction projects, i.e. site conditions, resources, project parties, and project features, and thirteen sub-criteria, i.e. environmental, sub-surface, site location, manpower, equipment, material, owner, engineering and design, contractor, project management, financial, political, and schedule. Eskander (2018) studied risk assessment in residential construction projects in Egypt and Saudi Arabia. There were six main groups of risk viz. acts of god, physical, economical, political, design, and construction with thirty-seven individual risks in total. Wang et al. (2004) developed a risk management framework for construction projects in developing countries and found twenty-eight risks within three categories, i.e. country, market, and project.

Delay risk assessment in the construction project of the Lazada warehouse was carried out by Apriliyani and Amin (2019). Moreover, a study of delay risk assessment in the crusher system's construction for underground mines was carried out by Muliano et al. (2021). There were seventy-nine delay risks discovered and grouped into five main categories, i.e. work area, construction drawing, material, administration, and resources. Adiam and Nel (2019) observed and pointed out sixteen delay factors associated with boiler maintenance projects during half-station shut-down in a coal-fired power plant.

3. METHODS

Risk identification was carried out by reviewing the literature which was not limited to maintenance projects but extended to other projects, e.g. construction, to discover more potential risks. These risks would be selected by the author based on their relevance to the maintenance projects and synthesized based on the expert judgment through an interview. The population of this research was the project team at the site, while the sample, which also act as respondents as

the research employed purposive sampling, was the experienced people in project planning or even executions so that they had capabilities to answer the questions, such as plant manager, maintenance manager, work planner, and maintenance engineer with a total of four people.

The work breakdown structure of the major inspection, or preventive maintenance of 18K, was also used to validate the selected risk from the literature. It was evaluated to define the critical activities to the project completion date for further analysis to discover other possible risks which might be not mentioned in the literature. This work breakdown structure includes the scope of work of the minor and medium inspections.

4. RESULTS

As stipulated in the previous chapter, risk identification was conducted by reviewing the literature. Then, some risks were selected based on their relevance to the maintenance project, validated by reviewing the work breakdown structure as given in the following figure, and input to Table 1 of the proposed risk breakdown structure.

There were thirty-seven identified risks from the literature and work breakdown structure of major inspection which were classified into seven categories, namely manpower, material, equipment, technical, contractor, client, and workplace. These risks would be proposed to the four respondents through an interview to obtain their judgment for risk synthesis.

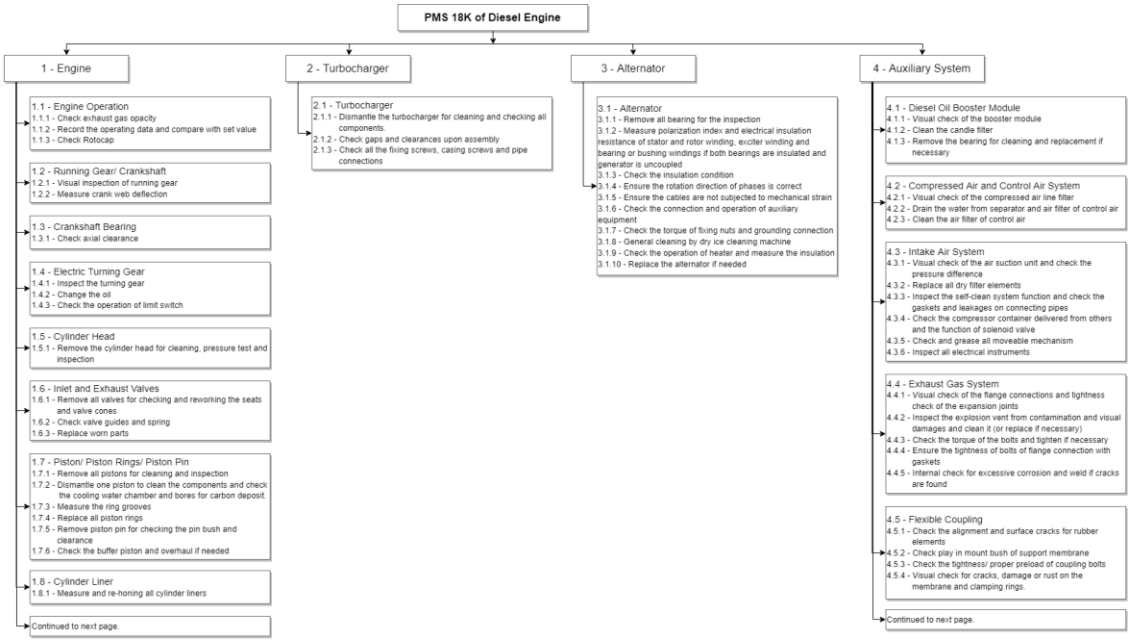


Figure 1. Part of Work Breakdown Structure of Major Inspection

Table 1. Proposed Risk Breakdown Structure

Risk Category	Description	Reference
Manpower	Lack of skilled manpower (R01)	Wang and Yuan (2016), Balta et al. (2021), Razi et al. (2019)
	Low productivity of manpower (R02)	Anggraini et al. (2018), Khan and Gul (2017), El-Karim et al. (2015)
	Manpower disputes and strikes (R03)	Adiam and Nel (2019), Antoniou (2021), Khan and Gul (2017)

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Table 1. Proposed Risk Breakdown Structure (Cont'd)

Risk Category	Description	Reference
Manpower	Cultural gap and language barrier (R04)	El-Sayegh and Mansour (2015), Hossen et al. (2015), Gebrehiwet and Luo (2019)
	Unexperienced manpower (R05)	Islam and Skitmore (2019), El-Karim et al. (2015), Hossen et al. (2015)
	Excessive workload (R06)	Adiam and Nel (2019), Yau and Yang (2012)
Material	Delay in material delivery (R07)	Anggraini et al. (2018), Adiam and Nel (2019)
	Incomplete material received (R08)	Muliano et al. (2021)
	Broken material (R09)	Muliano et al. (2021), Gebrehiwet and Luo (2019)
	Material missing in the warehouse (R10)	Muliano et al. (2021)
	Unavailable material in the local market (R11)	Anggraini et al. (2018), Hossen et al. (2015)
	The quality of material does not meet the specification (R12)	Anggraini et al. (2018), Alsharif and Karatas (2016), Khan and Gul (2017)
Equipment	Delay in equipment delivery (R13)	Anggraini et al. (2018), Adiam and Nel (2019), Razi et al. (2019)
	Broken equipment (R14)	Shangea et al. (2020), Eskander (2018)
	Low productivity of equipment (R15)	Anggraini et al. (2018)
	Inability to operate or use the equipment (R16)	El-Sayegh and Mansour (2015), Wang and Yuan (2016), Khan and Gul (2017)
Technical	Water supply availability issue (R17)	Muliano et al. (2021), Assaf and Al-Hejji (2006)
	Compressed air availability issue (R18)	Muliano et al. (2021)
	Rework (R19)	El-Karim et al. (2015), Hossen et al. (2015), Assaf and Al-Hejji (2006)
	Incorrect installation (R20)	Yau and Yang (2012)
	Improper inspection (R21)	Yau and Yang (2012)
	Unauthorized modification (R22)	Yau and Yang (2012)
Contractor	Inefficient resource planning (R23)	El-Sayegh and Mansour (2015), Shangea et al. (2020), Alsharif and Karatas (2016),
	Poor coordination and communication between people at site and head office (R24)	Muliano et al. (2021), Wang and Yuan (2016), Hossen et al. (2015)
	VISA for a specialist visit (R25)	Muliano et al. (2021)
	Additional work requested by head office (R26)	Anggraini et al. (2018)
	Head office interference (R27)	Gebrehiwet and Luo (2019)
	Complex approval procedure (R28)	Wang and Yuan (2016), Balta et al. (2021), Islam and Skitmore (2019)
Client	Poor coordination and communication between contractor and client (R29)	Wang and Yuan (2016), Adiam and Nel (2019), Assaf and Al-Hejji (2006)
	The conflict between contractor and owner (R30)	Islam and Skitmore (2019)
	Additional work requested by owner (R31)	Anggraini et al. (2018)
	Clients' decision (R32)	El-Sayegh and Mansour (2015)
Workplace	Force majeure (R33)	El-Sayegh and Mansour (2015), Wang and Yuan (2016), Kuo and Lu (2013)
	Accident at workplace (R34)	Anggraini et al. (2018), (2017), El-Karim et al. (2015), Eskander (2018)
	Differing site condition (R35)	Alsharif and Karatas (2016), El-Karim et al. (2015)
	Unavailable working space (R36)	Muliano et al. (2021)
	Site access issue (R37)	Antoniou (2021), Islam and Skitmore (2019)

After having a discussion with the respondents, the proposed risks were reduced to twenty-seven as detailed in Table 2. Several risks were simplified by merging them into a single risk, e.g. the risk of low productivity of equipment combined with the risk of inefficient resources planning, the risk of the inability to operate and use the equipment becomes the risk of lack of skilled and experienced manpower and the risk of conflict between contractor and client being the risk of poor communication and coordination between the contractor and client because the experts claimed that those risks were still related to each other. Risks of improper inspection, unauthorized modification, additional work requested by the head office, head office interference during the project, and quality of the material that does not meet the specification were removed due to their irrelevance with the preventive maintenance project. Furthermore, the risk of delay in payment by the owner was added to the risk breakdown structure because this risk might affect the project planning if occurred, even though this risk impact is not as higher as the construction project.

Table 2. Final Risk Breakdown Structure

Risk Category	Description	Reference
Manpower	Lack of skilled and experienced manpower (R01)	Wang and Yuan (2016), Razi et al. (2019) Islam and Skitmore (2019)
	Manpower disputes and strikes (R02)	Adiam and Nel (2019), Antoniou (2021)
	Cultural gaps and language barrier (R03)	El-Sayegh and Mansour (2015), Hossen et al. (2015), Gebrehiwet and Luo (2019)
	Excessive workload (R04)	Adiam and Nel (2019), Yau and Yang (2012)
Material	Delay in material delivery (R05)	Anggraini et al. (2018), Adiam and Nel (2019)
	Incomplete material received (R06)	Muliano et al. (2021)
	Broken material (R07)	Gebrehiwet and Luo (2019)
	Material missing in warehouse (R08)	Muliano et al. (2021)
	Unavailable material in the local market (R09)	Anggraini et al. (2018), Hossen et al.(2015)
Equipment	Delay in equipment delivery (R10)	Anggraini et al. (2018), Adiam and Nel (2019)
	Equipment breakdown (R11)	Shangea et al. (2020), Eskander (2018)
Client	Poor coordination and communication between contractor and client (R12)	Wang and Yuan (2016), Adiam and Nel (2019), Assaf and Al-Hejji (2006)
	Additional work by the client (R13)	Anggraini et al. (2018)
	Client's decision (R14)	El-Sayegh and Mansour (2015)
	Delay in payment by the client (R15)	Assaf and Al-Hejji (2006)
Workplace	Force majeure (R16)	Kuo and Lu (2013)
	Accident at workplace (R17)	Anggraini et al. (2018), Eskander (2018)
	Unavailable working space (R18)	Muliano et al. (2021)
	Unavailable utilities at the workplace (R19)	Gebrehiwet and Luo (2019), Assaf and Al-Hejji (2006), Muliano et al. (2021)
	Unavailable compressed air (R20)	Muliano et al. (2021),
	Limited accessibility to the workplace (R21)	Antoniou (2021), El-Karim et al. (2015)
Contractor	Inefficient resource planning (R22)	El-Sayegh and Mansour (2015), Shangea et al. (2020), Alsharif and Karatas (2016),
	VISA for a specialist visit (R23)	Muliano et al. (2021)

Continued to next page

Table 2. Final Risk Breakdown Structure (Cont'd)

Risk Category	Description	Reference
Contractor	Poor coordination and communication between site representative and head office (R24)	Muliano et al. (2021), Wang and Yuan (2016), Hossen et al. (2015)
	Complex approval procedure (R25)	Wang and Yuan (2016), Balta et al. (2021), Islam and Skitmore (2019)
	Rework due to errors during the executions (R26)	El-Karim et al. (2015), Hossen et al. (2015), Assaf and Al-Hejji (2006)
	Incorrect installation (R27)	Yau and Yang (2012)

According to Table 2, maintenance risks are divided into six categories, namely manpower, material, equipment, client, workplace, and contractor. Risk-related to manpower consists of lack of skilled and experienced manpower, excessive workload, manpower disputes and strikes, and cultural gaps and language barriers. Manpower plays important role in the project executions, unskilled and inexperienced manpower cannot do the job properly and/ or use the special tools or operate any equipment. The risk of excessive workload and less rest time during the project can worsen the manpower performance because of fatigue and increase the chance of disputes among them. Furthermore, every person has a certain culture or perspective that affects how he manages and executes the project based on his/ her background and/ or habits in the previous work. Having different culture from the organization may make him treat the project differently and influence the ongoing progress. Likewise, language barriers, the inability to communicate with each other due to differences in language, also may interfere with the progress because the information cannot be delivered properly.

There are five identified risks of material in maintenance projects, such as delay in material delivery, incomplete material received, broken material, material missing in the warehouse, and unavailable material in the local market. Materials can be in the form of spare parts and consumables, which are another essential resource of the project that requires to be planned properly to support the progress of the project. Unavailable materials during the executions because of the late delivery, incomplete or damaged material received, damaged or lost materials in the warehouse, and/ or not being sold in the local market, will indeed postpone the entire project. Delay in material delivery may be caused by any issue arising in the customs and/ or during the shipment. The risk of incomplete materials received may be affected by an order error or carelessness of the supplier which takes a longer time to deliver the remaining items. Furthermore, the materials can be damaged during the shipment or while being stored in the warehouse, or during the installation and require to be re-purchased, if the materials can not be found in the local market and require to be imported from the manufacturer, then they will take more time than if the materials are available in the local market. The risk of material missing in the warehouse can occur due to incorrect records or theft.

Delay in equipment delivery and equipment breakdown become potential risks because the equipment is supposed to support the maintenance executions. Less awareness of its maintenance and preservation, especially for electronic equipment, can lead to equipment breakdown before or during the project.

Risk-related to the client that may contribute to project delay involve the poor coordination and communication between contractor and client, additional work by the client, client's decision, and delay in payment by the client. The project planning and execution in the power plant can be

changed based on the client's decision, mostly caused by standby period, disturbance in the power transmission or other power plants as well as deficit power in the system, which lead to project delay, e.g. measurement of valve clearance must be postponed until the engine has cooled down because the engine is not allowed to stop on the schedule. The contractor may also lose an opportunity cost of not accepting another project due to the change in the client's decision for the project executions. Delay in payment by client affects the annual planning of maintenance projects, it can be monthly payment or the payment of services or goods excluding the contract, in which the project can be begun after the client has paid for it. Whereas, exceeding the interval of maintenance may lead to a major breakdown of the engine.

Six risks related to the workplace were discovered, such as force majeure, accident at the workplace, unavailable working space, unavailable compressed air and utilities, and limited accessibility to the workplace. Limited working space also means limited work to be done simultaneously and requires a little longer to move the parts out/ into the working space. Unavailable compressed air and utilities, e.g. water, can interrupt the outgoing progress of the project because compressed air and water are needed for engine parts' testing and manpower provision. Risk of force majeure and limited accessibility may arise in this project due to the location of the power plant which is in remote areas and earthquake-prone. These power plants have no nearby jetty for ship berthing and only have one main road leading to the site, so if there are fallen trees or roadblocks by people and/ or animals, the mobilization of project resources will be disrupted. Also, limited flight to these areas makes it impossible to transport goods or impromptu trips of interested people.

The last category of identified risk is contractor risks which consist of inefficient resource planning, VISA for a specialist visit, poor coordination and communication between site representatives and head office, complex approval procedure, rework due to errors during the executions (unsatisfied work), and incorrect installation. It is necessary to plan the project resources efficiently to avoid bottlenecks that occur during the project, e.g. lack of required material. A sudden plan of a specialist visit may cause problems in VISA issuance and make the project stop temporarily to await his arrival as there are some works to be done only by him. Complex approval procedures for ordering materials and/ or equipment and spontaneous action to be implemented which are not within the scope of the project may also increase the project duration.

5. CONCLUSIONS

This research on the "Delay Risk Identification for Maintenance Project in Gas Engine Power Plant (PLTMG)" has a conclusion, i.e. twenty-seven risks were identified from the literature review – expert judgment and the work breakdown structure of major inspection and grouped into six categories, namely manpower, material, equipment, client, workplace, and contractor.

PT XYZ shall conduct a further risk assessment to discover the critical risks by referring to the risk breakdown structure as presented in Table 2 and develop a risk response for those risks to minimize the project threats.

REFERENCES

Adiam, K., & Nel, H. (2019). Delay Analysis in Energy Utility Maintenance Project. *Proceedings of the International Conference on Industrial Engineering and Operations Management* (pp. 343-354). Pilsen: IBOM Society International.

Alsharif, S., & Karatas, A. (2016). A Framework for Identifying Causal Factors of Delay in Nuclear Power Plant Projects. *Procedia Engineering*, 1486-1492.

Andric, J. M., Wang, J., Zuo, P. X., Zhang, J., & Zhong , R. (2019). Fuzzy Logic-based Method for Risk Assessment of Belt and Road Infrastructure Projects. *Journal of Construction Engineering and Management*, 1-12.

Anggraini, D., Hatmoko, J. U., & Handajani, M. (2019). Quantifying Delay Risk Potential of Road Projects during Construction Phase: A Case Study. *MATEC Web of Conference*, 1-9.

Antoniou, F. (2021). Delay Risk Assessment Models for Road Projects. *MDPI*.

Apriliyani, M. A., & Amin, M. (2019). Analisis Keterlambatan Berbahasis Manajemen Risiko pada Proyek Warehouse Lazada Tahap 2. *Rekayasa Sipil*, 58-68.

Assaf, S. A., & Al-Hejji, S. (2006). Causes of Delay in Large Construction Projects. *International Journal of Project Management*, 349-357.

Balta, G. K., Dikmen, I., & Birgonul, M. T. (2021). Bayesian Network based Decision Support for Predicting and Mitigating Delay Risk in TBM Tunnel Projects. *Automation in Construction*.

Batool, A., & Abbas, F. (2017). Reasons for Delay in Selected Hydro-Power Projects in Khyber Paktunkhwa (KPK) Pakistan. *Renewable and Sustainable Energy Reviews*, 196-204.

El-Karim, M., El Nawawy, O. A., & Abdel-Alim, A. M. (2017). Identification and Assessment of Risk Factors Affecting Construction Projects. *HBRC Journal*, 202-216.

El-Sayegh, S. M., & Mansour, M. H. (2015). Risk Assessment and Allocation in Highway Construction Projects in the UAE. *Journal of Management in Engineering*, 1-12.

Eskander, R. F. (2018). Risk Assessment Influencing Factors for Arabian Construction Projects using Analytic Hierarchy Process. *Alexandria Engineering Journal*, 4207-4218.

Gebrehiwet, T., & Luo, H. (2019). Risk Level Evaluation on Construction Project Lifecycle using Fuzzy Comprehensive Evaluation and TOPSIS. *Symmetry*, 1-15.

Hossen, M. M., Kang, S., & Kim, J. (2015). Construction Schedule Delay Risk Assessment by Using Combined AHP-RII Methodology for An International NPP Project. *Nuclear Engineering and Technology*, 362-379

Islam, M. S., & Skitmore, M. (2019). Modified Fuzzy Group Decision-Making Approach to Cost Overrun Risk Assessment of Power Plant Projects. *Journal of Construction Engineering and Management*.

Khan, R. A., & Gul, W. (2017). Emperical Study of Critical Risk Factors Causing Delays in Construction Projects. *IEEE International Conference on Intelligent Data Acquisition and Advanced Computing System: Technology and Application* (pp. 900-906). Romania: Bucharest.

Kuo, Y.-C., & Lu, S.-T. (2013). Using Fuzzy Multiple Criteria Decision Making Approach to Enhance Risk Assessment for Metropolitan Construction Projects. *International Journal of Project Management*, 602-614.

Muliano, B. E., Fahmi, I., & Asnawi, Y. H. (2021). Delay Risk Assessment in Crusher System Construction at PT Freeport Indonesia Underground Mine. *Jurnal Aplikasi Manajemen dan Bisnis*, 602-613.

Pall, G. K., Bridge, A. J., Skitmore, M., & Gray, J. (2016). Comprehensive Review of Delays in Power Transmission Projects. *IET Generation, Transmission and Distribution*, 3393-3404.

Razi, P. Z., Ali, M. I., & Ramli, N. I. (2019). AHP-based Analysis of the Risk Assessment Delay Case Study of Public Road Construction Project: An Empirical Study. *Journal of Engineering Science and Technology*, 875-891.

Shangea, N. W., Misra, R. N., & Mishra, S. K. (2020). Construction Delay Analysis of Some Indian Hydropower Projects. *Water and Energy International*, 61-67.

Tabucanon, M. T., & Dahanayaka, N. (1990). Overhaul Maintenance of Large Power-Generating Units: Management by Subprojects. *International Journal of Project Management*, 116-121.

Trauner, T. J. (2009). *Construction Delays Understanding Them Clearly, Analyzing Them (Second Edition).* Amsterdam: Elsevier Butterworth-Heinemann.

Wang, J., & Yuan, H. (2016). System Dynamics Approach for Investigating the Risk Effects on Schedule Delay in Infrastructure Projects. *Journal of Management in Engineering*, 1-13.

Wang, S. Q., Dulaimi, M. F., & Aguria, M. Y. (2004). Risk Management Framwork for Construction Projects in Developing Countries. *Construction Management and Economics*, 237-252.

Wu, Y., Li, L., Song, Z., & Lin, X. (2019). Risk Assessment on Offshore Photovoltaic Power Generation Projects in China based on A Fuzzy Analysis Framework. *Journal of Cleaner Production*, 46-62.

Yau, N.-J., & Yang, J.-B. (2021). Factors Causing Design Schedule Delays in Turnkey Projects in Taiwan: An Empirical Study of Power Distribution Substation Projects. *Project Management Journal*, 1-12.

DEMATEL AND ANP APPROACH FOR DEVELOPMENT OF LEAN SUPPLY CHAIN PERFORMANCE ASSESSMENT IN GARMENT INDUSTRY

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ABSTRACT

This research is focused on analysis to identify and select the best alternative criterias for development of lean supply chain performance assessment in PTE garment factory. This analysis is motivated by the existence of overtime costs, long production lead times, process inefficiency, high rate of defects, and final delivery that is not on-time. The four perspectives from Balanced Scorecard approach and combines with DEMATEL and ANP methods used in this study, with lean supply chain performance assessment using Searcy model. Result of this research is current leanness degree in PTE is only 26%, which indicates that there are several aspects that need to be improved. Calculations using DEMATEL concluded that there are six criterias have a one-way relationship, while five criterias have a two-way relationship. The best selected alternative criterias for each balanced scorecard perspective is reducing additional production costs (for financial perspective), reducing the number of product defects (for customer perspective), increasing the flexibility of sending raw materials from suppliers (for internal business perspective), and increasing the number of products with new styles (for innovation and learning perspective).

Keywords: DEMATEL, ANP, Balanced Scorecard, Lean Supply Chain.

1. INTRODUCTION

Reporting from Verified Market Research (2021), Indonesian Textile Industry is expected to continue growing significantly in the forecast period from 2021 to 2028, thus textile and garment sector need to rethink the supply chain management to react more effectively and real time (Jouhri and Aziz, 2020). Many approaches have been suggested over the years to develop supply chain performance assessments of each industry, such as Supply Chain Operational Reference (SCOR) and Balanced Scorecard (BSC). SCOR only assesses performance from two perspectives: internal business processes and customers (Ervil, et al., 2010), but BSC evaluate from four perspectives: financial, internal business processes, customers, as well as innovation and learning (Chia, 2009). This study was conducted at PTE as export-oriented garment factory, which has a complex supply chain due to it is heavily involved with local and international suppliers and foreign buyers.

The existing problems are identified in PTE according to the perspective in the BSC approach. From financial perspective, PTE has additional non-value added costs about 1.2 hours

of overtime in 2021, thus reducing the company's revenue. From internal business processes perspective, PTE achieved process efficiency only 82% from target 90% in 2021. From customer perspective, PTE achieved only 96% from target 100% for ontime delivery, and only 99% for shipped quantity. From innovation and learning perspective, PTE achieved only 25% from target 34% for product development and innovation. These problems shows the low supply chain performance in PTE. According to Behrouzi (2011b), the strategy that can be used is to develop supply chain performance by considering the lean paradigm which means reducing waste and costs, as well as improving quality, flexibility, and on-time delivery. This statement is reinforced by another study from Orji, et al. (2020) that lean approaches are widely adopted to eliminate waste and achieve efficiency. Because there is no research that specifically describes the development of lean supply chain performance in the garment industry, further analysis is needed to identify and select the best indicators that have the potential to be developed in accordance with the conditions in PTE itself.

2. LITERATURE REVIEW

Lean philosophy aims to produce products according to customer requirements with minimum waste and help supply chains overcome inefficiencies (Al-Aomar and Matloub, 2018). To achieve optimization according to the lean philosophy, activities that are not valuable from the customer's point of view must be eliminated to improve quality, reduce costs and increase flexibility (Ruiz-Benitez, et al., 2017).

2.1 Lean Supply Chain Performance

Several indicators were extracted to assist companies in evaluating lean supply chain performance appropriately, namely quality, cost, delivery and reliability, and flexibility (Behrouzi, 2011b).

2.2 Balanced Scorecard (BSC)

This approach allows managers to have a formal mechanism that will strike a balance between financial and non-financial outcomes in the short and long term. The BSC approach is not specifically designed for Lean Supply Chain, but this approach provides a better guide for measuring supply chain performance (Brewer, 2000). Performance measurement from a financial perspective shows whether strategic planning and implementation will provide improvements with the aim of increasing company profits (Kadarova, 2015). According to Valderamma et al. (2009) internal business process perspective refers to innovation, quality operations, and after-sales service. The customer perspective identifies how the conditions of customers and target markets are chosen by the company competitively. The innovation and learning perspective describes the organization's ability to make improvements and changes to utilize human resources (Kadarova, 2015).

2.3 Decision Making Evaluation and Laboratory (DEMATEL)

Because all the elements used in the ANP analysis must be related elements, so all criterias must be tested to determine whether there is a dependency between the criterias or not. DEMATEL method can be used as a tool to find out those dependency criteria (Yoserizal and Singgih, 2012).

2.4 Analytical Network Process (ANP)

ANP method is a development of the Analytical Hierarchy Process (AHP) method, because it is able to improve AHP weaknesses by being able to accommodate inter-criteria or alternative linkages. Although the ANP method is more complex, but it obtains an accurate prediction, objective comparison, and stable results (Saaty and Shih, 2009).

3. METHODS

The measured object in this study lean supply chain performance in PTE, with research subjects is people who are involved in the garment production process. Key informan is expert from planning department with consideration the relevant work experience as well as knowledge and ability to analyze existing business processes. Participants of this research are experts who are grouped into four clusters, that is person in-charge or section head from sales and merchandising, production, warehouse, and planning department. Data analysis consists of problem identification, data collection, data processing, and analysis and conclusion stages.

3.1 Problem Identification Stage

Start with identifying the empirical data about inefficient supply chain performance, then formulated into a problem formulation and research objectives. Literature and theory studies on lean supply chain, performance assessment, balanced scorecard, DEMATEL, and ANP were conducted to adjust the supporting theory with the facts in the research object.

3.2 Data Collection Stage

Lean supply chain criterias based on the balanced scorecard approach that were adopted from previous research obtained from international journals. Furthermore, these criterias are communicated with key informan to be validated in order to obtain criterias that are truly relevant to the company's conditions and strategy. These criterias reference was used to formulate the DEMATEL and ANP questionnaires.

3.3 Data Processing Stage

Start with develop an analytical structure, then measures the relationship between criterias using DEMATEL method, calculates the weight of each criteria using ANP method, then choose the best alternative. In this study, DEMATEL calculations were using MS Excel and ANP calculations were using MS Excel and Superdecision software.

3.4 Analysis and Conclusion Stage

An evaluation of criterias is carried out to obtain which indicators have the highest weight and can be considered for the best development of a lean supply chain performance assessment. Then conduct a gap analysis using Searcy model to compare the target and the actual performance that has been achieved. The final step is to draw conclusions and suggestions based on the data analysis result and interpretation that have been carried out.

4. RESULTS

Business processes in PTE start with receiving orderd from customers, then material purchasing to nominated suppliers. The material received by PTE will be unloaded and stored by the warehouse section and then conduct several quality tests. Raw materials that meet the standards will be forwarded to the pattern and marker process. Garment production process itself start with fabric cutting process and then transferred to sewing process. The semi-finished goods are then sent to the laundry for a washing process according to formula set by the customer. The washed garments are transferred to the finishing section for labeling, ironing, quality checking, and then packing according to destination country and size breakdown requested by customer. The garments delivered to customer by sea (ship) or by air (airplane) according to the schedule.

4.1 Determination of Lean Supply Chain Performance Criteria

Criteria for assessing lean supply chain performance in this study is based on the balanced scorecard approach from previous research by Behrouzi and Wong (2011a), that is cost, quality, delivery and reliability and flexibility, which are the main indicators in lean supply chain. Criterias and sub-criterias that have been validated by key informants, with total of four criterias and 11 sub-criterias can be seen in **Table 1**.

Table 1. Approved Criterias and Sub-criterias

Criteria	Sub-criteria
Cost	Additional production cost
	Process efficiency
	Return on sales
Quality	Defect rates of production
	Supplier rejection rate
Delivery and Reliability	On-time delivery to customers
	Order fulfillment to customers
	On-time production
Flexibility	Supplier volume flexibility
	Supplier delivery flexibility
	Number of new products

4.2 Identification of Criteria Effects with DEMATEL

The questionnaire results in the form of pairwise comparisons were processed using MS Excel in accordance with DEMATEL stages, including calculating the vector (D+R) called "prominence" to show how important a criterion is. After that, the vector (D-R) is also calculated called "relation" which is then grouped into causes and effects. The results of the calculation of vector D, vector R, vector D+R, and vector D-R, and D+R can be seen in **Table 2**.

Table 2. Calculation Results of All DEMATEL Vectors

Sub-criteria	Vector D	Vector R	Vector D+R	Vector D-R	Explanation
Additional production cost	4.841	6.181	11.02	-1.34	Effect
Process Efficiency	5.391	6.041	11.43	-0.65	Effect
Return on sales	5.618	6.905	12.52	-1.287	Effect
Defect rates of production	6.434	5.498	11.93	0.935	Cause
Supplier rejection rate	6.975	5.062	12.04	1.913	Cause
On-time delivery to customers	6.595	6.785	13.38	-0.19	Effect
Order fulfillment to customers	6.996	6.77	13.77	0.226	Cause
On-time production	6.937	7.469	14.41	-0.532	Effect
Supplier volume flexibility	5.564	5.218	10.78	0.346	Cause
Supplier delivery flexibility	5.811	5.63	11.44	0.181	Cause
No. of new products	4.395	3.998	8.394	0.397	Cause

From the calculation results of all vectors in **Table 2**, it can be concluded that sub-criteria for defect rates of production, supplier rejection rate, supplier rejection rate, supplier volume flexibility, supplier delivery flexibility and number of new products only affect other sub-criteria (one-way relationship), while sub-criteria additional production cost, process efficiency, return on sales, on-time delivery to customers, and on-time production are correlated (two-way relationship). Thus, it can be concluded that all sub-criterias have a relationship, so it can meet the requirements for further analysis using ANP method.

The total relationship matrix is also used to obtain treshold value by calculating the average on the matrix to determine the influence or relationship between the sub-criteria. The threshold value obtained in the study is 0.542, so the inter-sub-criteria linkages obtained can be seen in **Table 3**.

Table 3. Total Matrix and Correlation Value Between Sub-criteria

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
Additional production cost (1)	0.397	0.470	0.523	0.409	0.356	0.517	0.516	0.560	0.390	0.416	0.286
Process Efficiency (2)	0.548	0.433	0.574	0.450	0.417	0.565	0.565	0.638	0.428	0.433	0.340
Return on sales (3)	0.541	0.532	0.514	0.491	0.433	0.587	0.586	0.661	0.444	0.475	0.353
Defect rates of production (4)	0.608	0.598	0.695	0.472	0.515	0.685	0.684	0.743	0.501	0.537	0.396
Supplier rejection rate (5)	0.652	0.640	0.744	0.616	0.469	0.710	0.732	0.796	0.563	0.627	0.425
On-time delivery to customers (6)	0.621	0.609	0.685	0.563	0.524	0.595	0.698	0.758	0.538	0.599	0.405
Order fulfillment to customers (7)	0.654	0.642	0.746	0.618	0.576	0.735	0.629	0.798	0.565	0.605	0.426
On-time production (8)	0.650	0.661	0.740	0.588	0.547	0.730	0.728	0.687	0.561	0.623	0.423
Supplier volume flexibility (9)	0.537	0.526	0.589	0.461	0.428	0.581	0.580	0.631	0.385	0.496	0.350
Supplier delivery flexibility (10)	0.557	0.522	0.612	0.480	0.446	0.629	0.603	0.680	0.484	0.436	0.363
No. of new products (11)	0.415	0.408	0.482	0.350	0.350	0.450	0.449	0.515	0.359	0.384	0.233

Each value in the total relationship matrix will be compared with the threshold value. If the value in the matrix is higher than threshold value, it means that those sub-criteria has an influence or is related to other sub-criteria. Meanwhile, if the value is smaller than the threshold value, then the sub-criteria do not have a strong relationship (not related). Values in the yellow highlight are sub-criteria that do not have a strong relationship.

4.4 Network Structure

There are four criterias and 11 alternatives that are tested in this study from the perspective of financial, customer, internal business, and innovation and learning. The network structure in this study can be seen in **Figure 1.**

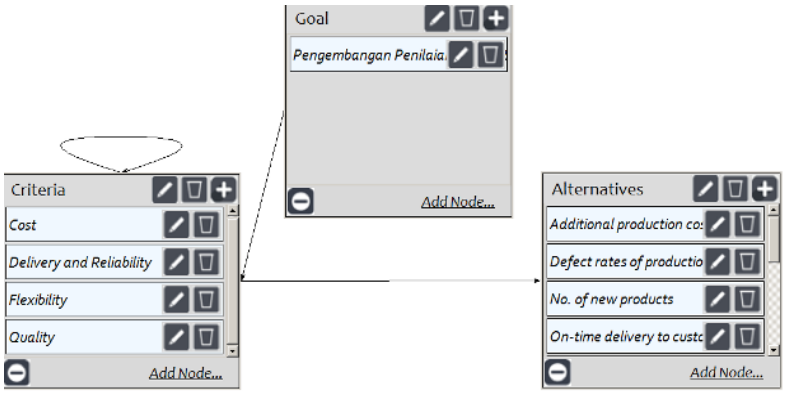


Figure 1. Network Structure

4.5 Weighting Using Expert Judgment

The weighting of ANP method is carried out by giving questionnaires to five participants who are expert in several related departments with varying work experience between 11-25 years. To unify the opinions of the five participants, the average of the results of the questionnaire was calculated with geomean as the final weighting result. The weighting of each criteria can be seen in **Table 4**.

Tabel 4. Weighting of Lean Supply Chain Performance Assessment Development Criteria

No.	Criteria	Weight
1	Cost	3.7%
2	Quality	24.2%
3	Delivery & Reliability	29.3%
4	Flexibility	42.7%

From the calculation results, it can be concluded that the highest weight percentage is the flexibility criteria, which is 42.7%, meaning that the flexibility criteria is the most influential criteria in the development of lean supply chain performance assessment at PTE, while the least influential criteria is cost criteria. The resulting Consistency Ratio (CR) value is 0.06, meaning that the value is accepted because it is smaller or equal to 10%. With a CR value of 0.06, it can be concluded that the criteria for developing lean supply chain performance assessment at PTE are considered consistent. Weighting is also carried out for each criteria which can be seen in **Table 5** to **Table 8** below.

Table 5. Alternative Weighting Criteria Cost

No.	Criteria	Weight
1	Additional production cost	21.0%
2	Process efficiency	69.4%
3	Return on sales	9.6%

Based on the calculation results, it can be concluded that the alternative in the cost criteria that has the highest weight percentage is process efficiency, which is 69.4%. Thus, the best alternative chosen in the development of lean supply chain performance assessment in terms of cost criteria is to increase the efficiency of the production process. The inconsistency value in the selection of this alternative is 0.008, so it can be concluded that the pairwise comparison for this alternative is considered consistent and acceptable because $CR \leq 0.1$.

Table 6. Alternative Weighting Criteria Quality

No.	Criteria	Weight
1	Defect rates of production	50.0%
2	Supplier rejection rate	50.0%

Based on the calculation results, it can be concluded that the two alternatives in the quality criteria have the same high weight percentage, which is 50%. Thus, the best alternative chosen in the development of lean supply chain performance assessment in terms of quality criteria is to simultaneously reduce the defect rates of production and the supplier rejection rate. The inconsistency value in the selection of this alternative is 0.008, so it can be concluded that the pairwise comparison for this alternative is considered consistent and acceptable because $CR \leq 0.1$.

Table 7. Alternative Weighting Criteria Delivery and Reliability

No.	Criteria	Weight
1	On-time delivery to customers	17.4%
2	Order fulfillment to customers	63.4%
3	On-time production	19.2%

Based on the calculation results, it can be concluded that the alternative in terms of delivery and reliability criteria that has the highest weight percentage is order fulfillment to customers, which is 63.4%. Thus, the best alternative chosen in the development of lean supply chain performance assessment in terms of delivery and reliability criteria is to fulfill customer orders with a predetermined quantity of goods. The inconsistency value in the selection of this alternative is 0.008, so it can be concluded that the pairwise comparison for this alternative is considered consistent and acceptable because CR ≤ 0.1.

Table 8. Alternative Weighting Criteria Flexibility

No.	Criteria	Weight
1	*Supplier volume flexibility*	26.0%
2	*Supplier delivery flexibility*	41.3%
3	*No. of new products*	32.7%

Based on the calculation results, it can be concluded that the alternative in the flexibility criteria that has the highest weight percentage is supplier delivery flexibility, which is 41.3%. Thus, the best alternative chosen in the development of lean supply chain performance assessment in terms of flexibility criteria is to increase delivery flexibility from suppliers, thereby supporting punctuality in starting production. The inconsistency value in the selection of this alternative is 0.008, so it can be concluded that the pairwise comparison for this alternative is considered consistent and acceptable because CR ≤ 0.1.

4.6 Best Framework Selection

This study uses a balanced scorecard approach, meaning that each criteria must be considered in the development of a supply chain performance assessment framework with this lean paradigm. This study limits one alternative from each perspective that has the largest weight according to calculations. **Figure 2** shows the selected alternative according to calculations using ANP.

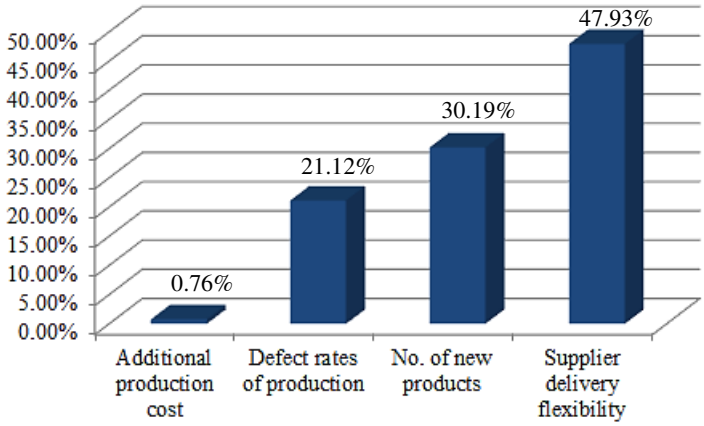


Figure 2. Selected Alternatives

Figure 2 concludes that to develop lean supply chain performance assessment in PTE, from a financial perspective, PTE must consider the cost criteria with alternative developments, namely additional production costs; from customer perspectives, PTE must consider quality criteria with alternative developments, namely defect rates of production; from internal business perspectives, PTE must consider flexibility criteria with alternative developments, namely supplier

delivery flexibility; from the perspective of innovation and learning, PTE must consider the flexibility criteria with its development alternative, namely the number of new products.

4.7 Sensitivity Analysis

Based on the results of the analysis using superdecision software, it appears that from the customer's perspective, if the priority vector (PV) value for the delivery and reliability criteria is increased by 63.7%, then there is a change in the priority ranking from the original defect rates of production to priority, turning into an alternative order fulfillment to customers which is a priority. For other criteria, there is no change in priority ranking even PV value up to the 100%. From a financial perspective, if the PV value for the quality criteria is increased by 82.5%, there will be a change in priority ranking, where the alternative of additional production costs is no longer a priority because the weight is the same as other alternatives from the same perspective. Likewise, if the delivery and reliability criteria and flexibility criteria are increased. Meanwhile, from an internal business perspective, if the PV value for the quality criteria is increased by 79.2%, there will be a change in the priority ranking from the previous alternative supplier delivery flexibility to being a priority, turning into an alternative supplier rejection rate which is a priority. For other criteria, there is no change in priority ranking even PV value up to the 100%.. Thus, it can be concluded that the criteria for quality, delivery and reliability, and flexibility have an effect on sensitivity to the chosen alternatives such as defect rates of production, additional production costs, and supplier delivery flexibility.

4.8 Gap Analysis

The selected alternative is then carried out a gap analysis by comparing the target and the actual performance that has been achieved by PTE. This performance appraisal process uses the Searcy model to assess how lean PTE's supply chain is currently doing. The Searcy model developed by Maskell and Baggaley (2004) compares the initial assessment (baseline) that corresponds to zero or the starting point of the assessment, the company's current supply chain performance, and the target or improvement to be achieved (Afonso and Maria, 2015). Calculation of lean performance in this analysis uses the weights obtained from calculations using the ANP method for each selected alternative. The baseline performance rating is zero because there has been no prior improvement. Assessment of current performance (current state) is used historical data at PTE in 2021. Assessment of future performance (future state) is 100% because it refers to increasing the maximum performance assessment in the future. The results of the lean performance assessment at PTE can be seen in **Table 9**.

Table 9. Lean Supply Chain Performance Assessment

Measure	*Weights*	*Baseline*		*Current State*		*Future State*	
		Results	*Score*	*Results*	*Score*	*Results*	*Score*
Additional production cost	0.4%	0%	0%	16%	0%	100%	0.4%
Defect rates of production	10.8%	0%	0%	6%	1%	100%	10.8%
Supplier delivery flexibility	24.2%	0%	0%	81%	20%	100%	24.2%
No. of new products	15.2%	0%	0%	37%	6%	100%	15.2%
Overall Score	**50.7%**		**0%**		**26%**		**50.7%**

Based on **Table 9**, it can be concluded that with the four selected alternatives used for analysis, the leanness degree of the PTE supply chain is 26% which indicates that there are several

aspects that need to be improved. Therefore, the next step that can be taken is to identify opportunities for improvement and implement lean measures that can result in better supply chain performance.

4.9 Identification of Business Process Effects on Lean Supply Chain Performance

Business process impact identification is based on the company's 2021 internal data for each process. From a financial perspective, with the alternative development being additional production costs (overtime costs), the panel sewing process, finishing, packing, and loading processes, and inspection processes are the processes that have the most influence on lean supply chain performance from a financial perspective. From the customer perspective, the development alternative is defect rates of production, the wet and dry washing processes, as well as the finishing, packing, and loading processes have a considerable influence on the high defect rates of production, thus causing the low performance of the lean supply chain from the customer's perspective. From an internal business perspective, with the alternative development being supplier delivery flexibility, the procurement process for materials by the purchasing party and the material receiving process are the core processes to assess the flexibility of material delivery from suppliers. From the perspective of innovation and learning, with the alternative development being the number of new products, the process of receiving orders by sales and merchandising is the main process that affects lean supply chain performance from this perspective.

6. CONCLUSIONS

The results of this study resulted in several conclusions. The assessment of lean supply chain performance from Maskell and Baggaley (2004) resulted in the leanness degree that PTE has achieved of 26%, which indicates that there are several aspects that need to be improved in the current PTE supply chain. The selection of the best framework for each balanced scorecard perspective is to reduce additional production costs (financial perspective), reduce the level of product defects during production (customer perspective), increase the flexibility of sending raw materials from suppliers (internal business perspective), and increase the number of products with new styles. (innovation and learning perspective). The selected framework is very helpful for PTE for the development of lean supply chain performance assessment in the future. If the framework is applied, PTE will be able to streamline the supply chain and integrate supply chain partners for the better. The corrective actions or strategies determined based on the results of the analysis and discussion are divided into four points and their respective managerial implications. First, reflection and repetition of the current Standard Operating Procedures (SOP). To reduce additional production costs that occur in several processes, PTE must be able to complete the process on time so that the final process is not rushed and does not increase working hours just to meet the delivery deadline. PTE must also select raw materials properly and correctly from the beginning of material receipt so as to reduce the excessive inspection process carried out in every business process. Foreman and supervisors have an important role in controlling this business process so that it runs correctly and is completed on time according to the SOP that has been set. Second, PTE must speed up the evaluation process, and speed up reporting of the evaluation results to related customers, so that customers will know from the start of the potential delay in the delivery of finished goods from PTE. This accuracy and speed can avoid PTE from penalties due to delivery delays, on the other hand can also improve lean supply chain performance from an internal business perspective. Third, skill improvement to increase production output and process efficiency. Fourth, process improvement to reduce the number of defective products. PTE must be able to apply the principle of "do the right thing on the first time". Operators who are processing

the goods correctly from the start will be able to reduce non-value added inspection processes and rework.

REFERENCES

Afonso, Hugo dan Maria do Rosário Cabrita. (2015). Developing a Lean Supply Chain Performance Framework in a SME: A Perspective Based on the Balanced Scorecard. *Procedia Engineering,* Portugal, 270-279.

Al-Aomar, Raid dan Matloub Hussain. (2018). An Assessment of Adopting Lean Techniques in the Construct of Hotel Supply Chain. *Tourism Management* 69, 553-565.

Behrouzi F, dan Wong KY. (2011a). An Investigation and Identification of Lean Supply Chain Performance Measures in the Automotive SMEs. *Scientific Research and Essays* 6, 5239-5252.

Behrouzi F, dan Wong KY. (2011b). Lean Performance Evaluation of Manufacturing Systems: A Dynamic and Innovative Approach. *Procedia Computer Science,* Malaysia, 388-395.

Brewer PC, dan Speh TW. (2000). Using the Balanced Scorecard to Measure Supply Chain Performance. *Journal of Business Logistics* 21, 75-93.

Chia A, Goh M, dan Hum S. (2009). Performance Measurement in Supply Chain Entities: Balanced Scorecard Perspective. *Benchmarking: An International Journal* 5, 605-620.

Ervil, Riko, Patdono Suwignjo, dan Ahmad Rusdiansyah. (2010). Pengembangan Model Pengukuran Kinerja Supply Chain Berbasis Balanced *Scorecard* (Studi Kasus PT. Semen Padang). *Article of Prosiding Seminar Nasional Manajemen Teknologi XI Program Studi MMT-ITS,* Surabaya.

Jouhri, Mohamed dan Aziz Soulhi. (2020). Lean Supply Chain Management: A Powerful Combination for Success. *International Journal of Science and Research* 9, 916-920.

Kadarova, J. J. R. T., Michaela, K, dan Gabriel K. (2015). The Proposal of an Innovative Integrated BSC-DEA Model. *Procedia Economics and Finance,*Prague, Czech Republic, 1503-1508.

Maskell B, Baggaley B. (2004). *Practical Lean Accounting – A Proven System for Measuring and Managing the Lean Enterprise*. Productivity Press, New York.

Orji, Ifeyinwa Juliet dan Shaoxuan Liu. (2020). A Dynamic Perspective on the Key Drivers of Innovation-Led Lean Approaches to Achieve Sustainability in Manufacturing Supply Chain. *International Journal of Production Economics* 219, 480-496.

Ruiz-Benitez, Rocio, Cristina López, dan Juan C. Real. (2017). .Environmental Benefits of Lean, Green and Resilient Supply Chain Management: The Case of the Aerospace Sector. *Journal of Cleaner Production* 167, 850-862.

Saaty, T. L. dan Shih, H. S. (2009). Structures in Decision Making: On the Subjective Geometry of Hierarchies and Networks. *European Journal of Operational Research* 199, 867-872.

Valderrama, Terasa G., Eva M., dan Daniel R. B. (2009). Relating the Perspectives of the Balanced Scorecard for R&D by Means of DEA. *European Journal of Operations Research* 196, 1177-1189.

Verified Market Research. (2021). Indonesia Textile Industry Market Size By Type, By Raw Material, By Distribution Channel, By Geographic Scope And Forecast. *Report Research*, 202.

Yoserizal, Yosta dan Moses L. Singgih. (2012). *Integrasi Metode DEMATEL (Decision Making Trial and Evaluation Laboratory) dan ANP (Analytic Network Process) dalam Evaluasi Kinerja Supplier Di PT. XYZ*, Thesis, Institut Teknologi Sepuluh Nopember, Surabaya.

EFFECT OF PROFITABILITY, LIQUIDITY, AND SOLVENCY RATIO ON STOCK RETURN CASE STUDY ON SHARIA COMPANIES DURING COVID-19 PANDEMIC Q1 2020 – Q3 2021

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ABSTRACT

Financial statements are a representation of the company's activities and conditions from the financial aspect through financial ratios Financial ratios commonly used are profitability ratios, liquidity ratios and solvency ratios In Muslim countries, the sharia label on shares on the stock market is an indicator for investors to invest their capital. The Indonesian Stock Price Index (IHSG) has experienced serious turmoil during the COVID-19 pandemic since the beginning of 2020. This is a special condition that has not happened in recent years. This study aims to analyze the effect of profitability, liquidity and solvency ratios on Islamic stock prices during the COVID-19 pandemic, during Q1 2020 to Q3 2021 using the SEM-PLS method. The results of the analysis of the influence of financial ratios will be the basis for formulating stock selection strategies during the pandemic. This study results that the profitability ratio has a significant effect while the liquidity and solvency ratios do not have a significant effect on stock returns. It was also found that the consumer raw goods, health and technology sector was worthy of investment during the COVID-19 pandemic.

Keywords: Profitability ratio, Liquidity ratio, Solvency ratio, Stock price, Stock Return, Sharia stock, Covid-19.

1. INTRODUCTION

As a country with the largest number of Muslims in the world, Indonesia is one of the countries that actively promotes sharia economy in various fields, including the capital market and investment. Nurlita et al. (2018) stated that it is important for the government to present a capital market that adheres to sharia principles that regulate activities in the Capital Market. The Financial Services Authority (OJK) alongside with *Majelis Ulama Indonesia* (MUI) conduct periodic studies to evaluate the stocks included in the Sharia Securities List (DES). OJK (2020) stated that several stock indices that classify sharia stocks are the Indonesian Sharia Stock Index (ISSI) and Jakarta Islamic Index (JII). The sharia label is given to shares that have met the criteria as sharia shares. This is a positive signal for Muslim investors who adhere to sharia principles in their activities.

Quoted from CNN (2020), the COVID-19 pandemic has emerged since 2019 spreading to various parts of the world including Indonesia. The first positive case of COVID-19 in Indonesia, was officially confirmed by the Indonesian government in early March 2020. The company's business activities were hampered due to various government policies to limit the spread of the corona virus, such as Work From Home (WFH) in several industrial sectors. Damayanti et al.

(2021) states that the implementation of mass social restrictions in various regions and big cities also affects the company's financial condition. Companies whose activities are hampered have difficulty in making profits. Therefore, the results of the analysis of the company's financial statements have experienced unusual conditions since the pandemic. Capital market activities in Indonesia experienced quite serious turmoil during the pandemic. Damayanti et al. (2021) states that this has resulted in many investors and market participants doing panic selling to take their capital and save it as cash to face the threat of recession and crisis.

Ezrad et al. (2017) states that a company is said to be financially healthy if it has healthy financial reports. To measure whether or not the company's financial performance can be analyzed with financial ratios. Financial ratios that are often used to analyze the company's financial condition include; profitability ratios, liquidity ratios and solvency.

Based on the background of the problem, researchers are encouraged to compare whether financial performance described by financial ratios on sharia stocks has an effect on stock returns during the COVID-19 pandemic using SEM-PLS method. The financial ratios used are the profitability ratios described by Return on Assets (ROA), the liquidity ratios described by the Current ratio (CR) and quick ratio (QR), and the solvency ratio described by the Debt to Equity Ratio (DER). The results of the influence analysis will be grouped by industry sector and then each industry will be used as the basis for choosing a stock portfolio strategy during the pandemic.

2. LITERATURE REVIEW

2.1 Basic Theory

2.1.1 Signaling Theory

Signaling theory was first described by Spence (1973). This theory explains that there is a signal sent from the owner of the information as the sender in the form of information that describes the condition of an entity or company that is used by the recipient, such as the investor. Jogiyanto (2017) states that the signal sent from the sending party will be analyzed and interpreted first by the investors and other stakeholders. The results of the analysis of the information are considered as good news (positive signal) or bad news (negative signal). In this study, signaling theory is used to explain the effect of signals in the form of company financial statements that have been analyzed using financial ratios to stock returns during the COVID-19 pandemic.

2.1.2 Sharia Enterprise Theory (SET)

According to Triyuwono (2007), Sharia Enterprise Theory (SET) is a theory that explains that the stakeholders of an entity or company in an Islamic perspective, are not only human (managerial, directors, community and employees) and the surrounding environment. But there is a God who is the center of the main and final responsibility of all activities in the world for both individuals and businesses. This theory is used as the basis for the importance of the sharia label for a company, namely as a legitimacy that sharia labeled companies always involve God as a stakeholder which is reflected in operational activities that pay attention to sharia values.

2.2 Financial Ratios and Stock Return

2.2.1 Profitability Ratio

According to Kasmir (2016), the profitability ratio is a ratio that describes a measure of the level of ability of the entity to generate profits. Putri and Jaharuddin (2018) states regarding the concept of profitability in an Islamic perspective, Islam pays attention to profitability in material and non-material forms. In Islam, profitability or profit must come from good and *halal* capital as ordered by Allah SWT. In the context of the company, it is obligatory to stay away from *riba*.

The profitability ratio commonly used by stakeholders in analyzing the company's financial statements is Return on Assets (ROA). Kasmir (2016) states that by using ROA it can be seen how big the level of the company's ability to be able to generate profits from a number of assets it has.

2.2.2 Liquidity Ratio

Kasmir (2016) states that the liquidity ratio is a ratio that measures the ability of an entity to pay off its short-term debt that will soon mature or a ratio that describes the ability of an entity or company to fulfill its responsibilities to pay its debts. In the view of Islam, debt activity is something that is permissible. But it is important for the company to pay its debts promptly and on time according to the due date. Prohibit delaying the payment of debts that are past due. This is in line with the concept of the liquidity ratio which measures how much the ability of an entity or company to pay its short-term debt. Kasmir (2016) states that the Current Ratio (CR) is the ratio used by the company to describe the entity's ability to pay off its short-term liabilities by utilizing the company's current assets. While the Quick Ratio (QR) is a ratio that describes the level of ability of an entity to meet its short-term obligations with current assets without involving inventory or merchandise inventory.

2.2.3 Solvency Ratio

Kasmir (2016) states that the solvency ratio is used to describe how much the company is able to pay off all of its liabilities, both short-term liabilities and long-term liabilities if the company is dissolved/liquidated. According to the sharia concept stipulated by OJK (2017) in OJK regulation Number 35/POJK.04/2017 concerning Criteria and Issuance of Sharia Securities List, it is explained that company debt is one of the parameters that a company is said to be sharia or not. Companies whose shares are categorized as sharia shares must have total interest-based debt compared to total assets of not more than 45% (forty five percent). The Debt to Equity Ratio (DER) according to Kasmir (2016) is a ratio that measures the value of debt to equity. This ratio aims to determine the level of company financing using debt.

2.2.4 Stock Return

Based on Jogiyanto (2017), In investment instruments in the form of stocks, the return obtained from profits distributed by the company (dividends) and from capital gains called stock returns. According to Rachmawati and Suhermin (2017), return from investment is one of the main factors that determine an investor to invest. The return is not always a profit but can also be a risk of loss. To measure the stock return value.

2.3 Structural Equation Modelling - Partial Least Square (SEM-PLS)

According to Hair et al. (2014), Structural Equation Modeling (SEM) is an analytical method that allows a separate relationship for each dependent variable. This method is composed of two components, among others: a structural model and a measurement model. The first is the structural model, or implemented as a path model (direction), which deals with the relationship of the independent and dependent variables. Both measurement models, with this model, researchers can use more than one variable (indicator) for one independent or dependent variable. Hair et al. (2014) also states that PLS-SEM (Partial Least Square) is commonly used to be able to develop theories from an exploratory type of research. This method is used by focusing on describing the variance in the dependent variable when examining the model.

3. METHODS

3.1 Data

This study uses quantitative methods with secondary data sources. In this study, the population of the research object is companies that are listed on the Indonesia Stock Exchange (IDX) and listed on the LQ45 or JII30 index and the Indonesian Sharia Stock Index (ISSI) in the 2020-2021 period. During the research period from the 1st quarter (Q1) of 2020 to the 3rd quarter (Q3) of 2021. The research sample was selected by purposive sampling on the basis of judgment (judgment sampling).

Table 1. Sampling Research

No.	Description	Count
1	List of Companies registered in Indonesian Sharia Stock Index (ISSI) during research period Q1 2020-Q3 2021.	497
2	List of Companies registered in Indonesian Sharia Stock Index (ISSI) consistent during research period Q1 2020-Q3 2021.	385
3	List of Companies registered in Index LQ45 consistent during research period Q1 2020-Q3 2021.	50
4.	List of Companies registered in Index JII30 consistent during research period Q1 2020-Q3 2021.	27
5	List of Companies registered in Index LQ45 or JII30 and ISSI consistent during research period Q1 2020-Q3 2021.	32
TOTAL SAMPLE 7 QUARTAL		224

Table 2. Number of samples per IDX industrial sector

Industrial Sector	Sample Count	Sector Member
Raw Material	6	BRPT, INCO, INTP, SMGR, TINS, TPIA
Non-Primary Consumer Goods	3	ACES, ERAA, MNCN
Primary consumer goods	4	CPIN, ICBP, INDF, UNVR
Energy	6	ADRO, AKRA, ITMG, PGAS, PTBA, ANTM
Infrastructure	4	EXCL, PTPP, TLKM, WIKA
Health	1	KLBF
Finance	1	BTPS
Industry	4	INKP, JPFA, TKIM, UNTR
Property and real estate	2	CTRA, PWON
Technology	1	EMTK

3.2 Operational Variable

The processed data are financial variables and stock prices which will be calculated into financial ratios and stock returns. As an indicator of the profitability ratio variable described by Return On Assets (ROA), liquidity ratio described by the Current Ratio (CR) and Quick Ratio (QR), the solvency ratio described by the Debt to Equity Ratio (DER) and dividends of each issuer and closing price shares in each quarter from the 1st quarter of 2020 to the 3rd quarter of 2021. Stock return is a dependent variable of this study the following formula can be used:

$$Stock\ Return = \frac{P_t - P_{t-1} + D_t}{P_{t-1}}$$

Whereas:
P_t = Stock price at t period
P_{t-1} = Stock price at previous of t period
D_t = Dividend price at t period

Independent variables of the study are profitability ratio which described by Return On Asset (ROA) To measure the profitability ratio using ROA, the following formula is used:

$$ROA = \frac{Earning\ After\ Tax}{Total\ asset}$$

The second independent variables of the study are liquidity ratio which described by Current Ratio (CR) and Quick Ratio (QR). To measure the liquidity ratio using CR and QR, the following formula is used:

$$Current\ Ratio = \frac{Total\ Current\ Asset}{Total\ Current\ Liabilities}\ \text{X } 100\%$$

$$Quick\ Ratio = \frac{Total\ Current\ Asset\ -Inventory}{Total\ Current\ Liabilities}\ \text{X } 100\%$$

The last independent variables of the study are solvency ratio which described by Debt to Equity Ratio (DER). To measure the DER value, the following formula can be used:

$$Debt\ to\ Equity\ Ratio = \frac{Total\ Liabilities}{Total\ Equity}\ \text{X } 100\%$$

The variables are used to measuring significant effect between independent on dependent variables using SEM-PLS method. Variables that have a significant effect will be used to analyze stock selection strategies during the pandemic. Based on the average value of the significant variables then compared the average of each industrial sector with the average of all sectors based on the selected sample of sharia company data.

4. RESULTS

4.1 Descriptive Statistics

Descriptive statistics show a description of variable data with statistics referring to the mean and standard deviation, minimum and maximum values and the variables studied include Stock Return, Debt to Equity Ratio, Return on Assets, Current Ratio and Quick Ratio during the Q1 research period. 2020 to Q3 2021 is presented in the table below:

Table 3. Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
ROA	224	-8,44	34,95	5,98	6,68
CR	224	0,29	8,89	2,16	1,35
QR	224	0,11	5,53	1,31	0,93
DER	224	0,00	204,26	49,03	48,45
Stock Return	224	-0,35	1,74	0,08	0,27

The table shows descriptive statistics of each research indicator. Based on the table above, it can be explained that: The ROA (Return On Asset) indicator has the lowest value of -8.44 found in EMTK issuers in the first quarter of 2020 and the highest at 34.95 in UNVR issuers in the third quarter of 2020 with an average of 5.98. The CR (Current Ratio) indicator has the lowest value of 0.29 found in EXCL issuers in the 3rd quarter of 2020 and the highest of 8.89 in ACES issuers in the 3rd quarter of 2021 with an average of 2.16. The QR (Quick Ratio) indicator has the lowest value of 0.11 which is found in the first quarter of 2020 TINS issuers and the highest of 5.53 which is found in the 2nd quarter of 2021 UNVR issuers with an average of 1.31. The DER (Debt to Equity Ratio) indicator has the lowest value of 0.00 found in ACES issuers in the first quarter of 2020 and the highest at 204.26 in TINS issuers in the first quarter of 2020 with an average of 49.03. The stock return indicator has the lowest value of -0.35 found in WIKA issuers in the fourth quarter of 2020 and the highest at 1.74 in ANTM issuers in the second quarter of 2020 with an average of 0.08.

4.2 Hypothesis Testing and Discussion

Using the SEM-PLS method, the analysis of the influence between variables was carried out after going through the validity and reliability testing of the model. Based on the results of the validity test, the loading factor value that all indicators have given the recommended value is above 0.5. It means that the indicators used in this study are valid or have met convergent validity. The AVE value is above 0.5 for all constructs contained in the research model. Based on the results of reliability testing with Cronbach's alpha analysis, all variable constructs are above the recommended value of 0.6. This means that all the variable constructs in the model are reliable and can be continued to the next processing stage.

The next stage after getting the best model that has passed the test is to test the hypothesis on the construct of the model obtained. The following are the results of hypothesis testing on the model:

Table 4. Hypothesis Testing Result

	Coefficient	P Values	Notes
LIQUIDITY -> STOCK_RETURN	0,902	0,1836	H1 Rejected
PROFITABILITY -> STOCK_RETURN	1,987	0,0176	H2 Accepted
SOLVENCY -> STOCK_RETURN	0,200	0,4216	H3 Rejected

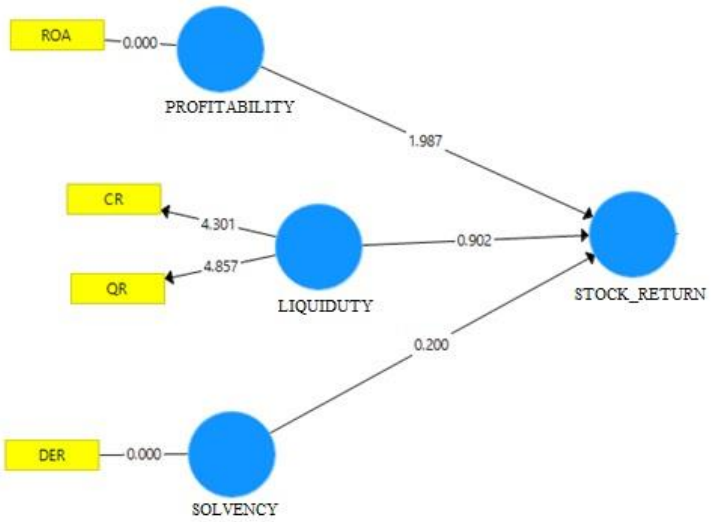


Figure 1. SEM-PLS Path Coefficient Result

4.2.1 Liquidity Ratio on Stock Return

H1: The hypothesis that explains that the liquidity ratio described by the Current ratio (CR) and Quick ratio (QR) has a significant effect on stock returns of Islamic companies during the COVID-19 pandemic.

Based on the test results, it is known that the liquidity ratio coefficient is 0.902, meaning the greater the value of the liquidity ratio described by the Current ratio and Quick ratio, the higher the stock return value. The test results show that the p-value is 0.1836 > 0.05 (alpha 5%), so it is concluded that the liquidity ratio described by the Current ratio and Quick ratio has no significant effect on stock returns during the COVID-19 pandemic. The results of this study support the results of Fauzan (2021) research which examines the effect of financial ratios on stock prices. The results of the study concluded that CR (Current Ratio) had no significant effect on the stock price of JII70. This is because the value of the liquidity ratio studied in each company during the 7 research quarters tends to be stable and there are no significant changes because the CR and QR values are calculated based on the components of current assets and liabilities with the value of each period being carried over to the next period so that there is no significant changes when analyzed with a quarterly range per three months.

4.2.2 Profitability Ratio on Stock Return

H2: The hypothesis that explains that the profitability ratio described by the Return on Assets (ROA) ratio has a significant effect on stock returns of Islamic companies during the COVID-19 pandemic.

Based on the test results, it is known that the coefficient of the profitability ratio is 1.987, meaning that the greater the value of the profitability ratio described by Return on Assets (ROA), the higher the value of stock returns. The test results show that the p-value is 0.0176 <0.05 (alpha 5%) so that it is statistically concluded at the 95% confidence level that the profitability ratio described by Return on Assets (ROA) has a significant effect on stock returns during the pandemic. COVID-19. The results of this study support the results of research by Ezrad (2017) which examine the effect of financial ratios on sharia stock returns on the Jakarta Islamic Index (JII). The results of the study conclude that ROA (Return on Assets) simultaneously has a significant effect on Islamic stock returns. The higher the ROA value indicates that the company

has good financial performance and shareholders will get high dividends so that it also increases the stock returns obtained by investors. During the COVID-19 pandemic, the public saw how the company's ability to survive and still managed to generate profits so that the profitability ratio became a reference for investors to make investment decisions.

4.2.3 Solvency Ratio on Stock Return

H3: The hypothesis that explains that the solvency ratio described by the Debt to Equity (DER) ratio has a significant effect on stock returns from Islamic companies during the COVID-19 pandemic.

Based on the test results, it is known that the solvency ratio coefficient of 0.200 means that the greater the value of the solvency ratio described by Debt to Equity (DER), the higher the stock return value. The test results show that the p-value is 0.4216 > 0.05 (alpha 5%) so that it is statistically concluded at the 95% confidence level that the solvency ratio described by Debt to Equity (DER) has no significant effect on future stock returns. COVID-19 pandemic. The results of this study support the results of previous research by Utami and Darmawan (2019) which stated that the DER value had no significant effect on Indonesian Islamic stock prices. This means that the solvency ratio described by DER is not an important consideration for investors in making investment decisions during the COVID-19 pandemic in Islamic companies.

4.3 Stock Selection Strategy for Investment in Sharia Stocks during the COVID-19 Pandemic

Based on the results of the research hypothesis testing, it was found that only the profitability ratio described by the Return on Assets (ROA) ratio had a significant effect on stock returns. The determination of the stock selection strategy for investment is carried out as follows: The ROA ratio will be grouped by quarter per industrial sector determined by the Indonesia Stock Exchange. Then according to Sidik and Rekino (2016), the average ROA per industrial sector every quarter will be compared with the average ROA in each quarter for the overall value of the Islamic companies studied. If the ROA value is less than the average value per quarter then the industrial sector will be categorized as poor, otherwise if the value is greater than or equal to the average in the quarter, it will be categorized as good.

Table 5. Average ROA by sector per quarter

Industrial Sector	Quarter						
	Q1 2020	Q2 2020	Q3 2020	Q4 2020	Q1 2021	Q2 2021	Q3 2021
Raw Material	1,3	1,4	2,04	2,3	3,34	4,39	4,52
Non-Primary Consumer Goods	9,55	8,13	8,39	8,45	8,62	9,21	8,86
Primary consumer goods	16,61	16,3	14,32	15,44	14,93	15,11	13,65
Energy	4,78	4,23	3,76	3,35	3,27	5,84	9,49
Infrastructure	4,02	3,78	3,54	2,51	1,95	2,05	2,35
Health	12,5	12,89	12,46	12,76	12,07	12,5	12,82
Finance	2,51	2,66	3,27	5,2	2,17	9	8
Industry	7,29	5,42	5,15	4,36	3,84	6,06	6,31
Property and real estate	0,36	1,13	1,43	3,44	0,75	2,5	1,68
Technology	-8,44	-4,38	-0,45	11,62	10,05	11,72	8,02
All Sectors	5,75	5,42	5,32	5,78	5,44	6,88	7,25

If the average value of ROA is less than the average value per quarter or negative value < 0 then the industrial sector will be categorized as unfavorable, otherwise if the value is greater than or equal to the average in the quarter it will be categorized as good. Example comparison as follows: The average ROA of the raw goods sector in Q1 2020 compared to the average ROA of all sectors is 1.30 < 5.75. So the raw goods sector in the first quarter of 2020 is categorized as NG (Not Good).

Based on the results of the categorization of the business sector, there are 4 (four) sectors that have dominantly good categories during the COVID-19 pandemic, including: Non-primary consumer goods sector have 6 (six) quarters in good category, Primary consumer goods sector have 7 (seven) quarters in good category, Health sector have 7 (seven) quarters in good category, and technology sector have 4 (four) quarters in good category. Sharia companies in the primary consumer goods sector are companies that are worth investing in during the COVID-19 pandemic. The primary consumer goods sector includes companies engaged in the supply chain of basic necessities. This allows Islamic companies in the primary consumer goods sector to survive and produce good financial performance during the COVID-19 pandemic. Sharia companies in the non-primary consumer goods sector are companies that are worth investing in during the COVID-19 pandemic. During the COVID-19 pandemic, Islamic companies in the non-primary consumer goods sector were flooded with sales of gadgets for WFH needs and online learning. Therefore, this sector can survive and produce good financial performance during the COVID-19 pandemic. Sharia companies in the health sector are companies that are worth investing in during the COVID-19 pandemic. Health sector companies that include businesses such as hospitals, supply chains of medicines and medical tools and others during the pandemic are the companies with the highest increase in share prices during the pandemic. COVID-19 has caused the operations of companies in this sector to be very busy with the number of sufferers of the disease, the high demand for medicines and medical tools as well as the need for vaccines and health facilities as well as the assistance from the government which eased the company's operational costs. This allows companies in the health sector to survive and produce good financial performance during the COVID-19 pandemic. Sharia companies in the technology sector are companies that are worth investing in during the COVID-19 pandemic. At the beginning of the pandemic period, companies in this sector experienced poor financial performance and began to show positive financial performance since the 4th quarter of 2020. This is because at the beginning of the pandemic, technology was the key for various parties to get through the pandemic. As with the emergence of the habit of online meetings using media such as zoom / skype and the increasing awareness of various parties how important information technology is in maximizing organizational performance so that it also increases the demand for goods and services in the field of technology. This allows Islamic companies in the technology sector to survive and produce good financial performance during the COVID-19 pandemic.

6. CONCLUSIONS

Based on the results of study and discussion, the authors obtained the following conclusions:

1. The liquidity ratio described by CR (Current Ratio) and QR (Quick Ratio) has no significant effect with alpha 5% on stock returns. Research was conducted on Islamic companies during the COVID-19 pandemic, namely the 1st quarter of 2020 to the 3rd quarter of 2021.
2. The profitability ratio described by ROA (Return on Assets) has a significant positive effect with alpha 5% on stock returns. The research was conducted on Islamic companies during the COVID-19 pandemic, namely the 1st quarter of 2020 to the 3rd quarter of 2021. Companies that can survive with Good financial performance and being able to make a profit during the

COVID-19 pandemic provides a positive signal for capital market players to invest in the company so as to increase stock returns in the quarter.

3. The solvency ratio described by DER (Debt to Equity Ratio) has no significant effect with alpha 5% on stock returns. Research was conducted on Islamic companies during the COVID-19 pandemic, namely the 1st quarter of 2020 to the 3rd quarter of 2021.
4. Sharia companies that are included in the raw goods, consumer goods, health and technology sectors are companies that have a good ROA (Return on Assets) during the COVID-19 pandemic and are worthy of investment.

REFERENCES

Al – Qur'an Perkata, Transliterasi, Terjemah Perkata, Terjemah Kemenag & Tajwid Warna. (2013). Sahabat.

Arifin, J., & Wardani, E. A. (2016). Islamic corporat social responsibility disclosure, reputasi, dan kinerja keuangan: Studi pada bank syariah di Indonesia. *Jurnal Akuntansi & Auditing Indonesia*, 20(1), 38–46.

Bursa Efek Indonesia. (2021). Retrieved from https://www.idx.co.id/

CNN. (2020). Retrieved from CNN: https://www.cnnindonesia.com/ekonomi/20200424154424-92-497014/ihsg-anjlok-2643-persen-sampai-april-ini

Darmayanti, N., Mildawati, T., & Dwi Susilowati, F. (2021). Dampak Covid-19 Terhadap Perubahan Harga Dan Return Saham. *EKUITAS (Jurnal Ekonomi Dan Keuangan)*, 4(4), 462–480.

Ezrad, A. M., & Ezrad , A. M. (2017). The Effect of Financial Ratios Toward Sharia Stock Return in Jakarta Islamic Index (JII). *QIJIS: Qudus International Journal of Islamic Studies Volume 5*.

Fauzan, A., & Matoati, R. (2021). Financial Ratios and Share Prices of JII70 Indexed Companies for the 2018-2020 Period. *The Management Journal of BINANIAGA*, 06(01).

Febriyanti, G. A. (2020). Dampak pandemi Covid-19 terhadap harga saham dan aktivitas volume perdagangan (Studi kasus saham LQ-45 di Bursa Efek Indonesia). *Indonesia Accounting Journal*, 2(2), 204.

Hair Jr, J. F., Hult, G., Ringel, C. M., & Sarstedt, M. (2014). *A Primer On Partial Least Squares Structural Equation Modelling (PLS-SEM)*. Los Angeles: SAGE Publications, Inc.

Hair Jr, J., Black, W., Babin, B. J., & Anderson, R. E. (2010). *Multivariate Data Analysis Seventh Edition*. United States of America: Pearson Prentice Hall.

Inayah, I. N. (2020). Prinsip-Prinsip Ekonomi Islam Dalam Investasi Syariah. *Jurnal Ilmu Akuntansi dan Bisnis Syariah*, 2(2): 89–100.

Jaya, I. G., & Sumertajaya, I. M. (2008). Pemodelan Persamaan Struktural Dengan Partial Least Square. 119-127.

Jogiyanto. (2017). *Teori Portofolio dan Analisis Investasi (Edisi ke 10)*. Yogyakarta: BPFE.

Jogiyanto, H. M. (2010). Teori Portofolio dan Analisis Investasi (Ketujuh ed.). *Yogyakarta: BPFE*.

Kasmir. (2016). *Analisis Laporan Keuangan*. Jakarta: Raja Grafindo Persada.

Otoritas Jasa Keuangan. (2021). Retrieved from https://www.ojk.go.id/

Pratama, P., & Jaharuddin. (2018). Rekonstruksi Konsep Profitabilitas Dalam Perspektif Islam. *IKRAITH-HUMANIORA*, 2(2).

Rachmawati, H. &. (2017). Pengaruh ROA, EPS dan Harga Saham Terhadap Return Saham. *Jurnal Ilmu dan Riset Manajemen*, Volume 6, Nomor 9.

Rahmani, A. N. (2020). Dampak Covid-19 Terhadap Harga Saham Dan Kinerja Keuangan Perusahaan. *Kajian Akuntansi Universitas Islam Bandung*, 21(2).

Sidik, I., & Reskino. . (2016). Pengaruh Zakat dan ICSR terhadap Reputasi dan Kinerja. *Simposium Nasional Akuntansi XIX, Lampung*.

Spence, A. (1973). Job Market Signaling. The Quarterly Journal of Economics, 87.

Utami, M. R., & Darmawan, A. (2019). Effect of DER, ROA, ROE, EPS and MVA on Stock Prices in Sharia Indonesian Stock Index. *Journal of Applied Accounting and Taxation Article History*, 15-22.

FACTORS AFFECTING THE DURATION OF CONSTRUCTION PROJECT ACTIVITIES

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ABSTRACT

Each construction project with different characteristics will cause different problems in the process. These problems are considered as unprecedented problems occursed in the implementation which is influenced by a series of uncertain factors. This study was aimed to obtain or determine the factors affecting the duration of project activities. This research was conducted by distributing questionnaires or direct interviews with related parties who are experienced in their fields. After collecting data from respondents, then data processing is done by calculating the mean value and the most significant factor can be selected based on the top factor ranking in each category. The results of the study showed that the top ranking of factors affecting the duration of construction project activities in human resource category, were labor supervision, worker experience and skills, communication, and contractor management leadership. In the material category, the top rank wasavailability of materials at the location, while in the work equipment category, the number of work equipment is obtained. The outcomes of this study would help to assist practitioners and other researchers by providing a summary of the findings of previous studies. It is also expected that by presenting a deeper and wider perspective of the research work performed will direct a more focused approach on productivity in terms of resources so as to reduce delays in construction project activities.

Keywords: Factors, project duration, construction project activity, work productivity

1. INTRODUCTION

Developments in the project management continue to increase along with the development of science and technology. According to Qiao (2021), construction projects have 3 main objectives, namely quality, safety, and duration of project activities. Quality of construction on the materials and construction technology used. Project management is a very important tool to ensure the safety of a project. Meanwhile, activity restrictions are influenced by uncertain factors so that it becomes the most uncontrollable aspect.

Construction project delays can be caused by inaccurate estimates of the time required to complete the project at the planning stage, or by various possibilities, such as improper management, problems with materials, labor, equipment, finances, and an unsupportive environment. Hassan, et al (2016) mentioned that delays in contractor projects will result in time and cost losses because the profits expected by the contractor will be reduced, or even not benefit from all of them. For the owner, late payments will result in time to utilize the results, so that the development results become the goal.

Each construction project with different characteristics will cause different problems in the process. The problem that often occurs in a job is a mismatch between the initial plan and the

realization of the project. Project planning and execution under time and budget pressure, work carried out almost entirely by a human workforce of varying skills, changing personalities, and weather and environmental conditions that have a strong impact on the progress of the work. Activities in construction themselves are interrelated, so that if one activity is hampered, it will hinder other activities. Elements that are an important part of construction work are cost, quality, and time in which there are also resources that must be controlled such as workers and materials (Kartika, et al., 2020).

In construction, it is measured at different levels of detail for different purposes. Measurement of productivity at the enterprise level or at the project level provides internal and external benchmarks for comparison with company or project norms. To estimate and schedule a project, its productivity is measured at its activity level. Loss of construction productivity is usually caused by a variety of factors, not just one. And also the factors that affect the duration of construction project activity are rarely independent of the others. Several factors may be the result of the same cause, or one factor may trigger the occurrence of another. It is therefore important that the factors that affect the duration of the project are identified properly so that efforts can be made to improve the situation, develop strategies and can increase work productivity with the factors that influence it.

2. LITERATURE REVIEW

Productivity is the ability to produce a product using existing resources properly and efficiently. In other words, productivity is a balance between output and input used to make a product or service (Sujana and Hakim, 2021). Productivity is also defined as the level of efficiency in producing goods or services. Various factors affecting construction productivity have been identified by different researchers. These factors include various problems that hinder project activity and cause delays in project completion in different geographic areas and construction works of a different nature. Identification of relevant factors that affect the duration of project activities is an important criterion for increasing productivity in the construction industry.

Research conducted by Jarkas, et al (2015) on the construction industry in Oman shows that the factors that affect work productivity are labor skills, coordination between design staff, lack of labor supervision, errors and omissions in design drawings, delays in responding demand, rework, strict inspection by engineers, overtime work, bad weather, change of orders during the work, and also physical fatigue of workers. While in the research of Hafez, et al (2014) the factors that affect the productivity of construction work in Egypt are late payments, labor skills, labor skills and experience, lack of labor supervision, work motivation, working overtime, construction manager leadership, clarity of specifications technical, lack of materials and tools, as well as high/low ambient temperature.

Jalal & Shoar (2019) stated that factors such as fatigue, lack of work motivation and lack of skills are the most influencing labor productivity in a construction project. While research conducted by Nasirzadeh & Nojedehi (2013) states that work productivity will decrease if there is a shortage of land in the work area, lack of worker skills and inefficiency of project managers in managing a project. Another study conducted by Li, et al (2016) only examined one of the factors that affect work productivity in the construction sector, namely the effect of high weather on workers. Meanwhile, Desfita & Hamid (2021) conducted research related to the productivity of construction workers on building construction projects by analyzing data using work sampling methods to measure the productivity of workers.

3. METHODS

According to Hasan, et al (2018) there were several research methods that can be carried out on construction projects, namely experiments, case studies or surveys. In this study, if using the experimental method in identifying the factors that affect the duration of project activities, it will take a long time and cost a lot of money. Meanwhile, using case studies will not give generalizable results because each different project will face different problems. Therefore, this study uses a survey method, namely through questionnaires and interviews as a tool in data collection to achieve research objectives.

The first stage was to review the relevant previous research literature and identify the factors that affect the duration of construction project activities. The second stage is to synthesize variables or filter factors that are significant in influencing the duration of project activities and categorize these factors into each category such as Human Resources (HR), materials, and work equipment. The third stage is compiling these variables in the form of a questionnaire with a likert scale of 1 (very not influential) to 5 (very influential) on the duration of project activities for each category. The last stage is data analysis. The data obtained from the questionnaire results were processed using the calculation of the average value (mean) to obtain the factors that affect the duration of project activities based on the top rank in each category. Purposive sampling technique was conducted in this study as Respondents in this study were person in charge for project schedule, such as project managers, engineers or project control on construction projects.

4. RESULTS

4.1 Identification of Research Variables

Based on the literature of previous studies in the last 10 years, 26 factors were identified as the results of the identification of variables that affect the duration of construction work project activities and grouped into categories of human resources (HR), materials, work equipment, management/technical, and external listed on Table 1.

Table 1 Identification of Variables Affecting the Duration of Construction Project Activities

Category	Variable	Source
Human Resources (HR)	Lack of labor supervision	Jarkas and Bitar (2012) ; El-Gohary and Aziz (2014) ; Hafez et al (2014) ; Chigara and Moyo (2014) ; Jarkas et al. (2015)
	Lack of worker skills	Adam, et al (2014) ; Alaghbari et al (2017) ; Chigara and Moyo (2014) ; El-Gohary and Aziz (2014) ; Hafez et al (2014) ; Jalal and Shoar (2019) ; Jarkas et al. (2015)
	Poor communication between workers, contractor, owner and consultant	Adam (2014) ; Jarkas and Bitar (2012) ; Jarkas et al. (2015)
	Lack of worker experience	Adam, et al (2014) ; Alaghbari et al (2017) ; El-Gohary dan Aziz (2014) ; Hafez et al (2014) ;
	Contractor management leadership and competence	Al Refaie, et al (2021) ; Alaghbari et al (2017) ; El-Gohary and Aziz (2014) ; Hafez et al (2014)
	Lack of work motivation	Hafez et al (2014) ; Jalal and Shoar (2019)

	Lack of training for workers	El-Gohary and Aziz (2014)
	Contractor experience	Adam, et al (2014)
	Lack of workers in the site	Adam, et al (2014) ; Ali, et al (2012) ; Ariefasa (2012)
	Physical fatigue	Al Refaie, et al (2020) ; Jalal and Shoar (2019) ; Jarkas et al. (2015)
	Workers' health conditions	Al Refaie, et al (2021)
	Work overtime	Al Refaie, et al (2021) ; Hafez et al (2014) ; Jarkas et al. (2015)
Materials	Availability of work materials on site	Alaghbari, et al (2017); Jarkas and Bitar (2012) ; El-Gohary and Aziz (2014) ; Hafez et al (2014) ; Chigara and Moyo (2014) ; Jarkas et al. (2015) ; Thomas and Sudhakumar (2014)
	Availability of materials at suppliers	Alaghbari, et al (2017) ; Hafez, et al (2014)
	Delay in delivery of materials	Al Refaie, et al (2021) ; Ali, et al (2012) ; Jalal dan Shoar (2019) ; Thomas and Sudhakumar (2014)
	Inflation	Ali, et al (2012)
Work Equipment	Lack of work equipment	Al Refaie, et al (2020) ; Alaghbari, et al (2017) ; Ariefasa, R. (2012) ; Chigara dan Moyo (2014) ; Ghoddousi dan Hosseini (2012) ; Jalal dan Shoar (2019) ; Thomas dan Sudhakumar (2014) ; Hasan, et al (2018)
	Damage to work tools	Adam, et al (2014) ; Alaghbari, et al (2017) ; El-Gohary dan Aziz (2014) ; Hafez et al (2014) ; Hasan, et al (2018)
	Ability to use work tools	Al Refaie, et al (2021)
Management/ Technical	Changes to drawings and specifications during implementation by consultants or owners	Jarkas and Bitar (2012) ; Jarkas, et al (2015)
	Delay in publishing construction drawings by consultant	Ghoddousi and Hosseini (2012) ; Jarkas, et al (2015) ; Thomas and Sudhakumar (2014)
	Clarity of technical specifications	Hafez et al (2014) ; Jarkas and Bitar (2012)
	Rework	Adam, et al (2014) ; Ali, et al (2012) ; Ghoddousi dan Hosseini (2012) ; Jarkas, et al (2015) ; Thomas and Sudhakumar (2014)
External	Bad weather conditions	Al Refaie, et al (2020) ; Ghoddousi and Hosseini (2012) ; Jalal and Shoar (2019) ; Jarkas, et al (2015)

	Contractors and owners experiencing financial difficulties	Ali, et al (2012) ; Ariefasa, R. (2012) ;
	Political situation	Alaghbari, et al (2017)

4.2 Synthesize of Research Variables

The variables that have been identified and grouped as in Table 1 are then synthesized to select the category of factors and their variables that are most often mentioned in the literature study or previous research as in Table 2 and Table 4. Figures 1-10 state the number of factors mentioned in previous research based on each category. The greater the number of factors in a category, the category will be selected as the variable to be studied in this study.

Table 2 Synthesize of Factor Category

Research By	**CATEGORY**				
	HR	**Materials**	**Work Equipment**	**Management/ Technical**	**External**
Adam, et al (2014)	5		1	1	
Al Refaie, et al (2020)	4	2	2		1
Alaghbari et al (2017)	3	2	2		1
Ali, et al (2012)	1	2		1	1
Ariefasa, R. (2012)	1		1		1
Chigara dan Moyo (2014)	2	1	1		
El-Gohary & Aziz (2014)	5	1	1		
Ghoddousi & Hosseini (2012)	1	1	2	2	1
Hafez et al (2014)	6	1	1	1	
Jalal & Shoar (2019)	3	1	1		1
Jarkas & Bitar (2012)	2		1	2	
Jarkas et al. (2015)	5		1	3	1
Thomas & Sudhakumar (2014)		2	2	2	
JUMLAH	**38**	**13**	**16**	**12**	**7**

From the results of the synthesis of the research factor categories in Table 2, the categories of factors that will be used in this study are the categories of Human Resources (HR) factors, material factors, and work equipment factors.

Table 3 Synthesize of Variables Affecting the Duration of Construction Project Activities in Each Category of Human Resources, Materials, and Work Equipment

CATEGORY	NO	VARIABEL	RESEARCH BY												JUMLAH
			Adam, et al (2014)	Al Refaie, et al (2020)	Alaghbari et al (2017)	Ali, et al (2012)	Anefasa, R. (2012)	Chigara dan Moyo (2014)	El-Gohary & Aziz (2014)	Ghoddousi & Hosseini (2012)	Hafez et al (2014)	Jalal & Shoar (2019)	Jarkas & Bitar (2012)	Jarkas et al. (2015)	Thomas & Sudhakumar (2014)	
Human Resource (HR)	1	Lack of labor supervision	✓					✓	✓	✓	✓		✓	✓		6
	2	Lack of worker skills	✓		✓			✓	✓		✓	✓		✓		7
	3	Poor communication between workers, contractor, owner and consultant	✓										✓	✓		3
	4	Lack of worker experience	✓		✓				✓		✓					4
	5	Contractor management leadership and competence		✓	✓				✓		✓					4
	6	Lack of work motivation									✓	✓				2
	7	Lack of training for workers							✓							1
	8	Contractor experience	✓													1
	9	Lack of workers in the site	✓			✓	✓									3
	10	Physical fatigue		✓								✓		✓		3
	11	Workers' health conditions		✓												1
	12	Work overtime		✓							✓			✓		3
Materials	1	Availability of work materials on site		✓	✓			✓	✓	✓					✓	6
	2	Availability of materials at suppliers			✓						✓					2
	3	Delay in delivery of materials		✓		✓						✓			✓	4
	4	Inflation				✓										1
Work Equipment	1	Lack of work equipment		✓	✓		✓	✓		✓		✓			✓	7
	2	Damage to work tools	✓		✓				✓		✓					4
	3	Ability to use work tools		✓						✓			✓	✓	✓	5

Table 4. Results of Shyntesize of Variables Affecting the Duration of Construction Project Activities in Each Category of Human Resources, Materials, and Work Equipment

Category	Variable
Human Resources (HR)	Lack of labor supervision
	Lack of workers experience and skills
	Workers' health conditions
	Lack of workers in the field
	Poor communication between workers, contractor, owner and consultant
	Contractor management leadership and competence
	Lack of motivation to work
	Lack of training for workers
	Contractor experience is not enough
	Work overtime
Materials	Availability of work materials on site
	Availability of materials at suppliers
	Delay in delivery of materials
	Inflation
Work Equipment	Lack of work equipment
	Damage to work tools
	Ability to use work tools

4.3 Respondent Analysis

The 17 factors obtained in Table 4 were then compiled in the form of a questionnaire with a likert scale of 1 (very not influential) to 5 (very influential). The analysis of respondents in this study is an analysis of data processing used to provide an overview of the results of the answers given by respondents to the questions on the questionnaire. Data processing is done by calculating mean to determine the most significant factor. The results of the calculation of the identification of factors that affect the duration of project activities can be seen in Table 5.

Table 5. Results of the Ranking of Factors Affecting the Duration of Construction Project Activities in Each Category of Human Resources, Materials, and Work Equipment

Category	Factors Affecting the Duration of Construction Project Activities	Mean	Ranking
Human Resources (HR)	Lack of labor supervision	4,6	1
	Lack of workers experience and skills	4,6	1
	Workers' health conditions	4,1	4
	Lack of workers in the field	4,4	2
	Poor communication between workers, contractor, owner and consultant	4,6	1
	Contractor management leadership and competence	4,6	1
	Lack of motivation to work	4,3	3
	Lack of training for workers	3,3	6
	Contractor experience is not enough	4,1	4
	Work overtime	3,5	5

Materials	Availability of work materials on site	4,8	1
	Availability of materials at suppliers	4,4	3
	Delay in delivery of materials	4,6	2
	Inflation	3,8	4
Work Equipment	Lack of work equipment	4,5	1
	Damage to work tools	4,1	2
	Ability to use work tools	4,0	3

4.4 Research Results

Based on the results of questionnaires and interviews with construction experts, 11 (eleven) factors were obtained that affect the duration of construction project activities based on the ranking of the top factors or rankings in each category, which are presented in Table 6.

Table 6. Significant Factors Affecting Construction Project Activity Duration

Category	Factors Affecting the Duration of Construction Project Activities
Human Resources (HR)	Lack of labor supervision
	Lack of workers experience and skills
	Poor communication between workers, contractor, owner and consultant
	Contractor management leadership and competence
Materials	Availability of work materials on site
	Availability of materials at suppliers
	Delay in material delivery
	Inflation
Work Equipment	Lack of work equipment
	Damage to work tools
	Ability to use work tools

4.5 Discussion

This section contains a discussion of the significant factors that affect the duration of construction project activities as shown in Table 6. Significant factors in the human resource category based on the top ranking are labor supervision, worker experience and skills, poor communication between workers, contractor, owner and consultant, as well as the leadership and competence of contractor management. Supervision of workers greatly affects the duration of activity because if the supervision of workers is negligent, many workers will be found relaxing and talking during working hours, or even causing rework, so that project completion will be delayed. Skilled and experienced workers are able to find practical solutions for the problems at hand, while the work done by less and unskilled work solutions is almost always rejected by supervisors and results in settlements causing late delays. Good communication between workers, contractor, owner and consultant will make it easier to coordinate while working so that the desired goals will be easily achieved.

The highest factors that affect the project duration on materials are the availability of materials on site, the availability of materials at suppliers, delivery delays and inflation category.

the provision of work materials at locations and suppliers, as well as delays in the delivery of materials will affect the duration of project activities, because if this is not achieved it will reduce work productivity so that the project progresses. inflation or an increase in execution costs as a result of sanctions that may affect the profitability of the project.

In the work equipment category, the factors with the highest ranking that affect the duration of the activity are the lack of work equipment, the condition of the work tools, and the ability to use work tools. The lack of work equipment and the condition of the work tools will affect the duration of the construction project activity, because if this is not fulfilled or the work tools are obsolete, it will accelerate the progress of the project. Likewise, the ability of workers to use work tools, because improper use of work tools will only hinder work or can even cause rework so that project completion will be late.

6. CONCLUSIONS

The purpose of this study was to identify or rank the main factors that affect the duration of construction project activities. Its purpose is to assist practitioners and other researchers by providing a summary of the findings of previous studies. It is expected that by presenting a deeper and wider perspective from previous research work will lead to a more focused approach to productivity in terms of resources so as to reduce delays in construction project activities.

From the survey, the 4 highest ranking factors that affect the duration of project activities in terms of human resource productivity are labor supervision, experience and skills of workers, poor communication between workers, contractor, owner and consultant, as well as leadership and contractor management competencies. In terms of materials, there are 4 factors with the highest ranking, namely the availability of work materials on site, availability of materials at suppliers, delays in material delivery and the occurrence of inflation. Meanwhile, in terms of work equipment, the 3 highest ranking factors that affect the duration of project activity are obtained, namely the lack of work equipment, the condition of work tools, the ability to use work tools.

REFERENCES

Adam, A.; Josephson, P.; Lindahl, G. (2014). Implications of Cost Overruns and Time Delays on Major Public Construction Projects. *Journal of Department Civil and Environmental Engineering*, Chalmers University of Technology, Gothenburg, Sweden.

Al Refaie, A. M., Alashwal, A. M., Abdul-Samad, Z., and Salleh, H. (2021). Weather and Labor Productivity in Construction: A Literature Review and Taxonomy of Studies. *International Journal of Productivity and Performance Management*, 70(4), 941–957.

Alaghbari, W., Al-Sakkaf, A. A., Sultan, B. (2017). Factors Affecting Construction Labour Productivity in Yemen. *International Journal of Construction Management*, 19(1), 79–91.

Ali, A. S.; Smith, A.; Pitt, M.; Choon, C. H. (2012). Contractors' Perception of Factors Contributing to Project Delay: Case Studies of Commercial Projects In Klang Valley, Malaysia. *Journal for Faculty of Built Environment*, University of Malaya, Malaysia.

Ariefasa, R. (2012). *Faktor Penyebab Keterlambatan Pekerjaan Konstruksi Bangunan Jembatan Yang Berpengaruh terhadap Perubahan Anggaran Biaya pada Pekerjaan Struktur*, Skripsi, Teknik Sipil Manajemen Konstruksi, Universitas Indonesia, Jakarta.

Chigara, B. and Moyo, T. (2014). Factors Affecting Labor Productivity On Building Projects In Zimbabwe. *International Journal of Architecture*, *Engineering and Construction*, 3(1), 57-65.

Desfita, M., and Hamid, F. (2021). Work Sampling Methods Dalam Analisis Produktivitas Tenaga Kerja Konstruksi Proyek Pembangunan Gedung. *Jurnal Teknologi Dan Sistem Informasi Bisnis*, 3(1), 259-266.

El-Gohary, K. and Aziz, R. (2014). Factors Influencing Construction Labor Productivity In Egypt. *Journal of Management in Engineering*, 30(1), 1-9.

Ghoddousi, P. dan Hosseini, M. R. (2012). A Survey of the Factors Affecting the Productivity Of Construction Projects in Iran. *Technological and Economic Development of Economy*, *18*(1), 99–116.

Hafez, S. M., Aziz R. F., Morgan E. S., Abdullah M.M., Ahmed E. K. (2014). Critical Factors Affecting Construction Labor Productivity in Egypt. *American Journal of Civil Engineering*, 2(2), 35.

Hasan, A., Baroudi, B., Elmualim, A., Rameezdeen, R. (2018). Factors affecting construction productivity: a 30 year systematic review. *Engineering, Construction and Architectural Management*, *25*(7), 916–937.

Hassan, HMangare, J.B., Pratasis P.A.K. (2016). Faktor-Faktor Keterlambatan Pada Proyek Konstruksi Dan Alternatif Penyelesaiannya : Studi Kasus di Manado Town Square III. *Jurnal Sipil Statik*, *4*(11), 657–664.

Jalal, M. P., and Shoar, S. (2019). A Hybrid Framework to Model Factors Affecting Construction Labour Productivity: Case Study of Iran. *Journal of Financial Management of Property and Construction*, 24(3), 630–654.

Jarkas, A.M. and Bitar, C.G. (2012). Factors Affecting Construction Labour Productivity in Kuwait. *Journal of Construction Engineering and Management*, 138(7), 811-820.

Jarkas, A. M., Al Balushi, R. A., Raveendranath, P. K. (2015). Determinants of Construction Labour Productivity in Oman. *International Journal of Construction Management*, 15(4), 332–344.

Kartika N., Robial S. M., Pratama A. (2020). Analisis Produktivitas Tenaga Kerja Pada Pekerjaan Kolom di Proyek Pembangunan Gedung Pemda Kabupaten Sukabumi. *Jurnal Momen*, 3(2), 103-112.

Li, X., Chow, K. H., Zhu, Y., Lin, Y. (2016). Evaluating The Impacts of High-Temperature Outdoor Working Environments on Construction Labor Productivity in China: A Case Study of Rebar Workers. *Building and Environment*, 95, 42–52.

Nasirzadeh, F., and Nojedehi, P. (2013). Dynamic Modeling of Labor Productivity in Construction Projects. *International Journal of Project Management*, 31(6), 903–911.

Qiao, C. (2021). Project Completion Probability Analysis Based On Bayesian Network. *Academic Journal of Engineering and Technology Science*, 4(1), 62-69.

Sujana Caroline, M., and Hakim Raka, A. (2021). Perbandingan Produktivitas Tenaga Kerja Pembesian dan Bekisting Saat Jam Kerja Normal dan Lembur Menggunakan Metode Productivity Rating, *Jurnal Rekayasa Konstruksi Mekanika Sipil*, 4(2), 145-152.

Thomas, A.V. and Sudhakumar, J. (2014). Factors Influencing Construction Labour Productivity: An Indian Case Study. *Journal of Construction in Developing Countries*, 19(1), 53-68.

FABA UTILIZATION STRATEGY FOR CIRCULAR BUSINESS MODEL PT PLN (PERSERO) PLTU XYZ

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ABSTRACT

Fly ash and bottom ash (FABA) produced by PLTU XYZ average 160 tons/day as non-B3 waste. This amount continues accumulating and is inversely proportional to the temporary storage capacity. FABA can be pulled back into a circular economy process for CSR to produce value-added products that benefit to PLN and the community. The method used in this research is the Business Model Canvas and SWOT analysis. Data was collected by Focus Group Discussion (FGD) and filling out questionnaires to respondents/ experts. The first step is conducting FGD with experts as stakeholders in PLTU XYZ. Then the expert filled out a questionnaire to determine the current condition and capability of the company PT PLN (Persero) PLTU XYZ. The result of this research using the Business Model Canvas method is that PLTU XYZ can determine the appropriate business strategy. Then after analyzing the nine canvas business models using the SWOT analysis method, it was found that the XYZ PLTU is in the first quadrant. This result is very profitable because strengths can take advantage of existing opportunities and become an advantage for PLTU XYZ. The strategy applied in this condition is aggressive.

Keywords: Fly Ash & Bottom Ash, Circular Economy, Business Model Canvas, SWOT

1. INTRODUCTION

PT PLN (Persero) PLTU XYZ, a power plant with a 4 x 65 MW capacity, produces an average of 160 tons/day of non-B3 FABA waste in Kalimantan. The following is FABA data produced by PLTU XYZ on average for one year in 2021.

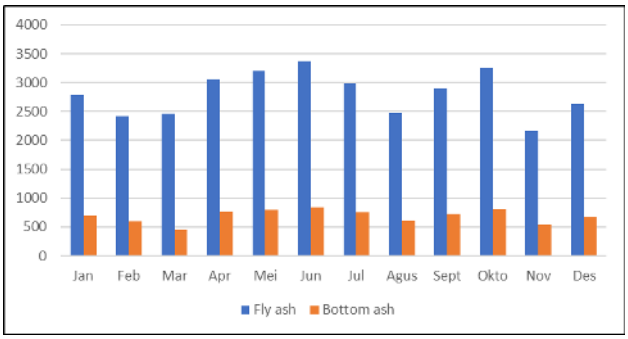


Figure 1. Data recapitulation of PLTU XYZ 2021 FABA balance

Based on the data above, the FABA balance produced by PLTU XYZ is, on average, 3,400 tons/month continuously if the total FABA balance accumulated from the previous year until the end of 2021 is 489,693 tons. The following is a large number of non-B3 FABA waste utilization in one year:

Table 1. Total utilization of FABA

Utilization 2021	
Jan	3,517.61
Feb	4,458.01
Mar	42.15
Apr	18.17
May	13.23
Jun	235.51
Jul	43.45
Agus	32.38
Sept	51.03
Okto	-
Nov	399.39
Des	2,164.85
Total	10,975.77
Average	997.80

Table 1 shows FABA utilization activities that have been carried out as much as 26% in 2021. The utilization is a CSR program such as road repairs and cooperation with cement companies. In contrast to non-B3 FABA waste for CSR, FABA utilization activities such as road repairs and cooperation with cement companies are relative to the demand for FABA needs. Utilization of non-B3 FABA waste is in line with the company's CSR program, where FABA utilization can maximize by using the circular economy concept by selling valuable products such as paving blocks and bricks, where the circular economy is an economic system with a business model that replaces the concept of the end of life of a product with the concept of recycling or alternative reuse (Kirchherr et al., 2017).

Therefore, it requires the selection of a business model as a strategy for utilizing non-B3 FABA waste to reduce waste with the circular economy concept as a CSR program of PT PLN (Persero) PLTU XYZ, where this study uses the Business Model Canvas and SWOT analysis to analyze the strengths, weaknesses, opportunities, and threats from the initial 9 Business Model Canvas blocks owned by PLTU XYZ as a step to increase the use of FABA and the company's CSR program.

2. LITERATURE REVIEW

According to Winans (2017), the circular economy aims to reduce the impact of society on the environment by utilizing recycled waste material flows and balancing economic growth by considering resources and environmental impacts. Business model products with a circular economy concept are difficult to accept as basic waste materials, but they are not the same as FABA, which is a non-B3 waste. Recycling non-B3 FABA waste to produce products with a selling value, such as paving blocks and bricks that require a suitable business model by analyzing the Business model canvas (BMC).

It is necessary to do a SWOT analysis of the nine elements of BMC. According to (Weber, 2019), It is necessary to conduct discussions or interviews to analyze the strengths, weaknesses, opportunities, and threats (SWOT) of the circular economy approach involving stakeholders to

discuss how these aspects benefit or hinder the company's internal and external factors approach, as well as how the company seeks to address and overcome internal challenges and external threats.

a. Business Model Canvas

The Business Model Canvas (BMC) is a simple yet effective and proven tool for understanding and improving business models to deliver value to the company. A business model canvas (BMC) is a business model with nine elements used to describe and modify the business model described on the design canvas. The nine elements include customer segments, value proposition, channels, customer relationships, revenue streams, key resources, key activities, key partnerships, and cost structures that affect the business model (Osterwalder & Pigneur, 2010).

b. SWOT Analysis

SWOT analysis is fundamental in mapping the actual condition of the company at this time. According to Emet (2017), SWOT aims to compare strengths, weaknesses, opportunities, and threats. Where strengths can minimize weaknesses and can be used to respond to threats to generate opportunities, SWOT analysis in the form of a matrix can help see the invisible sides of a company and helps conduct strategic analysis (Hidayat & Lesmana, 2020).

c. Matrix of IFE and EFE

According to Pangastuti et al. (2019), Internal factor evaluation (IFE) and external factor evaluation (EFE) consist of columns, with values from the results of grouping internal and external factors based on their level of importance. The IFE's purpose is to determine the company's position based on the company's strengths and weaknesses. On the other hand, the EFE Matrix determines the company's position by identifying external factors like opportunities and threats. That influence is evaluated for strategic planning following the results of the IE matrix, whether including growth and a build, hold and maintenance, or harvest and devest (Az Zahra et al., 2021).

3. METHODS

a. Focus Group Discussion

According to Gundumogula (2020), Focus group discussion (FGD) is a research tool with a qualitative exploration method to dig deeper into the possible relevance of the studied topic. The FGD was carried out at the BMC validation stage and SWOT analysis of the nine elements of BMC and was attended by stakeholders as experts in the XYZ PLTU Unit.

b. Data collection procedures

The data collection technique used a questionnaire filled out by the expert as the respondent with the Likert scale. According to Joshi (2015), the Likert scale consists of 4 level categories and requires respondents to indicate the degree of agreement or disagreement with each statement relating to the actual condition of the company.

c. Data Analysis

1. Create a business model canvas to identify each block of the business model canvas.
2. Conduct a focus group discussion (FGD) to discuss the proposed business model canvas with the selected experts.
3. SWOT analysis (strengths, weaknesses, opportunities, and threats) to find out the factors of strength, weakness, opportunity, and threats of the business model.

4. RESULTS

a. Business Model Canvas

The business model that is suitable for the use of PLTU XYZ FABA with the concept of a circular economy is the partnership business model. A partnership business model where PLTU XYZ, an investor and supplier of raw materials, works with BUMDes as a partner drives this business model from production to sales. This canvas business model can describe the condition of PLTU XYZ with nine BMC elements in a simple way. Nine elements of BMC are Customer segments, value propositions, channels, customer relationships, revenue streams, key activities, key resources, key partners, and cost structures. Here is the proposed partnership business model based on the nine elements of the business model canvas:

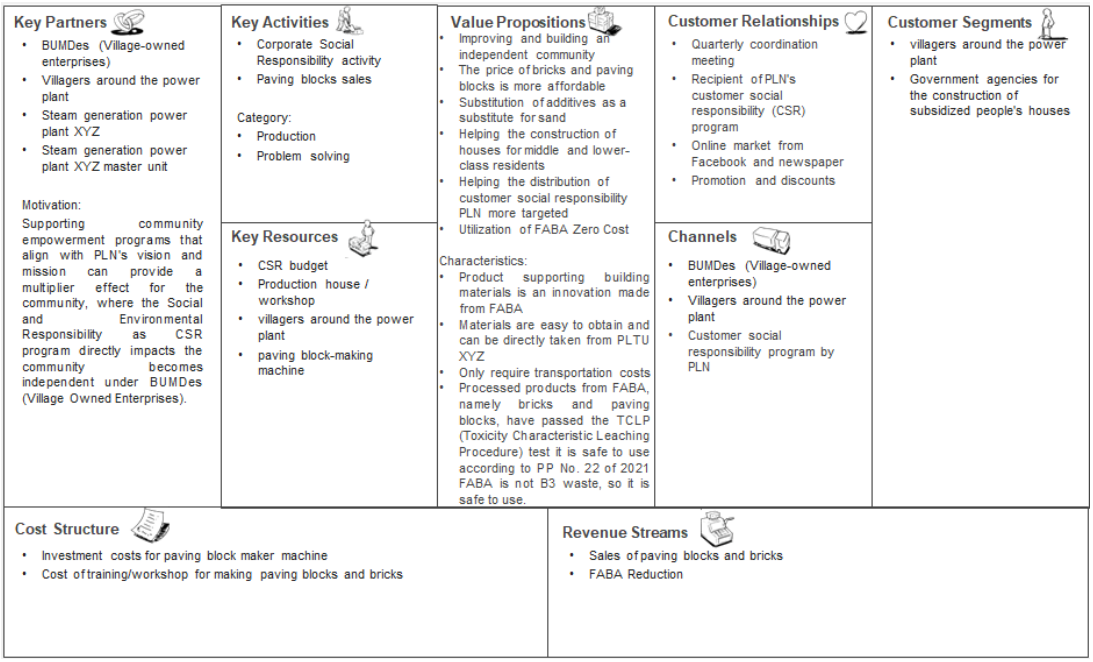


Figure 2. Partnership Business Model

b. SWOT Analysis on The Nine Elements of BMC

After finalizing the business model canvas through focus group discussions (FGD) and SWOT analysis of the nine elements of BMC together with PLTU XYZ stakeholders to help map the strengths, weaknesses, opportunities, and threats in the nine elements of the business model:

Table 2. SWOT of the nine elements of BMC

No.	Elemen BMC	Strengths (S)	Weaknesses (W)	Opportunities (O)	Threats (T)
1	Customer Segments	Has a good reputation in establishing social relations with the people community around the power plant as consumers and has established cooperative relationships with BUMDes and village officials as FABA processing partners.	Customers can compare prices from workshops with the same product but do not require promotional costs to expand customers/consumers, so they are not fixated on the manufacturing process.	Establish a good relationship with BUMDes as a managing partner to expand marketing and new customers for FABA consumers, both internal to the village and external to XYZ village, ignoring promotion costs.	Customer segments can be reduced if business competitors increase channel and key resources element by BMC to produce lower prices.
2	Value Propositions	Sufficient FABA resources can be used at no cost as raw material and can be directed toward CSR programs	Requires facilities, infrastructure, and training for processing the use of FABA	Able to strategically integrate products around steam generation power plant.	There are competing products from companies that were previously established.

3	Channels	The company has communication and marketing channels with village officials to reach customers and provide economic benefits.	Currently, the communication and marketing channels are only for the scope of villages around PLTU XYZ.	Can increase the number of customers with communication and marketing channels among PLN Groups in the Kalimantan area.	Competitors have an effective and integrated channel with the longevity of the first founded company with the same product.
4	Customer Relationships	Have a good relationship with the surrounding community and village officials, and be able to use the main channel well to add new customers and information related to products with online channels.	PLTU XYZ does not yet have a customer database to increase sales of paving block and brick products.	With positive news through the PLN communication team, WA or email greetings, and online marketing, most villagers use the Facebook platform to maintain relationships with customers and potential customers.	The number of customers may be lost or dropped if PLTU XYZ cannot utilize the communication channel.
5	Revenue Streams	Paving block and brick products from FABA PLTU XYZ have been widespread by CSR assistance programs.	This business model is constrained by FABA transportation costs if the production site is outside the XYZ power plant area	Sales potential can increase where there are still many houses, yards or roads with swampy textures.	all residents already have decent houses, so the demand for bricks and paving blocks has decreased
6	Key Resources	PLTU XYZ already has knowledge in FABA management which refers to Indonesian national standards.	Requires submission of a budget proposal for the procurement of paving block and brick maker machines.	Have workshops, laboratory test results, and FABA resources.	The budget is not approved.
7	Key Activities	Products according to SNI standard 03-0348-1989	The target customers are the villagers of PLTU XYZ operating, as the purpose of the CSR program.		
8	Key Partnerships	By establishing partnerships with village officials and communities, PLTU ZYX can simplify business processes so that PLTU XYZ does not need to focus on production and sales.	The location of the village community is close to PLTU XYZ, so for the beginning, it is still focused on the village of PLTU XYZ as the goal of the CSR program, but it can target sales outside the village in the future.	Opening opportunities for collaboration with many parties with BUMDes as control and sales function with the principle of zero cost.	
9	Cost Structure	Save training costs with XYZ PLTU internal trainers, promotion costs, process costs, transport and outsourcing management costs.	The training was conducted internally by PLTU XYZ.	We are empowering BUMDes as a business driver and collaborating with village officials as control and bookkeeping so that the process is more independent and at zero cost.	The budget is not approved.

c. IFE dan EFE analisis

After mapping the SWOT on nine elements of the business model canvas, the expert gives a score in the form of a questionnaire using the Likert scale assessment method to measure the current condition of PLTU XYZ. The selected expert will fill out the questionnaire, in this case, the PLTU XYZ stakeholders, namely the implementing unit manager, finance and general manager, and implementing environmental officials, and then evaluate the expert's internal and external factors.

Table 3. Evaluation of internal factors

No.	Internal Factor	NS 1	NS 2	NS 3	Amount	Weight	Rating	Score
	Strengths/ Kekuatan							
1	Has a good reputation in establishing social relations with the people community around the power plant as consumers and has established cooperative relationships with BUMDes and village officials as FABA processing partners.	4	4	4	12	0.06	4.00	0.23
2	Sufficient FABA resources can be used at no cost as raw material and can be directed toward CSR programs	4	4	4	12	0.06	4.00	0.23
3	The company has communication and marketing channels with village officials to reach customers and provide economic benefits.	4	4	3	11	0.05	3.67	0.20
4	Have a good relationship with the surrounding community and village officials, and be able to use the main channel well to add new customers and information related to products with online channels.	4	4	4	12	0.06	4.00	0.23
5	Paving block and brick products from FABA PLTU XYZ have been widespread by CSR assistance programs.	4	4	3	11	0.05	3.67	0.20
6	PLTU XYZ already has knowledge in FABA management which refers to Indonesian national standards.	4	4	4	12	0.06	4.00	0.23
7	Products according to SNI standard 03-0348-1989	4	4	4	12	0.06	4.00	0.23
8	By establishing partnerships with village officials and communities, PLTU ZYX can simplify business processes so that PLTU XYZ does not need to focus on production and sales.	4	4	4	12	0.06	4.00	0.23
9	Save training costs with XYZ PLTU internal trainers, promotion costs, process costs, transport and outsourcing management costs.	4	4	4	12	0.06	4.00	0.23
	Sub Total				106	0.52		1.80

No.	Internal Factor	NS 1	NS 2	NS 3	Amount	Weight	Rating	Score
	Weaknesses							
1	Customers can compare prices from workshops with the same product but do not require promotional costs to expand customers/consumers, so they are not fixated on the manufacturing process.	4	4	4	12	0.06	4.00	0.23
2	Requires facilities, infrastructure, and training for processing the use of FABA	3	4	3	10	0.05	3.33	0.16
3	Currently, the communication and marketing channels are only for the scope of villages around PLTU XYZ.	3	3	3	9	0.04	3.00	0.13
4	PLTU XYZ does not yet have a customer database to increase sales of paving block and brick products.	4	4	4	12	0.06	4.00	0.23
5	This business model is constrained by FABA transportation costs if the production site is outside the XYZ power plant area	4	4	4	12	0.06	4.00	0.23
6	Requires submission of a budget proposal for the procurement of paving block and brick maker machines.	4	4	4	12	0.06	4.00	0.23
7	The target customers are the villagers of PLTU XYZ operating, as the purpose of the CSR program.	2	3	3	8	0.04	2.67	0.10
8	The location of the village community is close to PLTU XYZ, so for the beginning, it is still focused on the village of PLTU XYZ as the goal of the CSR program, but it can target sales outside the village in the future.	4	4	4	12	0.06	4.00	0.23
9	The training was conducted internally by PLTU XYZ.	4	4	4	12	0.06	4.00	0.23
	Sub Total				99	0.48		1.57
	Total				205	1		3.37

The weighting of scores and ratings on each internal and external factor aims to determine the right strategy for implementing the business model of using FABA at PLTU XYZ. Table 3 shows the results of scoring by respondents/experts. External factor analysis with a strength score of 1.80 and a total threat score for a weakness factor of 1.57. The same treatment for the analysis of

external factors, from filling out the questionnaire by the expert, the score is obtained from the weighting and rating as follows:

Table 4. Evaluation of external factors

No.	External Factor	NS 1	NS 2	NS 3	Amount	Weight	Rating	Score
	Opportunities							
1	Establish a good relationship with BUMDes as a managing partner to expand marketing and new customers for FABA consumers, both internal to the village and external to XYZ village, ignoring promotion costs.	4	4	4	12	0.08	4.00	0.33
2	Able to strategically integrate products around steam generation power plant.	4	4	4	12	0.08	4.00	0.33
3	Can increase the number of customers with communication and marketing channels among PLN Groups in the Kalimantan area.	4	4	4	12	0.08	4.00	0.33
4	With positive news through the PLN communication team, WA or email greetings, and online marketing, most villagers use the Facebook platform to maintain relationships with customers and potential customers.	4	4	4	12	0.08	4.00	0.33
5	Sales potential can increase where there are still many houses, yards or roads with swampy textures.	4	4	4	12	0.08	4.00	0.33
6	Have workshops, laboratory test results, and FABA resources.	4	4	4	12	0.08	4.00	0.33
7	Opening opportunities for collaboration with many parties with BUMDes as control and sales function with the principle of zero cost.	4	4	4	12	0.08	4.00	0.33
8	We are empowering BUMDes as a business driver and collaborating with village officials as control and bookkeeping so that the process is more independent and at zero cost.	4	4	4	12	0.08	4.00	0.33
	Sub total				96	0.66		2.63

No.	External Factor	NS 1	NS 2	NS 3	Amount	Weight	Rating	Score
	Threats							
1	Customer segments can be reduced if business competitors increase channel and key resources element by BMC to produce lower prices.	3	3	3	9	0.06	3.00	0.18
2	There are competing products from companies that were previously established.	1	2	2	5	0.03	1.67	0.06
3	Competitors have an effective and integrated channel with the longevity of the first founded company with the same product.	1	2	2	5	0.03	1.67	0.06
4	The number of customers may be lost or dropped if PLTU XYZ cannot utilize the communication channel.	3	4	3	10	0.07	3.33	0.23
5	all residents already have decent houses, so the demand for bricks and paving blocks has decreased	3	3	3	9	0.06	3.00	0.18
6	The budget is not approved.	4	4	4	12	0.08	4.00	0.33
	Sub Total				50	0.34		1.04
	Total				146	1		3.67

Table 4 analyzes external factors with an opportunity score of 2.63 and a total threat score of 1.04. total scoring The results of consideration and assessment of each internal factor (strengths and weaknesses) and external factors (opportunities and threats) determine the position of PLTU XYZ with a quadrant strategy.

d. Matriks SWOT

The total score obtained based on the evaluation of internal and external factors obtained the following factor values.

Table 5. Score of factor

Description	Internal		External	
	Strengths	Weaknesses	Opportunities	Threats
Strategi	1.80	1.57	2.63	1.04
Total	0.23		1.59	

Table 5 shows the internal factor value of PLTU XYZ with a score of 0.23 and the value of external factors with a score of 1.59. The following is the identification of strategic quadrants based on internal and external factors of PLTU XYZ.

Table 6. Quadrant identification

Internal / External	Strengths	Weaknesses
Opportunities	1.80 + 2.63 = 4.43	1.57 + 2.63 = 4.2
Threats	1.80 + 1.04 = 2.84	1.57 + 1.04 = 2.61

Table 6 shows that the condition of PLTU XYZ can apply an aggressive strategy. Identifying quadrants in the SWOT matrix shows that the strengths and opportunities (SO) strategy is the right strategy for running the partnership business model as a business model to utilize FABA.

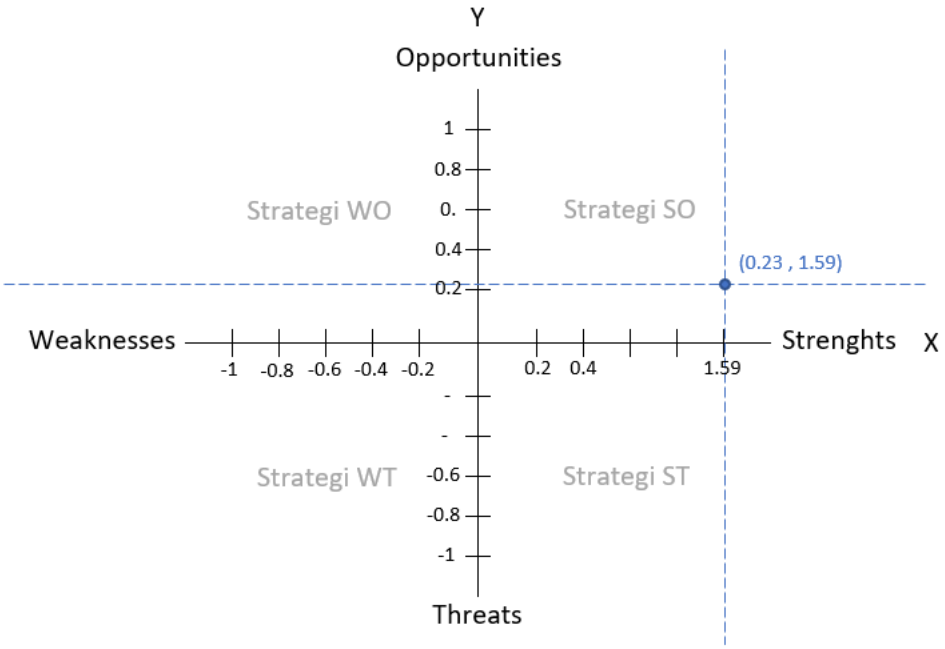


Figure 3. Matrix of SWOT

e. SO Strategy

1. PLTU XYZ must be Placing workshops/production houses close to sources of raw materials for transportation cost efficiency, as well as increasing CSR program activities to maintain good relations with consumers and make it easier to reach targeted consumers.
2. Improve cooperation with village officials and BUMDes as field control in this business model.
3. More focus as a provider of raw materials in using FABA so that it is more efficient in operational and transportation costs. In addition, managed by partners, this business model does not imply not adding employees or outsourcing, nor adding to the new section or changing the existing business processes at PT PLN (Persero) PLTU XYZ.
4. Having knowledge of FABA processing, products according to SNI standards, and a good relationship with the community, PLTU XYZ can train the community on how to use FABA in products with a selling value.

f. Cost and Profit

1. Product

   The paving block printing machine in a day can produce 250 paving blocks with a paving block weight of ± 2.5 Kg with a composition of 65% fly ash, 15% sand, and 10% cement. Then the calculation of production costs in a day is as follows:

   a. *65% fly ash*

   65% $fly\ ash$ = (2.5 kg x 65%) x 250 = 406,25 kg FA

   Transportation cost of Rp. 150,000 per 1 trip pick with a 5 m^3 load density of FA 2,500 kg/m^3. If the selected workshop is outside PLTU XYZ, then the cost of fly ash for production in a day.

   Rp. 150.000 x $\left(406{,}25 \text{ kg} / (5 \text{ m}^3 \text{ x } 2.500 \frac{\text{kg}}{\text{m}^3})\right)$ = Rp. 4.875

b. 15% sand
$15\%\ \text{sand} = (2.5\ \text{kg x}\ 15\%)\ \text{x}\ 250 = 93{,}75\ \text{kg sand}$
The purchase and transportation costs needed to supply sand raw materials are Rp. 750,000 for 5 m^3 with a sand density of 1,400 kg/m^3, then the cost of sand for production in a day:$\text{Rp.}\ 750.000\ \text{x}\ \left(93{,}75\ \text{kg}\ /\ (5\ \text{m}^3\text{x}\ 1.400\ \frac{\text{kg}}{\text{m}^3})\right) = \text{Rp.}\ 10.044{,}64$

c. 10% cement
$10\%\ \text{cement} = (2.5\ \text{kg x}\ 10\%)\ \text{x}\ 250 = 62{,}5\ \text{kg cement}$
The price of a bag of cement weighing 40 kg is Rp. 58,000, then the cost of cement for production in a day:
$(\text{Rp.}\ 58.000\ /\ 40\ \text{kg})\ \text{x}\ 62{,}5\ \text{kg} = \text{Rp.}\ 90.625$

d. Labor cost
Making paving blocks requires at least two workers to produce 250 paving blocks daily with a daily wage of Rp. 130,000 people a day. Then the total daily labor cost.
$\text{Total biaya pekerja} = \text{Rp.}\ 130.000\ \text{x}\ 2 = \text{Rp.}\ 260.000$

Meanwhile, the selling price of bricks that can be produced is 130 units/day with the same raw material capacity.
$\text{Total biaya} = \text{Rp.}\ 4.875 + \text{Rp.}\ 10.044{,}64 + \text{Rp.}\ 90.625 + \text{Rp.}\ 260.000$
$= \text{Rp.}\ 365.544{,}64 \approx \text{Rp.}\ 365.545$

2. Price
Than the production price per unit of the paving block is:
$$\frac{\text{Rp.}\ 365.545\ /\ \text{pcs}}{250\ \text{pcs}} = Rp.\ 1.462$$

The selling price of bricks that can be produced is 130 units/day with the same raw material capacity:
$$\frac{\text{Rp.}\ 365.545\ /\ \text{pcs}}{130\ \text{pcs}} = Rp.\ 2.812$$

The market price of paving blocks ranges from Rp. 2,300 to Rp. 2,500, then the selling price of the XYZ PLTU paving block is Rp. 2,000, it will be very competitive, likewise with bricks whose production price is Rp. 2,812 compared to the market price ranging from 3,300 to Rp. 3,500 with a selling price of Rp. 3,000 is still very much worth competing.

3. Promotion
PLTU XYZ has promoted the promotion in collaboration with agencies such as the regent and local district governments, who take care of regional development and subsidized housing at low prices. PLTU XYZ also cooperates with the TNI and Polri to improve public road facilities to the scope of the Regency. Implementing PLTU XYZ's CSR program is also a form of promotion of FABA-based paving block and brick products. In addition, online media and newspapers can further strengthen promotions for this business model.



Figure 4. Promotion of the utilization FABA

4. Place

a. If the house of production is outside the XYZ PLTU area, it will require land and require land acquisition costs and require workshop construction costs. Transportation costs will be required if the house of production is outside the XYZ PLTU area.

b. If the workshop is located in the PLTU XYZ area and is close to the source of raw materials, besides not requiring transportation costs, it can reduce production costs so that production costs fall to Rp. 1.443/unit.

c. If the house of production is in the area of PLTU XYZ, it will save production costs so that production costs fall to Rp. 1.443/unit.

d. PLTU XYZ must be Considering the closest competitor of PLTU XYZ with similar selling products on the district scale. Currently, the closest competitor is ± 65 km from PLTU XYZ, so the category of competitors is still minimal.

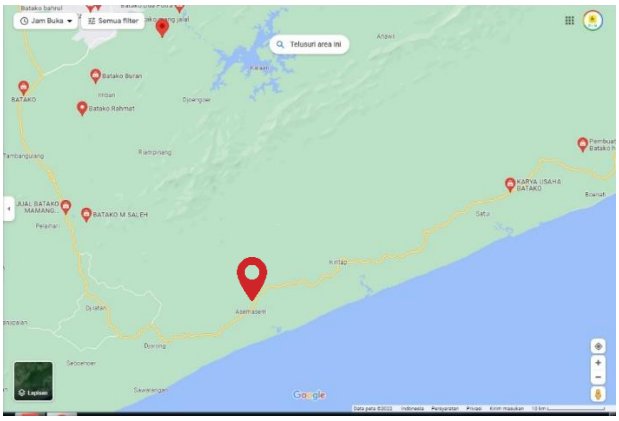


Figure 5. Existing competitor

5. Internal Benefit

The following are the advantages of selling paving blocks with a circular economy concept based on FABA in a day capable of producing 250 units/day. The net profit in 1 year that BUMDes can achieve is;

$$\text{Net profit in one year} = 250\frac{\text{unit}}{\text{days}} \text{x } 21\frac{\text{day}}{\text{month}} \text{x } 12\frac{\text{month}}{\text{year}} \text{ x Rp.}\frac{1.443}{\text{unit}}$$
$$= \text{Rp. } 90.909.000$$

This model business will make BUMDes an independent village-owned business that can generate value for village progress with the concept of a circular economy.

6. External Benefit
   The advantage other than the sale of paving blocks is the reduction in the balance of PLTU XYZ's FABA with a zero-cost concept, where handling FABA using landfills costs billions of rupiah and requires a long process.

6. CONCLUSIONS

Based on the results of the SWOT analysis on nine BMC blocks, the position of PLTU XYZ is in the first quadrant with an internal factor of 0.23 on the X axis and an external factor with a value of 1.59 on the Y axis, which indicates that PLTU XYZ is in an aggressive position. The partnership business model strategy involves investing in paving block printing machines for partners who manage production, marketing, and sales business processes. This strategy utilizes all the company's strengths to take advantage of current opportunities. The nine blocks of the partnership business model consisting of customers segment, value proposition, customer relationship, channel, revenue stream, key resource, key activities, key partnership, and cost structure can support the two main objectives to be achieved by PLTU XYZ, namely increasing the utilization of FABA as a source of energy. This model business is in line with the CSR target of the XYZ PLTU PLTU management contract, namely the distribution of funds for social and environmental responsibility programs, where this program also aims as a CSR to help the economy of the community around PLTU XYZ, as well as support the company's long-term achievement more measurably.

REFERENCES

Az Zahra, A. F., Wahyudin, W., & Nugraha, B. (2021). The Implementation of the Strategy of Marketing Management through a SWOT Analysis with the Matrix of IFE, EFE and IE. *Jurnal Serambi Engineering*, *6*(2), 1721–1729. https://doi.org/10.32672/jse.v6i2.2867

Gundumogula, M. (2020). Importance of Focus Groups in Qualitative Research. *The International Journal of Humanities & Social Studies*, *8*(11), 299–302. https://doi.org/10.24940/theijhss/2020/v8/i11/HS2011-082

Gürel, E. (2017). SWOT Analysis: a Theoretical Review. *Journal of International Social Research*, *10*(51), 994–1006. https://doi.org/10.17719/jisr.2017.1832

Hidayat, A., & Lesmana, I. S. (2020). TOWS Analysis (EFAS and IFAS) as an Implementation of Market Driven Strategy To Create Core Value Loyalty At PT. Carrefour Serang City of Banten. *Proceedings International Seminar on Accounting Society*, *2*(1), 193–202. http://www.openjournal.unpam.ac.id/index.php/PISA/article/view/8824

Joshi, A., Kale, S., Chandel, S., & Pal, D. (2015). Likert Scale: Explored and Explained. *British Journal of Applied Science & Technology*, *7*(4), 396–403. https://doi.org/10.9734/BJAST/2015/14975

Osterwalder, A., & Pigneur, Y. (2010). Business Model Generation. In *Selvedge* (Issue 59). https://doi.org/10.2307/j.ctvh9vtn3.17

Pangastuti, R. D., Angka, B. U., Lakhwani, M. A., Behuku, J., & Putra, J. L. (2019). Strategy Formulating Using IFE, EFE, SWOT and QSPM Matrix Case study: PT Total Bangun PersadaTbk. *International Journal of Innovative Research and Development*, *8*(4), 68–73. https://doi.org/10.24940/ijird/2019/v8/i4/apr19056

Weber, S. (2019). A circular economy approach in the luxury fashion industry: A case study of eileen fisher. In *Environmental Footprints and Eco-Design of Products and Processes*. Springer Singapore. https://doi.org/10.1007/978-981-13-0623-5_7

Winans, K., Kendall, A., & Deng, H. (2017). The history and current applications of the circular economy concept. *Renewable and Sustainable Energy Reviews*, *68*(September 2016), 825–833. https://doi.org/10.1016/j.rser.2016.09.123

ALTERNATIVE ROOFTOP PHOTOVOLTAIC BUSINESS MODELS IN INDONESIA

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ABSTRACT

As a tropical country, Indonesia has the potential for more than 600.000 Terra-Watt hours (TWh) of solar energy. Based on this potential, Indonesia should be able to become the top leader in the use of solar energy for electricity production. However, in 2021, solar energy only contributes less than 0,002% of the total electric power produced in Indonesia. One of the potential uses of solar energy is rooftop PV. This study aims to determine the alternative rooftop PV business model that Indonesia can adopt. The method used in this research is a literature study and questionnaire survey. According to the respondents, rooftop PV must be implemented in Indonesia because it can reduce global warming, save electricity bills, and meet electricity needs. Respondents also mentioned that the rooftop PV must be available at lower costs. Several known rooftop PV business models worldwide are host-owned, third-party-owned, solar lease, and community-based rooftop PV. The community-based solar PV has become the respondent's favourite because it has lower costs and flexibility as a community. Therefore, the community-based rooftop PV business model has the potential to be applied in Indonesia.

Keywords: rooftop PV, Indonesia, business models, community

1. INTRODUCTION

As a tropical country, Indonesia has the potential for more than 600.000 Terra-Watt hours (TWh) of solar energy (Silalahi, 2020). Based on this potential, Indonesia should be able to become the top leader in the use of solar energy for electricity production. However, in 2021, solar energy only contributes less than 0,002% of the total electrical energy produced in Indonesia (PT PLN (Persero), 2021). Based on this potential, Indonesia should be able to become the top leader in the use of solar energy for electricity production. One of the potential uses of solar energy is rooftop PV. Rooftop PV are solar panels installed above the roof to generate electricity and minimize the need for electric power from utility service providers (Harahap et al., 2021). Indonesia has the potential to use rooftop PV of 194-655 GWp for all houses covering 34 provinces in Indonesia (Damayanti *et al.*, 2019). The cities of Jakarta and Surabaya have tremendous potential for the rooftop PV installation market (Tumiwa & Citraningrum, 2019). However, since 2018, Indonesia has been lagging in using rooftop PV from other countries in Southeast Asia, such as Singapore, Thailand, the Philippines, and Malaysia (IESR, 2018). That can happen because of several challenges that must be faced, including complex tariff determination (Asian Development Bank,

2020), various complicated bureaucratic policies (Hamdi, 2019), as well as licensing and negotiation problems (Burke et al., 2019).

Indonesia is the fourth largest country in the world by population (ASEAN Secretariat, 2021). As mentioned before, Indonesia has a tropical climate and abundant solar energy potential because it is located on the equator (Rajendra, 2021). Based on its potential for solar energy and its large population, Indonesia should be able to lead the use of solar energy. Nevertheless, the most significant contributor to electricity production in Indonesia is the coal-fired power plant, with 39,70%. Even the contribution of solar energy to electricity production in Indonesia only reaches 0,00196% of the total energy mix (PT PLN (Persero), 2021).

Meanwhile, the total renewable energy electricity production is only 11.5% of the target of 23% in 2025 (Ministry of Energy and Mineral Resources (MEMR), 2022). One of the strategies for accelerating the renewable energy mix by 2025 is the addition of 335 MW rooftop PV capacity by 2022. Therefore, several business models are needed to attract public interest in installing rooftop PV. This study aims to determine the alternative rooftop PV business model that Indonesia can adopt to accelerate the renewable energy mix target by 2025 by 23%.

2. LITERATURE REVIEW

Research on the rooftop PV business model applied in Thailand has been carried out by Tongsopit et al. (2016). This study describes four types of business models in Thailand. The four business models include roof rental, solar PPA or solar shared savings, solar leasing, and community solar. The roof rental business model allows for a long-term agreement of 25 years between the owner of the roof or building and the rooftop PV company. The building owner gets a roof rental fee as the asset owner, and the rooftop PV provider receives the electricity sales fee from the utility provider. The second business model is solar PPA, where the roof owners get electricity prices below the current introductory rate. Rooftop PV owners get benefits because they do not have to pay roof rental fees while receiving the electricity sales fee from the utility provider. The third business model is solar leasing, which allows building owners to purchase rooftop PV in instalments for a certain period according to the contract to avoid expensive initial investment costs for the roof owner, including the cost of providing assets, installation, and monthly routine maintenance. The last business model is community solar, where there is a cooperation between investors, rooftop PV providers, and several roof owners to build a community. This structure allows the community to manage their rooftop PV mini-grid system as a combined portfolio of various capital, operating, and maintenance costs. This scheme allows the rooftop PV system to have high quality and standards.

Another research conducted by Hoogduin (2017) is about the potential of a rooftop PV business model in the Netherlands. Three business models are offered: customer-owned, third-party PV, and community solar/solar shares. Customer-owned is a business model where customers buy a rooftop PV module to install, then use it or sell the electrical energy generated to the system. On the other hand, the community solar/solar shares business model is generated by several customers who are members of a community and can take advantage of several rooftop PV that are operated as one system. The ownership of the rooftop PV module belongs to the group or community, not individuals. In addition, the third-party PV business model allows customers not to incur costs in procuring rooftop PV modules. However, the ownership status of rooftop PV belongs to the developer company that has collaborated with customers.

Another study about apartment rooftop PV business models in Germany was done by Fina et al. (2018). The study explains that Germany successfully implemented a shared PV system in apartment buildings. It means that the owner of an apartment unit can produce their own electricity.

Germany has two main business models for rooftop PV: Enabling and Contracting. Enabling allows apartment owners who have installed rooftop solar panels to sell all of the electrical energy produced by their PV to the grid system. The advantage of this business model is that all residents who are members of a shared PV system will buy electricity at a lower price than the regular price. The electrical energy provider buys all the energy produced by the rooftop PV. The benefit of this business model is that everyone who belongs to a communal PV system will pay less for power than the going rate. The electrical energy provider purchases all of the energy generated by the rooftop PV. In order to install a rooftop PV unit, the contracting business model relies on a long-term agreement with the owner of the property or apartment building that leases out the land.

Another study that compared host-owned, community-shared, and third-party-owned business models was done by Horváth Szabó (2018). The study explains that the community-shared business model can increase competitiveness for companies. Companies need to pay attention to the condition of strategic assets and how competent they are in the field of rooftop PV. The community-shared business model can generate significant benefits such as increased digitization and socio-economic impact. In addition, the company can establish long-term solid cooperation with third parties in the procurement and maintenance process.

Research has also been carried out on the development of rooftop solar PV in India by Trivedi et al. (2018). This study states two main rooftop PV business models in India: CAPEX and OPEX. The CAPEX business model is when consumers fully own the rooftop solar power plant. The consumer will bear the entire cost of installation, maintenance, and all risks. The CAPEX model has accounted for at least 84% of all rooftop PV mini-grid in India and is mainly run by the commercial industry. In comparison, the OPEX model is when an energy service company provides all of the capital and is responsible for installing, operating, and maintaining a rooftop solar power plant in exchange for a Power Purchase Agreement (PPA) with consumers. The OPEX model is also known as the third-party financing or third-party financing model. The OPEX model allows customers not to spend the capital or bear the risk of installing rooftop PV. The development company has completed the installation, operation, and maintenance process. However, India's OPEX model has not increased at the expected rate due to a lack of capital availability. So that the capital financing scheme through bonds will be cheaper and help promote renewable energy projects, especially rooftop solar power plants.

Cai et al. (2019) researched China's rooftop PV business model. The study outlined the host-owned, third-party-owned, and energy management contract (EMC) rooftop solar PV business models that are available in China. The host-owned business model allows customers to privately install a rooftop PV system and generate electricity for their needs. Customers can choose to sell all of their energy to the grid or just the excess that exceeds their requirements. When the customer chooses to sell all of their produced electricity, they can get benefit from the sale of electricity according to the national electricity tariff. On the other hand, customers will pay less than the appropriate national tariff when they only sell excess energy to the grid. However, customers receive priority and subsidies of 0.42 yuan/kWh from the central and local governments for purchasing electrical energy from national electricity providers.

Meanwhile, the two most significant obstacles to developing rooftop solar power plants are high investment costs and long payback periods. A third-party-owned (TPO) business model can be a solution. Customers can get rooftop PV services without incurring high investment costs. A third party will handle the entire process of repair and maintenance of the rooftop PV system during the period of use. Customers receive the price of solar electricity 80-90% lower than the national electricity price.

The basis of EMC model is that the customer does not need to do anything except provide a sufficient area for the rooftop PV while the developer company invests, builds, and maintains. The customer does not need to make a high initial investment and does not bear the risk of operating the system. In addition, customers can use electrical energy at a lower price than the market price. The most fundamental difference between EMC and TPO models is that in the EMC model, the rooftop PV equipment will be credited to the customer after 20 years and will become the customer's property. Regulation and legislative obstacles, funding, technology, network connections, awareness, and rooftop resources can all be considerably reduced using the EMC paradigm. Therefore, the EMC business model performs the best among the other three rooftop PV business models in China.

Another research about the market potential of rooftop solar PV in Indonesia has been done by Damayanti et al. (2019). The potential for installing rooftop PV in Indonesia is estimated based on the availability of residential roof space. The estimation of market potential is done by using the assumption that the installation of rooftop PV in Indonesia is very dependent on the financial condition of the house/building owner. The estimation only considers the single house connected to the PLN network. The enormous market potential for rooftop solar power plants in Indonesia is in the provinces of DKI Jakarta, West Java, and East Java. Homeowners in Jakarta and Surabaya desire to use rooftop solar panels in their homes. The government can use the market potential as supporting data to implement renewable energy policies.

Barbose and Satchwell (2020) explain that the ownership status of the rooftop PV module in the TPO (third-party-owned) business model belongs to a third party (developer company), while in the utility-owned business model, the PV module belongs to an official government utility company. Such utility-owned business models can potentially offer income opportunities for utility shareholders. So, if the company can obtain a rooftop solar PV module at a low cost and minimize the monthly rental costs from the house or building owner, this business model is highly recommended.

Another study by Deutsch and Berényi (2020) compared Hungary's utility-owned and community-financed business models. The study explains that the community-financed business model provides more significant financial benefits than the old (utility-owned) business model. This profit is based on the calculation of NPV in the community-financed business model in Hungary, which is higher than the utility-owned business model. However, utility companies must find a suitable target market for the community-financed business model for rooftop solar panels to maximize these profits.

Research about three rooftop PV business schemes based in Jakarta, Indonesia, has been done by Haryadi et al. (2021). In the first scheme, consumers submit purchases by way of instalments to the bank for a certain period, which automatically makes the ownership of the rooftop solar power plant to the consumer. Second, consumers can rent PLN's rooftop PV on their houses and have to pay a lower amount. The calculation can be taken from the difference in the use of imports from PLN subtracted by the kWh income from rooftop solar power plants. This method requires consumers to subscribe for a certain period. The third scheme is that PLN sets the price of LCOE (Levelized Cost of Electricity), or PLN buys electricity produced by customers at a flat price. Furthermore, PLN sets up a margin and sells it at a lower price than the current basic electricity tariff. This system makes the ownership of rooftop PV remain with PLN so that consumers will always buy electric energy from rooftop PV at a lower price than the basic electricity tariff

According to the literature review, based on the ownership of rooftop PV modules, there are several rooftop PV business models around the world as follows: host-owned, third-party-owned, utility-owned, solar loan/lease, and community-based rooftop PV. Community-based rooftop PV model has become famous because it can significantly reduce the initial investment costs and share the risks with all community members (Farrell, 2010). As a multi-ethnic country, Indonesia makes its citizens build communities, from small neighbourhoods to large communities with a high tolerance level (Suryahadi et al., 2020). Accordingly, the community-based business model is suitable to be implemented in Indonesia.

3. METHODS

The method used in this study is a literature review and questionnaire survey. The target respondents are PLN customers with a minimum house type of 45 (Tumiwa & Citraningrum, 2019) and have an installed electricity connection of at least 1300 VA. Before being used in the study, validity and reliability tests were conducted to determine whether the question items in the questionnaire were valid and could be used for the analytical process (Moses & Yamat, 2021). The questionnaire items to be tested consist of 9 questions, each with a scale of 1 (strongly disagree) to 5 (strongly agree).

The validity test of the questionnaire was conducted to test whether the questions were valid or not. The method used in the validity test is the Pearson correlation test. If the Pearson correlation coefficient (r) of the question items is more than 0.6, then the question is valid and can be used in research (Selvanathan et al., 2020). The Pearson correlation coefficient category can be seen in Table 1.

Table 1. Pearson correlation coefficient (Selvanathan et al., 2020)

Correlation coefficient (r)	Correlation Category
$0 < r \leq 0,19$	Very low
$0,2 \leq r \leq 0,39$	Low
$0,4 \leq r \leq 0,59$	Fair/moderate
$0,6 \leq r \leq 0,79$	High
$0,8 \leq r \leq 1.0$	Very high

Similarly, the questionnaire reliability test aims to test whether the questionnaire is reliable or not. A questionnaire's reliability can indicate whether the results are consistent or not (Aithal & Aithal, 2020). Consistency of the questionnaire is when it gives the same results every time it is used. The reliability of the questionnaire is represented by Cronbach's Alpha value (Creswell & Guetterman, 2019). If Cronbach's Alpha is less than 0.70, the questionnaire is considered unreliable or cannot be used in the subsequent analysis (Nawi et al., 2020). The category of Cronbach's Alpha coefficient can be seen in Table 2.

Table 2. Cronbach's Alpha category (A. S. Singh, 2017)

Cronbach's Alpha (α)	Consistency Category
$\alpha < 0,5$	Unacceptable
$0,5 \leq \alpha < 0,6$	Poor
$0,6 \leq \alpha < 0,7$	Questionable
$0,7 \leq \alpha < 0,8$	Acceptable
$0,8 \leq \alpha < 0,9$	Good
$\alpha \geq 0,9$	Excellent

4. RESULTS

The questionnaires have been distributed and filled out by 196 respondents. The results of testing the validity of the questionnaire show that the correlation of all questions has a positive value of more than 0, with eight items in the high correlation category and 1 item in the moderate/moderate correlation category. Then the results of the validity test of the questionnaire are all questions in the questionnaire are valid and can be used in the next process. Such as validation test results, reliability test results show that the Cronbach Alpha coefficient value of all question items is worth more than 0.8 or in a suitable category. So, all of the questions in the questionnaire are reliable and consistent when used in the next process.

According to the questionnaire results, around 86,2% of respondents agreed that rooftop PV is very important to be implemented in Indonesia. Three significant reasons are reducing carbon emissions, saving the electricity bill, and meeting the electricity needs (B. P. Singh et al., 2019). Then, the respondents were asked about what they complained about rooftop PV services. The main idea of the respondent's answers was extracted to make a word cloud (Bletzer, 2015). For example, if a respondent answered with a "lack of information and education to the public," the main idea of that answer is lack of socialization. A visualization of the respondent's answers is shown in Figure 1.



Figure 1. Respondent's complaints about rooftop PV service

From Figure 1, the most common complaint is lack of socialization, followed by "do not know" and "expensive". The "do not know" expression is related to a lack of socialization about rooftop PV service. Only around 20,9% of respondents know that PLN also offers rooftop PV services. The Indonesian government and PLN, as state-owned enterprises in the electricity sector, must pay attention to this lack of socialization issue. Furthermore, the expensive factor depends on the financial condition. Indonesia's average electricity consumption per household is about 1.544,02 kWh (Basconcillo & Rimkute, 2022). Installing a rooftop PV system in Indonesia may cost between 14 and 20 million rupiahs per kilowatt, depending on the location, size, and inverter quality (Siregar, 2020). This complaint about rooftop PV expensiveness is related to research on public opinion about rooftop PV services in Bali (Citraningrum & Tumiwa, 2021a) and Central Java (Citraningrum & Tumiwa, 2021b). The respondents were also asked about their wishes for rooftop PV services in Indonesia. Respondents want inexpensive rooftop PV services, obviously related to their complaint about the rooftop PV expensiveness. Not only for the PV module price but also the maintenance should be inexpensive. Secondly, respondents want electricity bill savings by implementing rooftop PV. Besides environmental factors, savings are also why rooftop PV should be installed. The respondent's wishes about rooftop PV services in Indonesia are shown in Figure 2.



Figure 2. Respondent's wishes about rooftop PV

Next is the respondent's opinion on choosing a rooftop PV service scheme. When respondents were asked about their interest in the community-based business model, a total of 165 were interested in that scheme. Then when respondents were asked about their interest in the school and office-based business model, 160 respondents were interested in the scheme. However, when respondents were asked about the leasing-based scheme, only 88 respondents were interested in the scheme. Thus, the scheme that most respondents are interested in is rooftop PV services based on residential communities or offices, or schools.

It turns out that the most successful business model in New York is a community-based solar PV business model. With 414 GWac installed for solar community projects from 2016 to 2020 (Feldman et al., 2022). According to the Solar Energy Industries Association (SEIA) (Solar Energy Industries Association (SEIA), 2022), the community-based PV business refers to neighbourhood solar installations used by several community members. Each member earns credit on their electricity bills for the power they contributed to the creation. In addition, community-based business models are also becoming popular in Thailand (Tongsopit et al., 2016), Netherland (Hoogduin, 2017), the UK and other European Countries (Peters et al., 2018), Australia (Hansen et al., 2020), Hungary (Deutsch & Berényi, 2020), England (Nolden et al., 2020), Nigeria (Dunmade, 2021), and South Korea (Yang et al., 2021).

Customers who do not have enough solar resources or cannot afford them can purchase or lease a portion of a shared solar PV system in the community-based business model (Reese et al., 2018). In addition, the advantages of a community-based business model include generating new job opportunities (Grafakos et al., 2020), no need to own a house, low upfront cost (sometimes, there is no upfront cost), saving electricity bills, energy independence, and supporting the local economy (Young, 2017). On the other hand, the community-based rooftop PV business model also has some weaknesses. Despite the business model, solar energy has a fundamental weakness because of its dependency on sunlight. The solar module will decrease its performance if the sunlight is low or gone. This can potentially disrupt the stability of the electricity system (Singh et al., 2019). The disadvantages of community-based rooftop PV business models are that the solar PV subscribers will not have access to any of the tax benefits of solar PV because they do not own it, there will be administrative costs, and community solar is not available in all areas (Schell, 2021). Although it has drawbacks, the advantages of the community-based rooftop PV business model are still feasible to be implemented in Indonesia with the right strategy. The difference between rooftop PV installations on owned properties and community-based ones can be seen in Table 3. So, the community-based rooftop PV business model can be a potential for the government to formulate national renewable energy strategies, reaching 23% of the total energy production by 2025.

Table 3. Difference between rooftop PV installation on owned properties and community-based (Pirro, 2020)

#	Owned property	Community-based
1	Must own the property	Unacceptable
2	Upfront solar panel installation cost	Lower or no upfront cost
3	On-going cost (maintenance or repairs)	No maintenance required
4	Increase the property value	No impact on property
5	The application process takes time	Do not have to wait

6. CONCLUSIONS

The advantages of the community-based rooftop PV business model are: generating new job opportunities, lower/no upfront cost, no need to own a house/property, saving the electricity bills, energy independence, and supporting the local economy. While the disadvantages are its dependence on sunlight, the subscribers will not have access to any of the tax benefits from solar PV, and still not available in all areas. Even though it has pros and cons, the community-based rooftop PV still became the respondent's top choice. The Indonesian government must cooperate with related parties, especially PLN, a state-owned company in the electricity sector, to develop a strategy for implementing a community-based rooftop PV business model. The community-based business model is expected to accelerate the realization of 23% energy production using renewable energy by 2025.

REFERENCES

Aithal, A., & Aithal, P. S. (2020). Development and Validation of Survey Questionnaire & Experimental Data – A Systematical Review-based Statistical Approach. *International Journal of Management, Technology, and Social Sciences*, *104830*, 233–251. https://doi.org/10.47992/ijmts.2581.6012.0116

ASEAN Secretariat. (2021). *ASEAN Key Figures 2021*. ASEAN Secretariat. https://www.aseanstats.org/wp-content/uploads/2021/12/ASEAN-KEY-FIGURES-2021-FINAL-1.pdf

Asian Development Bank. (2020). *Renewable Energy Tariffs and Incentives in Indonesia: Review and Recommendations*. https://www.adb.org/publications/renewable-energy-tariffs-incentives-indonesia

Barbose, G., & Satchwell, A. J. (2020). Benefits and costs of a utility-ownership business model for residential rooftop solar photovoltaics. *Nature Energy*, *5*(10), 750–758. https://doi.org/10.1038/s41560-020-0673-y

Basconcillo, J. A., & Rimkute, A. (2022). GMM Approach to Residential Electricity Consumption in Indonesia. *Energy RESEARCH LETTERS*, *3*(Early View), 1–7. https://doi.org/10.46557/001c.33899

Bletzer, K. V. (2015). Visualizing the qualitative: making sense of written comments from an evaluative satisfaction survey. *Journal of Educational Evaluation for Health Professions*, *12*, 12. https://doi.org/10.3352/jeehp.2015.12.12

Burke, P. J., Widnyana, J., Anjum, Z., Aisbett, E., Resosudarmo, B., & Baldwin, K. G. H. (2019). Overcoming barriers to solar and wind energy adoption in two Asian giants: India and Indonesia. *Energy Policy*, *132*(December 2018), 1216–1228. https://doi.org/10.1016/j.enpol.2019.05.055

Cai, X., Xie, M., Zhang, H., Xu, Z., & Cheng, F. (2019). Business Models of Distributed Solar Photovoltaic Power of China: The Business Model Canvas perspective. *Sustainability (Switzerland)*, *11*(16), 1–27. https://doi.org/10.3390/su11164322

Citraningrum, M., & Tumiwa, F. (2021a). *Apa Kata Mereka Tentang Plts Atap? (Survei persepsi rumah tangga, sektor komersial, dan UMKM terhadap penggunaan PLTS Atap di Bali*.

Citraningrum, M., & Tumiwa, F. (2021b). *Apa Kata Mereka Tentang Plts Atap? (Survei persepsi rumah*

tangga, sektor komersial, dan UMKM terhadap penggunaan PLTS Atap di Jawa Tengah).

Creswell, J. W., & Guetterman, T. C. (2019). *Educational Research: Planning, Conducting, and Evaluating Quantitative and Qualitative Research* (6th ed.). Pearson.

Damayanti, H., Tumiwa, F., & Citraningrum, M. (2019). *Residential Rooftop Solar Technical and Market Potential in 34 Provinces in Indonesia* (Issue 20). http://iesr.or.id/pustaka/residential-rooftop-solar-potential-in-34-provinces-in-indonesia/#

Deutsch, N., & Berényi, L. (2020). Economic potentials of community-shared solar plants from the utility-side of the meter – A Hungarian case. *Electricity Journal*, *33*(8), 106826. https://doi.org/10.1016/j.tej.2020.106826

Dunmade, I. (2021). Community/shared solar power option: A pathway to sustainable rural electrification in Nigeria. *Agronomy Research*, *19*(4), 1734–1746. https://doi.org/10.15159/AR.21.150

Farrell, J. (2010). Community Solar Power: Obstacles and Opportunities. In *New Rules Project* (Issue November). https://ilsr.org/wp-content/uploads/files/communitysolarpower2.pdf

Feldman, D., Dummit, K., Zuboy, J., Heeter, J., Xu, K., & Margolis, R. (2022). *Spring 2022 Solar Industry Update*.

Fina, B., Fleischhacker, A., Auer, H., & Lettner, G. (2018). Economic Assessment and Business Models of Rooftop Photovoltaic Systems in Multiapartment Buildings: Case Studies for Austria and Germany. *Journal of Renewable Energy*, *2018*, 1–16. https://doi.org/10.1155/2018/9759680

Grafakos, S., Senshaw, D., Wahono, J., & Toro, A. (2020). Employment Assessment of Renewable Energy: Indonesian Power Sector Pathways. In *Global Green Growth Institute* (Issue May).

Hamdi, E. (2019). *Indonesia's Solar Policies Designed to Fail?* (Issue February). https://ieefa.org/wp-content/uploads/2019/02/Indonesias-Solar-Policies_February-2019.pdf

Hansen, P., Morrison, G. M., Zaman, A., & Liu, X. (2020). Smart technology needs smarter management: Disentangling the dynamics of digitalism in the governance of shared solar energy in Australia. *Energy Research and Social Science*, *60*(October 2019), 101322. https://doi.org/10.1016/j.erss.2019.101322

Harahap, P., Pasaribu, F. I., Siregar, C. A. P., & Oktrialdi, B. (2021). Performance of Grid-Connected Rooftop Solar PV System for Households during Covid-19 Pandemic. *Journal of Electrical Technology UMY*, *5*(1), 26–31. https://doi.org/10.18196/jet.v5i1.12089

Haryadi, F., Simaremare, A., & Indrawan, H. (2021). Rooftop PV business scheme in Jakarta. *IOP Conference Series: Materials Science and Engineering*, *1098*(4), 042038. https://doi.org/10.1088/1757-899x/1098/4/042038

Hoogduin, E. (2017). *Business Model Innovation Opportunities in The Dutch Downstream Photovoltaic Industry*. TUDelft.

Horváth, D., & Szabó, R. Z. (2018). Evolution of photovoltaic business models: Overcoming the main barriers of distributed energy deployment. *Renewable and Sustainable Energy Reviews*, *90*(March), 623–635. https://doi.org/10.1016/j.rser.2018.03.101

IESR. (2018). *Memacu Pembangunan Listrik Surya Atap, Belajarlah dari India*. https://iesr.or.id/memacu-pembangunan-listrik-surya-atap-belajarlah-dari-india-3

Ministry of Energy and Mineral Resources (MEMR). (2022). *Ini Capaian Kinerja Tahun 2021 dan Rencana Kerja 2022 Subsektor EBTKE*. https://ebtke.esdm.go.id/post/2022/01/17/3055/ini.capaian.kinerja.tahun.2021.dan.rencana.kerja.2022.subsektor.ebtke

Moses, R. N., & Yamat, H. (2021). Testing the Validity and Reliability of a Writing Skill Assessment. *International Journal of Academic Research in Business and Social Sciences*, *11*(4), 202–208. https://doi.org/10.6007/ijarbss/v11-i4/9028

Nawi, F. A. M., Tambi, A. M. A., Samat, M. F., & Mustapha, W. M. W. (2020). a Review on the Internal Consistency of a Scale: the Empirical Example of the Influence of Human Capital Investment on Malcom Baldridge Quality Principles in Tvet Institutions. *Asian People Journal (APJ)*, *3*(1), 19–29. https://doi.org/10.37231/apj.2020.3.1.121

Nolden, C., Barnes, J., & Nicholls, J. (2020). Community energy business model evolution: A review of solar photovoltaic developments in England. *Renewable and Sustainable Energy Reviews*, *122*(January),

109722. https://doi.org/10.1016/j.rser.2020.109722

Peters, M., Fudge, S., High-Pippert, A., Carragher, V., & Hoffman, S. M. (2018). Community solar initiatives in the United States of America: Comparisons with – and lessons for – the UK and other European countries. *Energy Policy*, *121*(June), 355–364. https://doi.org/10.1016/j.enpol.2018.06.022

Pirro, J. (2020). *The Pros and Cons of Community Solar*. https://www.hahasmart.com/blog/3199/the-pros-and-cons-of-community-solar

PT PLN (Persero). (2021). *Statistik PLN 2021*. PT PLN (Persero). https://web.pln.co.id/statics/uploads/2022/03/Statistik-PLN-2021-Unaudited-21.2.22.pdf

Rajendra, A. (2021). Contemporary challenges of the Indonesian vernacular architecture in responding to climate change. *IOP Conference Series: Earth and Environmental Science*, *824*(1). https://doi.org/10.1088/1755-1315/824/1/012094

Reese, M. O., Glynn, S., Kempe, M. D., McGott, D. L., Dabney, M. S., Barnes, T. M., Booth, S., Feldman, D., & Haegel, N. M. (2018). Increasing markets and decreasing package weight for high-specific-power photovoltaics. *Nature Energy*, *3*(11), 1002–1012. https://doi.org/10.1038/s41560-018-0258-1

Schell, A. (2021). *Community Solar: The Pros and Cons*. https://www.paradisesolarenergy.com/blog/community-solar-the-pros-and-cons

Selvanathan, M., Jayabalan, N., Saini, G. K., Supramaniam, M., & Hussin, N. (2020). Employee Productivity in Malaysian Private Higher Educational Institutions. *PalArch's Journal of Archaeology of Egypt/ Egyptology*, *October*, 1948–1949. https://doi.org/10.48080/jae.v17i3.50

Silalahi, D. F. (2020). *Why solar energy can help Indonesia attain 100% green electricity by 2050*. https://theconversation.com/why-solar-energy-can-help-indonesia-attain-100-green-electricity-by-2050-134807

Singh, A. S. (2017). Common Procedures for Development, Validity and Reliability of a Questionnaire. Swaziland: Department of AEM, Faculty of Agriculture, University of Swaziland. *International Journal of Economics, Commerce and Management*, *5*(5), 790–801.

Singh, B. P., Kumar Goyal, S., & Ahmed Siddiqui, S. (2019). Grid Connected-Photovoltaic System (GC-PVS): Issues and Challenges. *IOP Conference Series: Materials Science and Engineering*, *594*(1). https://doi.org/10.1088/1757-899X/594/1/012032

Siregar, K. (2020). *Why Indonesia struggles to tap its solar energy potential*. https://www.channelnewsasia.com/climate-change/why-indonesia-struggles-tap-its-solar-energy-potential-1339626

Solar Energy Industries Association (SEIA). (2022). *Community Solar*. https://www.seia.org/initiatives/community-solar

Suryahadi, A., Rishanty, A., & Sparrow, R. (2020). *Social Capital and Economic Development in a Large Multi-ethnic Developing Country: Evidence from Indonesia* (WP/4/2020). 1–51. http://publication-bi.org/repec/idn/wpaper/WP042020.pdf

Tongsopit, S., Moungchareon, S., Aksornkij, A., & Potisat, T. (2016). Business Models and Financing Options for a Rapid Scale-up of Rooftop Solar Power System in Thailand. *Financing Renewable Energy Development in East Asia Summit Countries*, *April*, 79–136.

Trivedi, S., Ray, I., Vulturius, G., Goldar, A., Prakash, L. J., Paul, S., & Sagar, A. (2018). *Scaling up Rooftop Solar Power in India: The Potential of Municipal Solar Bonds* (Issue 353). http://icrier.org/pdf/Working_Paper_353.pdf

Tumiwa, F., & Citraningrum, M. (2019). *Energi Surya untuk Kota: Analisa Potensi Pasar dan Rekomendasi untuk Akselerasi Pengembangan Rooftop Solar di Dua Kota Metropolitan di Indonesia* (Issue 20).

Yang, S., Chen, W., & Kim, H. (2021). Building Energy Commons: Three Mini-PV Installation Cases in Apartment Complexes in Seoul. *Energies*, *14*(1), 1–14. https://doi.org/10.3390/en14010249

Young, C. (2017). *What Are the Benefits of Community Solar?* https://blog.solstice.us/solstice-blog/community-solar-benefits/

OMNICHANNEL MARKETING STRATEGY TOWARD SUZUKI PASSENGER CAR WITH DESIGN THINKING PROCESS

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ABSTRACT

Digital Transformation has caused numerous car dealerships including UMC Suzuki to widely apply multichannel marketing that focuses on the presence of the brand. However Pandemic COVID-19 has accelerated the transformation that leads these car dealerships to adjust their strategy to stay relevant to the market. One of the strategies is to switch from multichannel marketing to omnichannel that aims for the most effective channel to reach the customer. This study tries to describe the details of omnichannel role in the marketing strategy of Suzuki passenger car to anticipate the digital transformation and adjust to the customer behavior of the automotive market in East Java. By using the design thinking method, this study starts with empathizing the customer journey through marketing channels, defining the relevant customer journey, and revealing the most effective idea from multichannel to omnichannel marketing. The customer journey should be based on the flywheel marketing concept that attracts, enganges, and delights the customer. The study will deliver a recommendation for Suzuki Indonesia and its car dealership to market Suzuki passenger car through an effective omnichannel marketing strategy.

Keywords: Digital Transformation, Pandemic COVID-19, Omnichannel Marketing, Customer Journey, Design Thinking, Flywheel Marketing.

1. INTRODUCTION

United Motors Centre (UMC) is a Suzuki car dealership for the East Java region. Market share data for 2019 before the COVID-19 Pandemic when compared to market share data for 2020 showed a 47.15% decline in all brand automotive sales in East Java. Suzuki experienced a decline of 32.16% in the same period. During the COVID-19 pandemic, UMC has closed 7 of the 25 showrooms operating throughout East Java. But at the same time, UMC also opened 1 new Digital and E Commerce division as a virtual showroom to support the role of conventional showrooms. The COVID-19 pandemic is a trigger for various sectors to evaluate and adapt to massive changes that occur both in terms of digital transformation, consumer behavior, or market changes.

The conditions experienced by UMC during the COVID-19 pandemic were evaluated through the marketing strategy that is currently being implemented, in terms of the marketing channel used. UMC is present through as many marketing channels as possible to meet its customers, but there is no integration between channels. With this multichannel marketing system, from the company's perspective, the resources needed are very large where each channel requires energy, cost, and time independently because there is no integration between channels. From the consumer side, the shopping experience is not integrated so there is no seamless experience in getting information and making transactions.

Based on the above background, the main problem to be solved through this research is to determine UMC's omnichannel marketing strategy that is effective in marketing Suzuki passenger cars in the midst of the digital transformation of the automotive market. These problems include obstacles in implementing the omnichannel marketing strategy program at UMC Suzuki, the transformation process of changing the multichannel marketing strategy into omnichannel marketing at UMC Suzuki, as well as efforts to carry out an effective omnichannel marketing strategy with the flywheel marketing concept approach (attract, engage, delight).

This research is expected to give car dealership a new perspective in designing relevant marketing strategies in the midst of digital transformation of the automotive market as well as providing recommendations and implementation opportunities for the development of omnichannel marketing strategies in the automotive market in various segments. This research is also expected to be an opportunity for the continuation of further research related to digital transformation in the automotive market, omnichannel marketing, design thinking, flywheel marketing, or a combination of them.

2. LITERATURE REVIEW

Digital transformation, globalization and fierce competition will lead the way (Gao et al., 2016). Digital transformation strategy is very important because it reflects the omnipresence (presence everywhere) in the change by digital technology in an organization. Thus, organizations must change their traditional business models, which have been running for more than decades, and transform to adapt to trends (Llopis-Albert et.al, 2020). Retailers, in this case manufacturers, salespeople, and consumers, will also be affected where they will dynamically iterate the way they interact and communicate with each other. In fact, consumers will expect interactions that flow simultaneously physically and digitally in buying products and services. Consumer data in the automotive market will also be a key factor, where customer offers can be targeted accurately, data efficiency and correct analysis will make data a gold mine in the automotive market. Customer experience has been and will always be a differentiating factor in the automotive market, both during the sales process, driving experience, and in the aftersales period. (Llopis-Albert et al, 2020). The COVID-19 pandemic has accelerated digital transformation which has directly or indirectly changed consumer behavior in transactions. (Matthews et. al, 2021). Face-to-face interactions are reduced, the use of technology is getting stronger, so that consumer behavior leads to a new normal hybrid, a blend of online and offline. The researchers found the concept of a marketing strategy based on the channel used and the level of integration (Hajdas et. al, 2019), which is divided into:

1. Single-channel: defined as the use of only one type of channel, for example traditional stores
2. Multi-channel : There are several types of channels used, without integration between channels
3. Cross-channel : There are several types of channels used with integration across multiple channels

4. Omni-channel: There are several types of channels that are used with full integration between channels (store, website, mobile channel, social media, and all consumer touchpoints)

If depicted in a graph, the differences between channels and their level of integration are presented in the following figure:

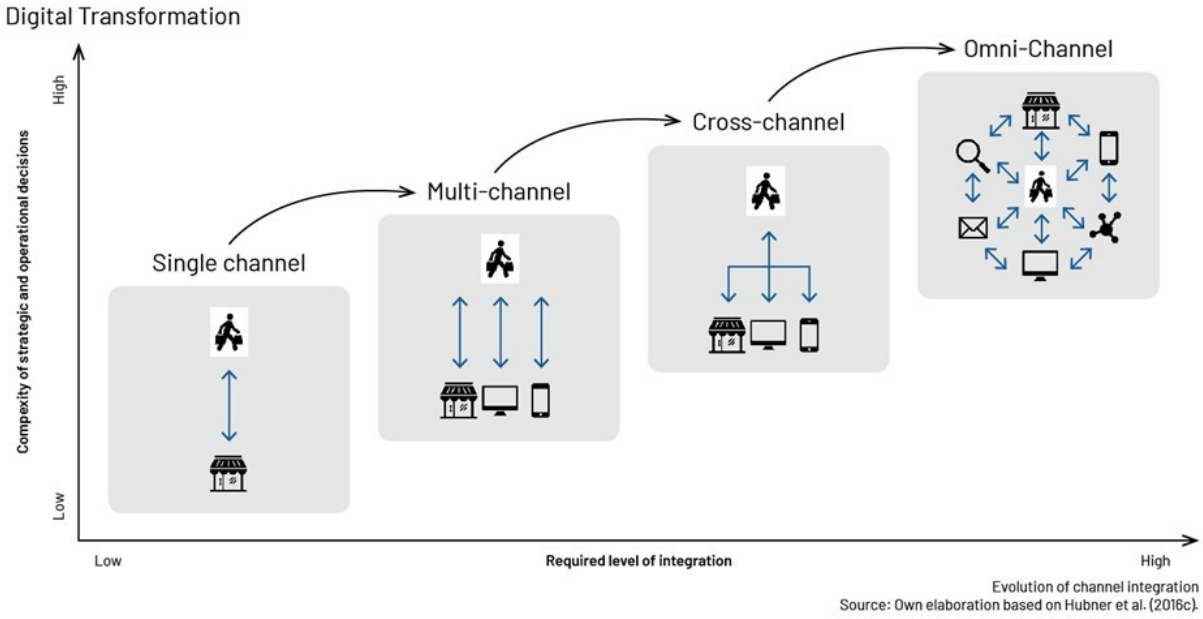


Figure 1. Evolution of channel integration

When it comes to marketing channels, of course, it cannot be separated from the content that needs to be prepared regarding the marketing channel strategy. The marketing funnel that forms the basis of channel content is flywheel marketing. Flywheel marketing is a development of the traditional marketing funnel strategy, which is a cyclical process in which consumers are the input for business growth (Sharma, 2020). The stages of flywheel marketing consist of:

1. Attract: provide value that originally attracts the target audience to increase leads (Sharma, 2020)
2. Engage: presenting more detailed information and content to convince the audience to try the product or find out more details about the products offered (Sharma, 2020)
3. Delight: upselling stage by maintaining good relations with consumers. Consumers are also invited to make reviews or user generated content at this stage, which is considered effective for convincing new leads (Sharma, 2020)

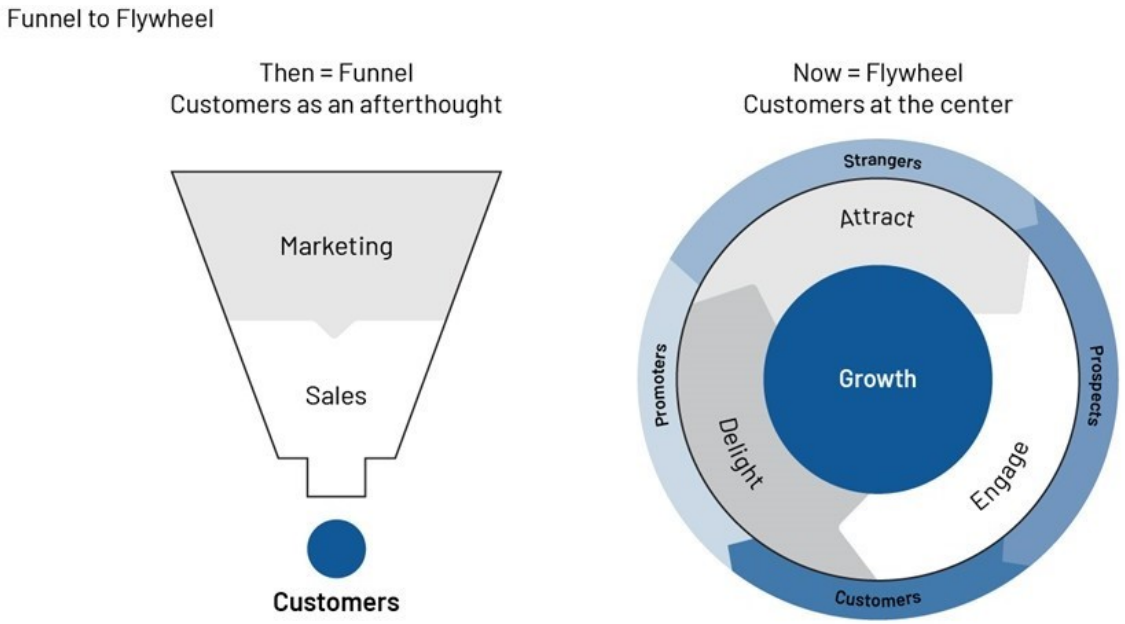


Figure 2. Flywheel marketing concept

Design Thinking

Design thinking approach is a creative approach to solving problems by involving users in their thinking processes where the user's perspective is the main consideration in solving problems (Brown, 2008). Thinking like a designer will transform the way we develop products, services, processes, and even strategies (Brown, 2008). Five stages of Hasso-Platner Design Thinking are used as methods in this research, which consist of Empathize, Define, Ideation, Prototype and Testing. Attached a picture to explain the 5 stages of Design Thinking:

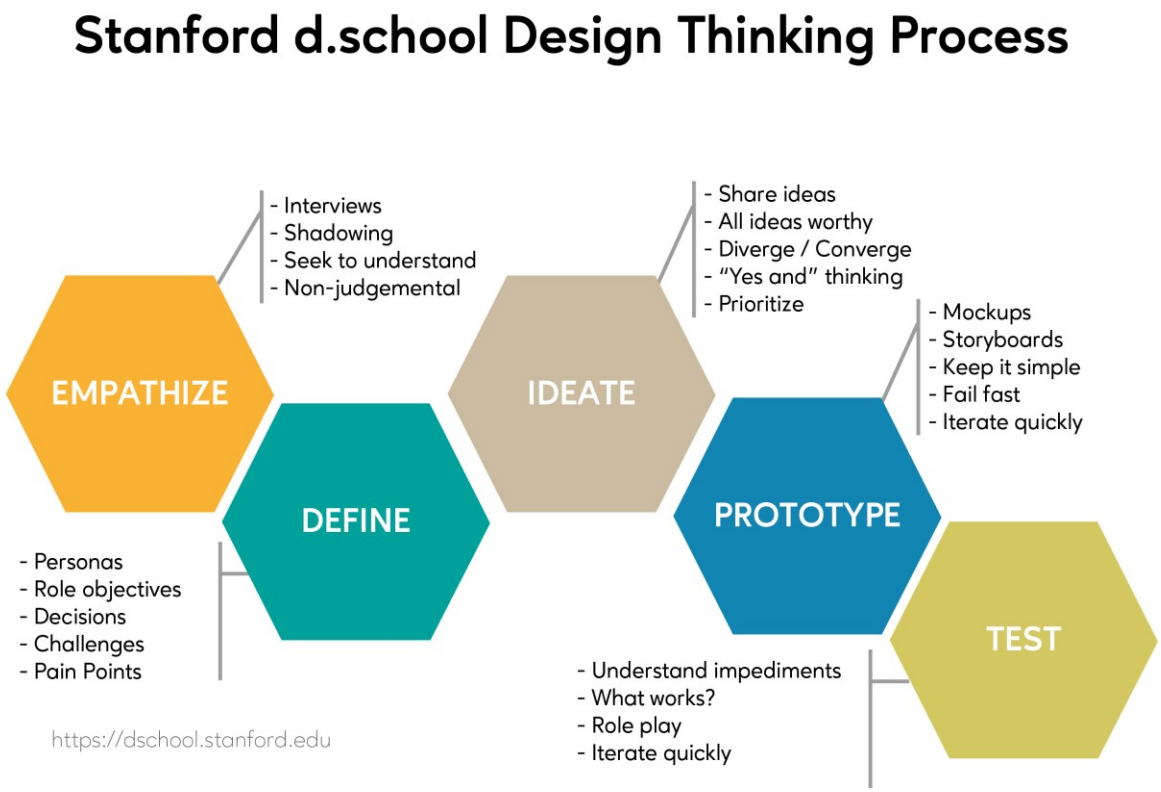


Figure 3. Design thinking Hasso-Platner according Stanford (d.school)

3. METHODS

From the 5 method stages of Design Thinking, the research will be carried out to the third stage, namely Ideation. Beginning with a literature study and user classification, the research will continue with empathize, define, and ideation methods. The user typology for the research is the 159 (one hundred fifty nine) Suzuki passenger car customer period Jan to June 2022. They need to fill the Google Form questionnaire. And then 5 (five) customers is being interviewed through in depth interview by zoom application. Empathizing process will create user persona, empathy map, user journey mapping from Suzuki customer passenger car. Those user persona, empathy map, and user journey mapping will use to define problem, POV analysis, and HMW question. Based on HMW question, the process will continue to ideation to gather alternative omnichannel strategies to set the most effective omnichannel marketing strategy.

4. RESULTS

The empathize stage of the design thinking process that was carried out raised various obstacles as well as opportunities in the implementation of omnichannel marketing, where the following insights were obtained to reveal the obstacles :

1. There are several UMC Suzuki marketing channels that do not have any contact with consumers who purchase Suzuki passenger car units. Meanwhile, UMC

Suzuki's resources focus on the presence of the brand in various available marketing channels (multichannel) without taking into account their effectiveness.
2. The content that determines consumers to make purchases is on comparison and review content by both influencers and consumers, while reviews on various marketing channels used by UMC Suzuki have not been maximized.
3. The content presented to consumers is the same content that is distributed across various channels without a flywheel marketing concept approach (attract, engage, delight) and without taking into account the effectiveness of the channel used.
4. There are many opportunities for integration between channels that have not been maximized, UMC Suzuki's focus is on the number of channels that are maintained to meet consumers.
5. Whatsapp is the most widely used channel to persuade consumers as well as transact, so it needs to be integrated in various existing marketing channels. By multichannel marketing strategy, Whatsapp seen as a single channel.
6. Offline transactions or meeting with the sales force still dominate the way to obtain SPK (Vehicle Order Letter), so it is necessary to integrate online and offline channels comprehensively. By multichannel strategy, online and offline interactions work separately.
7. A trusted official marketing channel is very likely to be an entry for Suzuki passenger car transactions. Some of the UMC Suzuki official channels have not been signed as trusted official marketing channel.
8. Many, credible, and reliable consumer reviews can replace the test drive event to convince consumers to purchase units, especially those who previously had Suzuki vehicles. Customer reviews in many channels have not been intentionally accelerated.
9. The fun and uncomplicated process encourages consumers to immediately make transactions and at the same time be satisfied so that they recommend it to other consumers. Online channels need to be integrated with offline channels to create a seamless experience for customers to trigger the sales.
10. Value for money content is Suzuki's highest selling point among other content. The content of existing channels contain mostly from sales and marketing program.
11. Easy and reliable payment access will encourage Suzuki passenger car transactions digitally. UMC Suzuki web has not been integrated with various e-money platform.
12. Accelerating the reach of marketing channels, especially to areas where there are no Suzuki dealers / showrooms. UMC Suzuki focus on spreading Suzuki information through as many channels as possible, regardless its location.
13. Bonus content / digital sales program is the main content that accelerates the process of purchasing Suzuki passenger cars. Bonus content / digital sales program should be placed in delight channels according to flywheel marketing concept.
14. Consumers interact through multiple marketing channels before making a transaction. Thus the UMC Suzuki marketing channels should be integrated wisely.
15. The additional third-party cashback from the E Commerce platform makes consumers feel that they are getting more discounts than they should be. The

connection between non e commerce channels with official store in e commerce channels should be seamless.

Based on various ideas through the HMW Question, the process of transforming multichannel marketing into omnichannel marketing at UMC Suzuki began with channel mapping and channel integration strategies.

4.1 Channel Mapping

The initial strategy taken by UMC Suzuki to transform into omnichannel marketing was to conduct channel mapping to divide the various marketing channels used by UMC Suzuki into several categories to determine the priority scale. This is based on a Google Form questionnaire that was circulated to Suzuki consumers and In Depth Interviews conducted on Suzuki consumers who purchased units for less than 6 months for passenger car types in the East Java region. From the results of these studies, the resulting channel mapping is:

a. An effective channel that needs focus: Website www.umcsuzuki.com and My UMC Mobile Apps, Facebook UMC Suzuki, Instagram @umcsuzukijatim , Tiktok @umcsuzukiofficial , Youtube: UMC Suzuki, Exhibition, Showroom, Event, Whatsapp
b. Supporting channels: E Commerce Marketplace (Tokopedia, Blibli, Bukalapak), Email marketing: marketing@umcsuzuki.com, LinkedIn: PT. United Motors Centre, Google My Business (GMB), Affiliate Marketing (Oto.com, OLX), Endorsement
c. Channels that do not need focus or will be handled directly by PT. Suzuki Indomobil Sales : TV, Radio, Billboard, Brochure, Newspaper, Display Ads

The next channel mapping is to classify various marketing channels based on their main functions with flywheel marketing directions. The marketing channels used are divided into 3 categories:

a. Channels focused on Attract content: IG @umcsuzukijatim, FB UMC Suzuki, Tiktok @umcsuzukiofficial, Youtube: UMC Suzuki
b. b. Channels focused on Engage content: IG @umcsuzukijatim, FB UMC Suzuki, Tiktok @umcsuzukiofficial, Youtube: UMC Suzuki Exhibition, Showroom, Event, Whatsapp, Web www.umcsuzuki.com , Apps My UMC, and Google My Business / GMB Suzuki United Motors Center
c. Channels focused on Delight content: Exhibitions, Events, Showrooms, Web www.umcsuzuki.com, Apps My UMC, Whatsapp, E Commerce marketplace (Tokopedia, Bukalapak, Blibli)

4.2. Channel Integration

After doing Channel Mapping, the next step is to carry out various integrations between channels to transform from multichannel to omnichannel.

a. Offline to online: encourage interaction from offline channels to online channels to anticipate digital transformation
b. Online to offline: drive lead conversion by utilizing offline channels to increase engagement
c. Online to online: encourage integration between online channels so that consumers get a holistic customer experience

Meanwhile, the effort to run an effective omnichannel marketing strategy with a flywheel marketing approach (attract, engage, delight) is the channel content strategy:

4.3. Channel Content

After launching various ideation programs to integrate various channels, the next strategy is to determine content that is in accordance with the flywheel marketing concept (attract, engage, delight). Each campaign delivered is followed by a sustainable content strategy (attract, engage, delight) and placed on the appropriate channel according to the channel mapping that was done

previously. Attached is an example of the Suzuki Ertiga Hybrid campaign as the first hybrid LMPV in Indonesia.



Figure 4. Channel Content Management

6. CONCLUSIONS

Based on the results of the study, the problem regarding how an effective omnichannel marketing strategy is in marketing Suzuki passenger cars in the midst of the digital transformation of the automotive market, is resolved through the following research results:

1. Knowing the obstacles in implementing the omnichannel marketing strategy program at UMC Suzuki with the empathize and define stages through design thinking and obtained various insights related to the customer journey and customer experience of Suzuki passenger car consumers so that conditions that are not in line with the omnichannel marketing strategy can get improvisation.
2. Produce recommendations for the transformation process of changing the multichannel marketing strategy into omnichannel marketing for UMC Suzuki with the ideation stage where UMC Suzuki needs to do channel mapping first, followed by channel integration for both online and offline channels. The integration is carried out starting from offline to online channels to anticipate digital transformation, online to offline to increase engagement leads, and online to online to integrate various online channels so that consumers get a holistic customer experience.
3. Generating the effectiveness of the omnichannel marketing strategy in terms of the flywheel marketing concept with the ideation of channel content strategy in which the content of various channels is formulated based on the attract, engage, and delight functions through channels that are relevant to the attract, engage, or delight functions according to the results of the channel mapping.

The managerial implication of this research is that the marketing division workflow is no longer based on the ATL (Above the Line) and BTL (Below the Line) divisions but is based on the following diagram:

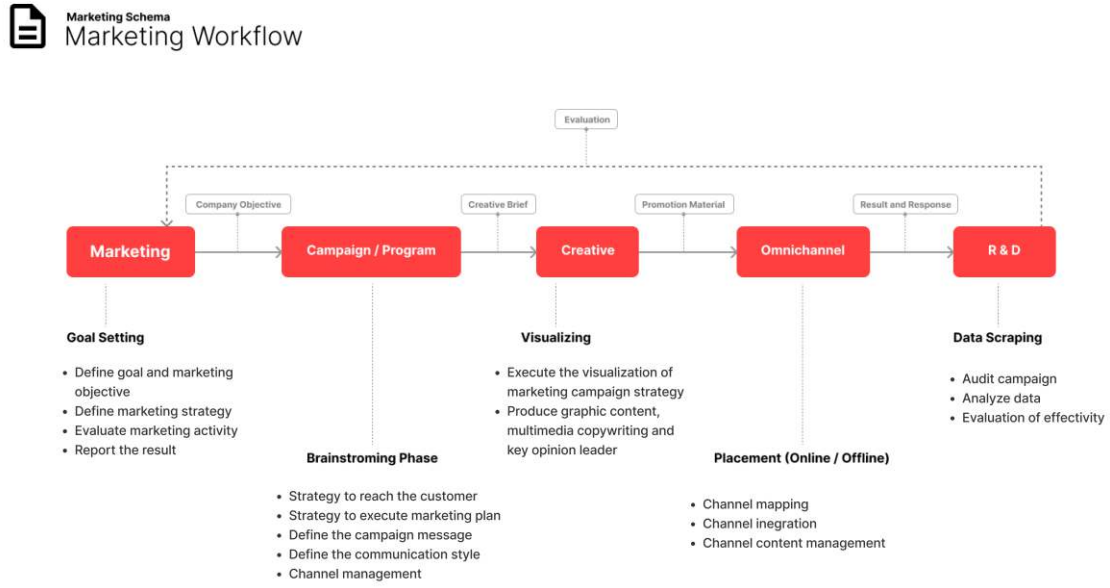


Figure 5. Marketing workflow recommendation

REFERENCES

Brown, Tim (2008). Design Thinking. *Harvard Business Review Paperback Series*,1

Chang, Y. P., and Li, J. (2021). Seamless Experience in the context of Omnichannel Shopping: Scale development and empirical validation. *Journal of Retailing and Consumer Services,* 64

Dam, Rikke Friis, T.Y. (2020). Define and Frame Your Design Challenge by Creating Your Point of View and Ask "How Might We". Accessed from https://www.interaction-design.org/literature/article/define-and-frame-your-design-challenge-by-creating-your-point-of-view-and-ask-how-might-we, December 2021.

Dam, Rikke Friis, T.Y. (2020). Empathy Map, Why and How We Use It. Accessed from https://www.interaction-design.org/literature/article/empathy-map-why-and-how-to-use-it,

Gasparin, I., Panina, E., Becker, L., Yrjola, M., Jaakkola, E., Pizzutti, C. (2021). Challenging the "Integration Imperative": A customer perspective on omnichannel journeys. *Journal of Retailing and Consumer Services* 64

Hasso, P. (2010), An Introduction to Design Thinking: Process Guide. Hasso Plattner Institute of Design at Stanford University

Kim, S., Connerton, T. P., Park, C. (2022). Transforming the Automotive Retail: Driver for Customer's Omnichannel BOPS (Buy Online and Pick Up in Store) Behavior. *Journal of Business Research* 139, (2022) 411-425.

Llopis-Albert, C., Rubio, F., & Valero, F. (2020). Impact of Digital Transformation on the Automotive Industry. *Journal of Technological Forecasting & Social Change* 162

Matthews, R., Rutherford, B. N., Edmondson, D., Matthews, L. (2022). Uncertainty in Industrial Markets: The Covid-19 Pandemic. *Journal of Industrial Marketing Management* 102, (2022) 364-376.

Hadjas, Monika, Costa E. Silva, Susana, Radomska, Joanna (2019). Omnichannel Approach : A Utopia for Companies?. *Journal of European Marketing Academy Hamburg*.

Nelsin, S. A. (2022). The Omnichannel Continuum: Integrating online and offline channels along the customer journey. *Journal of Retailing*.

Sharma, Sharanyan. (2020). Marketing Flywheel : The Effective Way to Drive Business Growth and Customer Delight. Accessed from www.linkedin.com/pulse/marketing-flywheel-effective-way-drive-business-growth-sharma,2-6

Suzuki Indomobil Sales. (2022). Kontribusi untuk Bangsa dan Masyarakat dengan Memberikan Produk-produk Bermanfaat bagi Perkembangan Bangsa. Accessed from www.suzuki.co-id/corporate/tentang-suzuki

United Motors Centre. (2022). Company Profile. Accessed from www.umcsuzuki.com/about-us

Verhoef, Peter C., P.K. Kannan, Inman, J. Jeffrey. (2015). From Multichannel Retailing to Omnichannel Retailing. Introduction to the special issue on Multichannel Retailing. *Journal of Retailing*

RISK ANALYSIS OF PIPELINE CONSTRUCTION BUSINESS PROCESS WITH TRADITIONAL PROJECT MANAGEMENT OF OIL & GAS COMPANY IN SIDOARJO, EAST JAVA

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ABSTRACT

Oil and gas company in Sidoarjo, did not carry out proper planning in pipeline construction projects in 2018. Main facilities were forced to be commissioned for avoiding loss production opportunity (LPO), ignoring other unprioritized works. This resulted significant delay of project handover. Whereas, a company detail business process was existed using traditional project management approach. But it is considered not applicable because require long preparation and time. An evaluation is needed to optimize existing business process. Therefore, this study was conducted to analyze the gap and the risks of existing business process with the actual condition in gas pipeline project. Work Breakdown Structure (WBS) and Risk Breakdown Structure (RBS) is compiled based on interviews and historical data, then Failure Mode and Effect Analysis (FMEA) is carried out. Data validation and analysis were carried out by practitioner's Focus Group Discussions. There are 15 risks were analyzed and identified. Biggest risk came from engineering design delays and social disturbances, causing job delays, cost overruns and LPO. Recommended actions are to carry out adequate social mapping and implement traditional project management which is considered provide smaller risk priority number and more proper.

Keywords: Traditional Project Management, Risk Analysis, FMEA, Pipeline Construction

1. INTRODUCTION

An oil and gas company in Sidoarjo has developed a business process that adopted a traditional project management approach for production facilities construction projects, including gas pipeline construction program. This business process often could not be applied to gas pipeline construction projects because it requires long preparation, less flexible, high cost and long project duration with sequentially stages. As a result of not implementing existing business processes, several problems arisen, they are project management run improperly, schedule messed up due to high variation and the work results quality was not as expected according to the project plan.

Streule, etc. (2016) explained that one of the biggest challenges in a construction project is predicting the unexpected risk. To minimize the unexpected risks, project managers usually use templates, checklists and detailed models. This method is commonly called the traditional project management approach with the aim of planning a project in detail and trying to implement it without deviation. Traditional project management often consumed large resources even before the construction project begins. Lalmi, etc. (2021) explained the weakness of the traditional project management approach is that it ignores the fact that environmental conditions and external factors

are constantly changing and difficult to predict. Because the implementation is sequential, if there is a change and the response to the change is delayed, it will greatly affect the progress of the work progress. Špundak (2014) explained that sometimes it is very difficult to create a complete project plan early in the project due to the inability to clearly define the project objectives. The main reasons for the imprecision of traditional approaches for most projects today are structural complexity, uncertainty in the definition of objectives and project time constraints.

A gas pipeline construction project which has been done in 2018 to 2019, had some gaps between traditional project management business process and actual condition. In actual condition, various obstacles arisen such as changes outside the specifications, and unexpected additional time and a long process were needed to overcome these changes. These caused delay in fulfilling project deadlines. In addition, several stages of the gas pipeline construction project business process must be passed to meet the project deadline, and the quality of the work was not as expected. Therefore, the Company was deemed necessary to evaluate the existing traditional project management business processes. In this study, an analysis was be carried out to identify project risks and their mitigation measures. The purpose of this study is to identify the gap between the traditional project management business processes and the actual conditions of the gas pipeline construction project in the upstream oil and gas industry using the Work Breakdown Structure (WBS) evaluation. Then to conduct a project business process risk analysis, the Failure Modes and Effects Analysis (FMEA) was carried out where the existing risks were identified with the Risk Breakdown Structure (RBS).

2. LITERATURE REVIEW

2.1 Traditional Project Management

Sebastian (2008) defined the project is a temporary activity that has a predetermined start and completion time, usually limited by time, and funding sources, to achieve specific and unique goals and results. Moreover, Wysocky (2019) explained that the completion of the project will produce the expected business value and the main focus of each project is the satisfaction of client needs. Related to project terms, the term project management is also known. PMI (2017) defined project management as the application of knowledge, skills, tools, and techniques to project activities to meet project requirements through proper application and integrated project management processes that enable organizations to implement projects effectively and efficiently. Lami, etc. (2021) said that project management is the basis of all construction projects. Failures on construction projects can be caused by cost overruns, delayed schedules, or additional work.

One of the types of project management approach is the traditional approach. Lami, etc. (2021) explained that traditional project management is also often called the waterfall or predictive project management approach. The principle of the traditional approach is based on a clear definition of each phase. The basic idea is that projects are relatively simple, predictable and linear, with well-defined content, thus enabling detailed planning and monitoring without too many changes. While the traditional management approach has the advantage of being a robust approach when applied to all projects. It is also a disadvantage of this approach in a complex project environment with a large number of activities. However, because it uses a linear relationship, the traditional approach does not reflect the complexity of the project.

2.2 Failure Mode and Effect Analysis (FMEA)

Ford Motor Company (2011) defined FMEA as a collection of activities carried out to: (1) identify and evaluate the risk of failure of a product or process and the impact that will be caused, (2) identify actions or responses that can eliminate or reduce the possibility of failure risk, and (3) documenting the process. Based on Bahrami (2012), there are three measures that are considered in conducting FMEA are as follows.

a. Deterioration rate or Severity (S), is a level of effect can be caused by the risk.
b. The possibility of risk rate or Detection (D), is an assessment that exists to identify the cause/mechanism of risk.
c. The probability of event or Occurrence (O), is the possibility of the emergence of a particular cause and determines how often the potential error can occur.

The severity level, the detection level and the probability of occurrence is assessed with scale 1 to 10 according to **Table 1**. To determine the number, it is necessary to examine historical data and expert's or practitioner justification.

Table 1 Severity (S), Detection (D) and Occurrence (O) on FMEA

Severity (S)	
Scale	Effect
1	Negligible Severity
2	Mild Severity
3	
4	Moderate Severity
5	
6	
7	High Severity
8	
9	Potential Severity
10	

Detection (D)		
Scale	Effect	Frequency
1	The prevention is very effective. There is no chance the cause might appear.	0,01/1000 items
2	The probable cause is very low	0,1/1000 items
3		0,5/1000 items
4	Possible cause is moderate. Prevention methods sometimes allow the cause to occur.	1/1000 items
5		2/1000 items
6		5/1000 items
7	Possible cause is still high. Prevention methods are less effective.	10/1000 items
8		20/1000 items
9	Possible cause is still very high.	5/1000 items
10	Prevention methods are not effective.	100/1000 items

Occurrence (O)		
Scale	Probability	Degree
1	0,01/1000 items	Remote
2	0,1/1000 items	Low
3	0,5/1000 items	
4	1/1000 items	Moderate
5	2/1000 items	
6	5/1000 items	
7	10/1000 items	High
8	20/1000 items	
9	5/1000 items	Very High
10	100/1000 items	

After knowing the scale of S, O and D, then the value of the Risk Priority Number (RPN) is calculated. RPN is the multiplication of S, O and D. The RPN value can vary between 1 and 1000. Carlson in Ridlo (2019) explained that the Calculated RPN is divided into three (3) categories i.e., minor risk for RPN 1-124, moderate risk for RPN 125-324 and major risk for RPN 343-1000.

3. METHODS

The research began by studying and reviewing the business process of pipeline construction of one of oil and gas company in Sidoarjo, East Java. The Work Breakdown Structure (WBS) is prepared to find out the gap between the existing project management business processes and actual conditions. Risk identification of pipeline construction was compiled into a Risk Breakdown Structure (RBS) through interviews with 30 practitioners and references from several sources. Then a risk analysis was carried out using Failure Mode and Effect Analysis (FMEA) method. The result was considered to analyze the risk mitigation and recommended action as proposed improvements. For data analysis and verification, Focus Group Discussions (FGD) were being conducted with 7 participants consisting of engineers from several disciplines involved in the project. The flow of this research method is as follows in **Figure 1**.

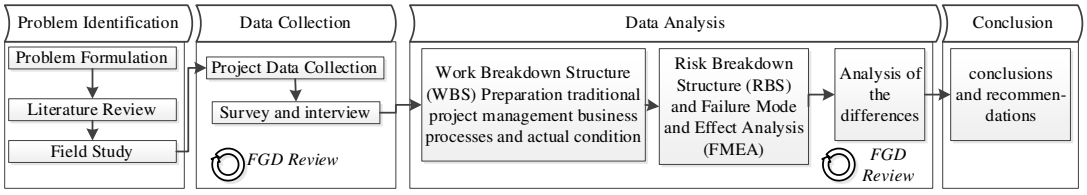


Figure 1 Flow of the Research Methods

4. RESULTS

4.1 PROJECT ORVERVIEW

In 2018 to 2019, one of the oil and gas companies in East Java had several new well drilling activity programs carried out at several locations in the Tanggulangin Field, one of them was TGA#10 well. The objective of this project is to build a pipeline facility from well TGA#10 to the gas processing field. The detail of project studied is shown in the following **Table 2**.

Table 2 Gas Pipeline Construction Project Details

No.	Data	Description
1	Project Name	EPCI Underground Flowline from TGA#02/#10 to Tanggulangin Gas Plant
2	Line from:	Well Head TGA#2 dan TGA#10
3	To	Existing Prod. Manifold di Tanggulangin Gas Plant
4	Location	Tanggulangin, Sidoarjo, Jawa Timur
5	Scope of Work	*Survey, Detail Engineering, Procurement, Construction & Installation, Commissioning & Certification*
6	Contract Value	IDR18.658.614.535, -
7	Contractor	JO PT AMA- PT ADP
8	Project Started	1 August 2018
9	C*ommissioning finished*	17 January 2019 (169 days since project started)
10	Project handover	19 December 2019 (506 days since project started)

4.2 EXISTING BUSINESS PROCESS OF PIPELINE CONSTRUCTION

The company had developed a production facilities construction business process that can be used as a reference for pipeline construction project. The business process was explained in the company's management system document which was first issued on June 28, 2010 and revised to be reissued on September 11, 2017. The business process for the construction of production facilities starts from Detail Engineering Design (DED), Procurement, Construction and installation, and Pre-Commissioning and Commissioning. DED is the initial stage to compile and to prepare the required engineering documents from various disciplines. The business process of DED activities can be seen in **Figure 2 (a)**. After the DED stage is completed, then procurement stage is carried out which is activities to obtain goods/services which refers to the DED documents. The business processes of procurement activities can be seen in **Figure 2 (b)**. Construction and installation is the next stage of procurement activities when the required goods/services have been on site. Construction and installation of a project refers to approved construction drawings and planning from DED stage. The business process of construction and installation activities can be seen in **Figure 2 (c)**. The last stage is pre-commissioning and commissioning. This stage is carried out to test and to guarantee the entire system and components that have been installed. The design plans, installation, operation, function, maintenance and performance must comply in accordance with the expected capacity. After commissioning, start-up is then carried out and handover to the operations department. The business processes of the pre-commissioning and commissioning activities can be seen in **Figure 2 (d)**.

From the business processes explained in **Figure 2** in next page, it can be seen that the business processes are carried out with very detailed and sequential activities. But in fact, the detailed business processes are not implemented for pipeline project. The actual business processes of the projects that have been running are actually starting from (1) survey, (2) Engineering, (3) Procurement, (4) Preparation, Construction, Fabrication, and Installation, (5) NDT and hydrotest, (6) Pre -Commissioning & Commissioning, Start Up, and (7) Permit. The seven main activities are carried out not sequentially and in parallel, so that it is difficult to visualize them in the form of diagrams.

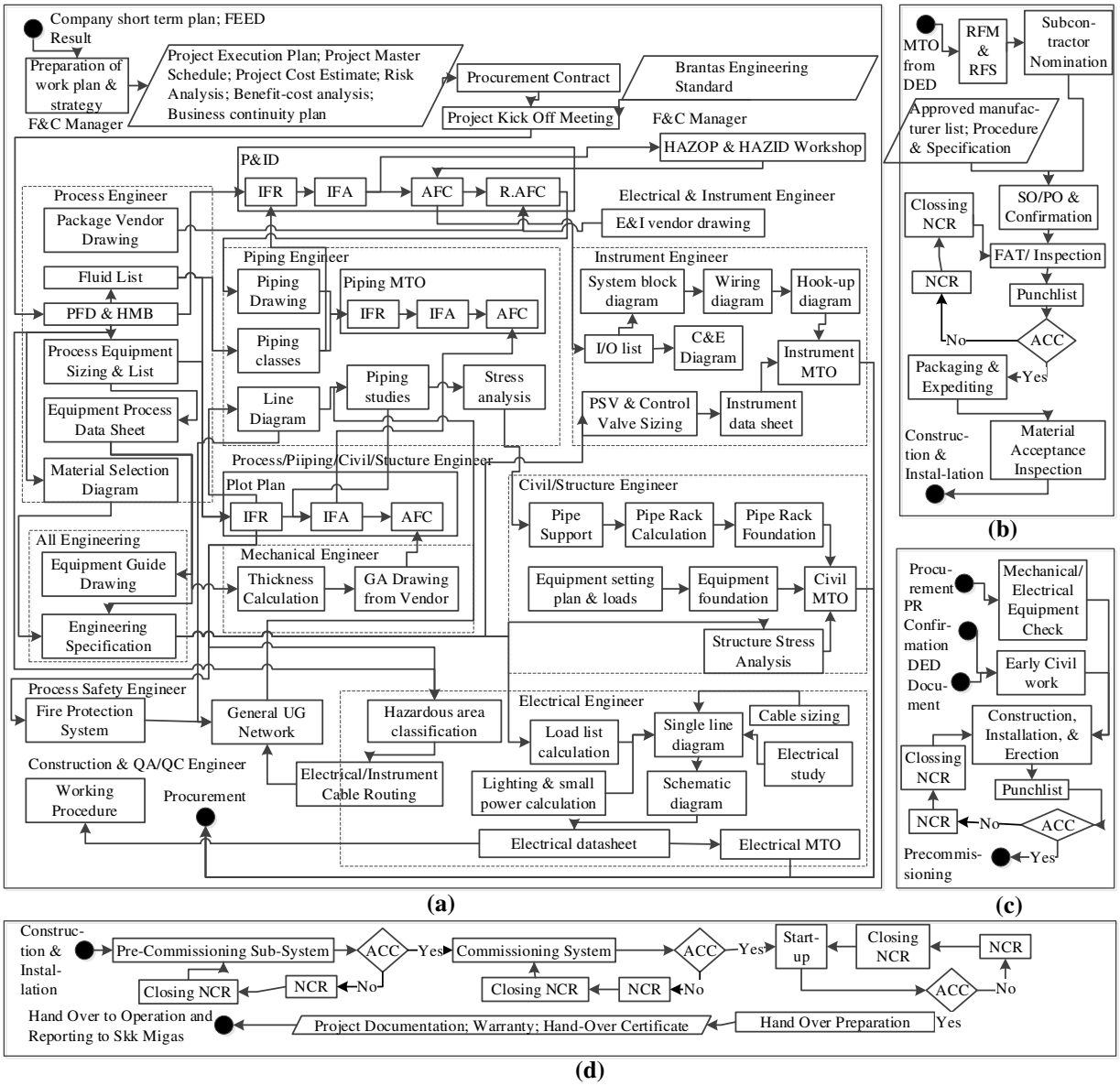


Figure 2 Business Process of: **(a)** Detail Engineering Design **(b)** Procurement **(c)** Construction and Installation and **(d)** Pre-commissioning and Commissioning

4.3 WORK BREAKDOWN STRUCTURE (WBS)

In this study, WBS was prepared to find out the gap between planning using traditional project management business processes and actual conditions that have been running. Therefore, the preparation of the WBS was carried out twice. The first WBS was prepared based on a gas pipeline construction plan using the traditional project management business processes described in **Figure 2**. The WBS was prepared, checked, and approved through FGDs with a team of 7 experienced practitioners in pipeline construction projects. The WBS was prepared with the assumption that work was carried out with a duration of 11 hours a day and 7 days per week without any holidays with a start date of August 1, 2018. The resources involved in the work were assumed to be unlimited, so that work could be carried out in parallel. The WBS of pipeline construction project based on traditional management project business process can be seen in **Table 3**.

The second WBS was prepared based on the actual condition of the "EPCI Underground Flowline from TGA#02/#10 to Tanggulangin Gas Plant" activity. The first step was to study the information taken from project documents including (but not limited to): project s- curve/timeline, bill of quantity, traceability report, stringing report, trenching report, welding report, inspection report, lowering & backfilling report, daily progress report and engineering design documents. If there is a lack of project reports, the data collection method is carried out through interviews with resource persons who participate in leading the project. The WBS of pipeline construction project based on actual condition can be seen in **Table 4**.

Table 3 WBS of Pipeline Construction with Traditional Project Management Business Process

WBS	Task Name	Duration	Start	Finish
1	WBS of Pipeline Construction with Traditional Project Management Business Proces	187 days	01/08/18	04/02/19
1.1	Project Kick Off Meeting	1 day	01/08/18	02/08/18
1.2	Detail Engineering Design	78 days	02/08/18	19/10/18
1.2.1	Project Management	6 days	02/08/18	08/08/18
1.2.2	Process Engineering	52 days	02/08/18	23/09/18
1.2.3	Mechanical Engineering	42 days	02/08/18	13/09/18
1.2.4	Piping Engineering	71 days	02/08/18	12/10/18
1.2.5	Civil & Structure Engineering	74 days	02/08/18	15/10/18
1.2.6	Electrical Engineering	69 days	02/08/18	10/10/18
1.2.7	Instrument Engineering	53 days	02/08/18	24/09/18
1.2.8	Construction & QA QC	78 days	02/08/18	19/10/18
1.3	Procurement	79 days	13/09/18	01/12/18
1.3.1	Civil/Structure	24 days	15/10/18	08/11/18
1.3.2	Piping	50 days	12/10/18	01/12/18
1.3.3	Mechanical	25 days	13/09/18	08/10/18
1.3.4	Electrical	41 days	10/10/18	20/11/18
1.3.5	Instrument	13 days	24/09/18	07/10/18
1.4	Construction & Installation	162 days	02/08/18	11/01/19
1.4.1	Preconstruction Preparation	60 days	02/08/18	01/10/18
1.4.2	Package/Mechanical/Electric al Equipment Mobilization	13 days	19/10/18	01/11/18
1.4.3	Civil/Structure	48 days	01/11/18	19/12/18
1.4.4	Aboveground Piping	54 days	03/11/18	27/12/18
1.4.5	Underground Flowline	71 days	01/11/18	11/01/19
1.4.6	Mechanical	25 days	01/11/18	26/11/18
1.4.7	Electrical	8 days	20/11/18	28/11/18
1.4.8	Instrument	3 days	04/12/18	07/12/18
1.5	Pre-Commissioning & Commissioning	121 days	06/10/18	04/02/19
1.5.1	Pre-Commissioning	106 days	06/10/18	20/01/19
1.5.2	Commissioning	2 days	20/01/19	22/01/19
1.5.3	Project Hand Over	24 days	11/01/19	04/02/19

Table 4 WBS of Pipeline Construction Project based on Actual Condition

WBS	Task Name	Duration	Start	Finish
2	WBS of Pipeline Construction Project based on Actual Condition	505,88 days	01/08/18	19/12/19
2.1	Project Kick Off Meeting	1 day	01/08/18	02/08/18
2.2	Detail Engineering Design	324 days	02/08/18	21/06/19
2.2.1	Project Management	28 days	02/08/18	29/08/18
2.2.2	Process Engineering	324 days	02/08/18	21/06/19
2.2.3	Mechanical Engineering	14 days	29/11/18	12/12/18
2.2.4	Piping Engineering	156 days	02/08/18	05/01/19
2.2.5	Civil & Structure Engineering	182 days	02/08/18	30/01/19
2.2.6	Electrical Engineering	131 days	18/08/18	26/12/18
2.2.7	Instrument Engineering	14 days	13/12/18	27/12/18
2.2.8	Construction & QA QC	34 days	02/08/18	04/09/18
2.3	Procurement	496,88 days	02/08/18	11/12/19
2.3.1	Civil/Structure	186 days	05/11/18	10/05/19
2.3.2	Piping	156 days	02/08/18	05/01/19
2.3.3	Mechanical	394 days	13/11/18	11/12/19
2.3.4	Electrical	29 days	02/04/19	01/05/19
2.3.5	Instrument	57 days	31/12/18	26/02/19
2.4	Construction & Installation	494 days	12/08/18	19/12/19
2.4.1	Preconstruction Preparation	263 days	12/08/18	02/05/19
2.4.2	Package/Mechanical/Electric al Equipment Mobilization	15,88 days	16/08/18	31/08/18
2.4.3	Civil/Structure	192,88 days	12/11/18	23/05/19
2.4.4	Aboveground Piping	71,88 days	18/12/18	27/02/19
2.4.5	Underground Flowline	167 days	28/08/18	11/02/19
2.4.6	Mechanical	8 days	11/12/19	19/12/19
2.4.7	Electrical	126 days	04/01/19	10/05/19
2.4.8	Instrument	2 days	17/01/19	18/01/19
2.5	Pre-Commissioning & Commissioning	343,88 days	10/01/19	19/12/19
2.5.1	Pre-Commissioning	343,88 days	10/01/19	19/12/19
2.5.2	Commissioning	0,88 days	17/01/19	17/01/19
2.5.3	Project Hand Over	133 days	18/01/19	31/05/19

Table 5 Differences between WBS with Traditional Project Management Business Process and WBS of Project Actual Condition

Based on the WBS in **Table 3** and **Table 4** above, the summary of information to difference between the two WBSs above is shown in **Table 5**. A significant difference is shown. The first is duration of the project from start to handover. Traditional project management approach requires 187 days, while the actual condition was delayed so it took 506 days. This happened because the actual project had minimal preparation, lack of project monitoring and control. So that the requirements for project handovers have not been fulfilled, such as FEED, DED documents, punch

lists/closing punch lists, equipment certificates and others. As a result, even though the pipeline facility has been operated, it leaves quite a lot of uncomplete task. This made the contractor unable to do 100% invoicing. Companies also experienced a decrease in their Key Performance Index (KPI) because they had not been able to close their project on time. In this case, the use of the company's traditional project management business processes is considered more profitable.

On the other hand, for the duration of the project from start to commissioning, traditional project management approach takes 174 days, while the actual project that is already running takes 169 days faster. Actually, the new well had been completed and ready to be produced on January 2, 2019, meaning that there had been a delay of 15 days. The company experienced LPO because of these conditions. If the traditional project management business process is carried out, the commissioning delay can be longer, about 20 days. In this case, the use of the company's traditional project management business processes is considered ineffective.

Table 5 Difference of Pipeline Construction WBS between Traditional Project Management Business Process and Actual Condition

No	Information	WBS with Traditional Project Management Business Process	WBS of Project Actual Condition
1	*Project Started*	1 August 2018	1 August 2018
2	Project Finished	4 February 2019	19 December 2019
3	*Commissioning Date*	22 January 2019	17 January 2019
4	Project Duration until handover	187 days	506 days
5	Project duration until commissioned	174 days	169 days

4.4 RISK ANALYSIS

4.4.1 Risk Breakdown Structure (RBS)

Risk analysis was carried out to determine the potential risks that can occur in the pipeline construction project. The first step was identifying the risks. The data that was used as references in conducting risk identification are (a) business processes and WBS that was explained in paragraph 4.2 and 4.3, (b) Project's HAZOP and HAZID reports, and (c) Risk registers from the results of questionnaires and interviews with 30 practitioners. Based on these 3 references, then the RBS was prepared by only listing the most significant main risks. The risks were categorized into three, they are design risks, construction risks, and management risks. The RBS that has been prepared is shown in **Table 6** below.

Table 6 Risk Breakdown Structure of Pipeline Construction Project

Level 0	Level 1	Level 2
0. Project Risks	1. Design Risks	1.1 Adding unknown equipment specifications and affecting existing designs and resources. 1.2 Inaccurate survey information and results affect the quality of the proposed design and cost plan estimates. 1.3 Engineering design delays, scope of work, and risk not in accordance with FEED and contract. 1.4 Design approval from the company with significant comments and issues 1.5 The unavoidable risk analysis recommendations lead to additional costs.
	2. Cons-truction Risks	2.1 Delays in deciding requests for changes leading to problems with prolonged construction and re-work periods. Delay in issuing instructions. 2.2 Poor workmanship. Work does not match/follow work plans/procedures. The construction and installation specifications do not match the design. 2.3 Social risks; Failure to provide land ready for construction before construction begins. Social permits were not approved by the community and the village government. 2.4 Accidents or injuries to personnel and the general public (pedestrians, traffic accidents) cause delays or claims; Weather conditions such as humidity, wind and precipitation; Force majeure & pandemic. 2.5 Transfer of responsibility for performance delays; unrealistic timescale estimates; cost overrun.

Level 0	Level 1	Level 2
	3. Manage-ment Risks	3.1 Inability to finance in accordance with the timeline; Lack of funding for project completion. 3.2 Regulatory revisions from competent authorities that cause cost overruns. 3.3 There is no contractual guarantee in order to achieve the project requirements and the risk of missing out on the contract. 3.4 Failure to agree on the interface of responsibilities between the Company and the Contractor. 3.5 The actual gas volume delivered by the new well does not match the initial forecast. The gas price is not high enough for the project's economy.

4.4.2 Failure Mode and Effect Analysis (FMEA)

Based on the RBS in Table 6, then through an FGD a risk analysis was carried out using the FMEA method. The FGD was conducted by involving 1 group consisting of 7 participants who are practitioners involved in gas pipeline construction projects with 5 to 25 years of experience and have participated in previous risk analysis workshops. In this study, FMEA was prepared to find out the gap between planning using traditional project management business processes and actual conditions that have been running. Therefore, risk analysis was carried out twice. The first FMEA was prepared based on a gas pipeline construction plan using the traditional project management business processes. The second FMEA was analyzed for actual condition of the "EPCI Underground Flowline from TGA#02/#10 to Tanggulangin Gas Plant" activity. Both of them had same risk identification but different RPN. The detail of FMEA can be seen in **Table 7**.

Table 7 FMEA of Pipeline Construction with Traditional Project Management Business Process

No	Process Require-ments	Potential Failure Mode	Potential Effect(s) of Failure (S)	Potential Cause(s)/ Mechanism(s) of Failure (O)	Current Controls/ Detection (D)	RPN for Tradi-tional Manage-ment Business Process	RPN for Actual Condi-tion
1	Perform flowline facility design activities in accordance with the contract, project objectives and the established timeline.	Adding unknown equipment specifications and affecting existing designs and resources.	Additional costs and volume of work; Over specifications.	DED do not comply company specifications; Lack of field survey data; Miss communication.	Company Standard; Site survey and review of historical production data.	48	96
2		Inaccurate survey information and results affect the quality of the proposed design and cost plan estimates.	DED results are not accurate; Construction failure; Re-work during construction in the field; Additional costs and volume of work; Wrong material purchase; LPO due to delayed pipeline commissioning.	Limited access to survey sites; The survey encountered technical and social problems; Inadequate survey equipment; Wrong survey method.	Proper survey in construction procedures; Ensuring that required survey data is sufficient; Surveys are carried out by experienced personnel; Involving all stakeholders in surveys; The contractor may immediately send a notice to the Company about requested work instruction.	64	96
3		Engineering design delays, scope of work, and risk not in accordance with FEED and contract.	Additional costs; Rework engineering design process; Project handover is delayed. LPO due to delayed pipeline commissioning.	Change of plans. Reviews are not careful during the FEED process.	Prepare Risk analysis report, Project Execution Plan, Project Master Schedule, Work Breakdown Structure (WBS)	256	432
4		Design approval from the company with significant comments and issues	DED process is late; Delay the start of the next job.	Change of plans; Required data/documents are not available; Less accurate survey; less engineer's number. Hastily DED preparation.	Ensuring the number of engineers is sufficient; Ensuring that survey data is sufficient; Document Management Procedures; Project Execution Plans; Project Master Schedule.	120	168
5		The unavoidable risk analysis recommendations lead to additional costs.	Additional work volume; cost escalation.	Risk analysis recommendations are not included in the contract.	Risk analysis reports; The contractor may immediately send a notice to the Company about requested work instruction.	72	72
6	Carry out construction and installation activities in accordance with the DED and the work timeline in the contract.	Accidents or injuries to personnel and the general public cause delays or claims; Weather conditions such as humidity, wind and precipitation; Force majeure & pandemic.	Construction activities are hampered; Cost escalation. Minor injury to fatality; Project handover is hampered; LPO due to delayed pipeline commissioning.	Extreme weather; Not socializing the emergency response plan; There has not been a discussion on the JSA of work with the equipment and safety mobilization team; Inadequate flood risk mitigation strategy; Not using APD properly.	Always supervised during work; Construction Procedures; Job safety analysis; safety meetings; Toolbox meeting; work permits; Emergency Response Procedures; Proper use of PPE; Estimate the cost of the damage claim; Insurance.	72	192

No	Process Requirements	Potential Failure Mode	Potential Effect(s) of Failure (S)	Potential Cause(s)/ Mechanism(s) of Failure (O)	Current Controls/ Detection (D)	RPN for Traditional Management Business Process	RPN for Actual Condition
7		Poor workmanship. Work does not match/follow work plans/procedures. The construction and installation specifications do not match the design.	Re-work the results of the work; Construction activities are hampered; Project handover is delayed.	The construction team did not know the stages of the construction work; Less competent workforce; The inspection and supervision system is weak.	Always supervised during work. Approved Drawing Design. Construction Procedure. Inspection & Test Plan. QA-QC Procedures; Job safety analysis; safety meetings; Toolbox meeting.	140	240
8		Social risks; Failure to provide land ready for construction before construction begins. Social permits were not approved by the community and the village government.	Construction activities are hampered. Project handover is hampered. Re-route the pipeline. cost escalation. LPO due to delayed pipeline commissioning.	Fear of landowners from the risk of pressure pipelines that will be posed; The land compensation price is not appropriate; Lack of socialization to the community; Project activities disturb residents.	Adding pipeline protection so that people feel safe as outlined in the DED; Routine CSR activities to the community and village government; Risk analysis reports; Mapping of potential social disturbances; Provide compensation to the community.	192	384
9		Delays in deciding requests for changes leading to problems with prolonged construction and re-work periods. Delay in issuing instructions.	Project handover is delayed. LPO due to delayed pipeline commissioning.	Project controller has not worked optimally; Poor coordination and communication.	Project Execution Plans; Project Master Schedule; Document Management Procedures; Ensure that the project controller coordinates all parties involved; the contractor may immediately send a notice to the Company about requested work instruction.	64	144
10		Transfer of responsibility for performance delays; unrealistic timescale estimates; cost overrun.	Late work timelines; Additional costs; Project handover is delayed; LPO due to delayed pipeline commissioning.	Default; Responsibility interface; Contractor/Vendor absent from contract.	The contractor selection process is carried out transparently; Ensure tenders are carried out according to procedures; Applying a bid bond for a contract value above a certain threshold.	72	72
11	Carry out project management in accordance with company goals and objectives.	Inability to finance in accordance with the timeline; Lack of funding for project completion.	Default; Late work timelines; Damage to construction equipment; Project handover is delayed; LPO due to delayed pipeline commissioning; Cause disputes and claims because they are not in accordance with the contract; Stalled Project	Do not apply payment terms; Project costs exceed the company's financial capacity; There are no alternative investors; The company's cash flow is disrupted; Hard cash for material purchases; Do not apply payment terms; Short work timeline.	Project Master Schedule; Cost Schedule; Looking for vendor/contractor partners who can accommodate payment terms into several terms that the company can afford; Work to get realistic timescales for acquisition, demolition, and construction within the entire program to complete.	72	96
12		Regulatory revisions from competent authorities that cause cost overruns.	Increased construction costs; Change of plans. Re-design changes.	Technology update	Tolerating overall budget overruns for small/insignificant increases; Collaborate with competent authorities/independent consultants to ensure the design complies with applicable government regulations	32	32
13		There is no contractual guarantee in order to achieve the project requirements and the risk of missing out on the contract.	Absentee contractors; Failed Tenders; stalled project; Companies need more time to find alternative contractors.	No bid bonds; No construction bonds; The contractor/vendor selection process was not carried out carefully; Contract direct appointment	The contractor/vendor selection process is carried out transparently; Ensure tenders are carried out according to procedures; Applying a bid bond for a contract value above a certain threshold.	96	96
14		Failure to agree on the interface of responsibilities between the Company and the Contractor.	Default; Late work timelines; Damage to construction equipment; Project handover is hampered; LPO due to delayed pipeline commissioning; Cause disputes and claims because they are not in accordance with the contract.	Hard cash for material purchases; Do not apply payment terms; Short work timelines; The company's cash flow is disrupted.	Project Master Schedule; Cost Schedule; The contractor may immediately send a notice to the Company about requested work instruction; Work to get realistic timescales for acquisition, demolition, and construction within the entire program to complete.	72	120
15		The actual gas volume delivered by the new well does not match the initial forecast. The gas price is not high enough for the project's economy.	The economic value of the project changes/unfavorable; The final cost is far from the planned project budget	Gas drilling failed; Gas demand is down; Dollar prices weaken; Approval for additional work not confirmed.	Revise the Benefit-Cost Analysis as soon as possible to get further consideration from management; The final cost estimate should be obtained as soon as possible to report to the company.	160	256

Based on **Table 7**, it can be seen that the company's gas pipeline construction business process with a traditional project management approach has a smaller RPN value than the actual condition. This means that there is a risk gap between traditional project management business

processes and actual conditions. The traditional project management business process is considered better because it provides a lower level of risk.

There are 11 out of 15 risks identified from the traditional approach business process have a lower RPN value than the actual condition, while there is only 4 risk whose RPN has the same value. The risks that have the biggest RPN are the engineering design delay, scope of work, and risk not in accordance with FEED and contract. This is evidenced by the significant difference in project handover with a difference of 187 compared to 506 days. This is caused by a very improper project planning. The next risks that have a high RPN value are social risks, failure to provide land ready for construction before construction begins, social permits were not approved by the community and the village government. This is because social risks have high uncertainty, and historically there have been many barriers from the community in every project undertaken by the company. As a result, the company had to incur quite expensive social costs in order for the project to run smoothly according to plan.

5. CONCLUSION

There were significant gaps between the existing traditional project management business process and the actual condition of the gas pipeline construction in the EPCI Underground Flowline project from TGA#02/#10 to Tanggulangin Gas Plant which was carried out from 2018 to 2019. Based on work breakdown structured that were prepared, significant difference is shown on duration of the project from start to handover. Traditional project management approach requires 187 days, while the actual condition was delayed so it took 506 days. This happened because the actual project had minimal preparation, and left uncomplete work. In addition, from 15 risks that had been identified and categorized into design risks, construction risks and management risks. Through risk analysis using FMEA method and FGD with 7 expert practitioners. Traditional project management approach has a smaller RPN value than the actual condition and considered better because it provides a lower level of risk. Biggest risk came from engineering design delays and social disturbances, causing job delays, cost overruns and loss production opportunity. Recommended actions are to carry out adequate social mapping and implement traditional project management which is considered provide smaller risk priority number and more proper

REFERENCES

Bahrami, M., Bazzaz, D. H., & Sajjadi, S. (2012). Innovation and Improvements In Project Implementation and Management; Using FMEA Technique. Procedia - Social and Behavioral Sciences, 41, 418-425.

Ford Motor Company. (2011). Failure Mode and Effects Analysis Handbook Version 4.2. Dearborn: Ford Motor Company.

Lalmi, A., Fernandes, G., & Souad, S. B. (2021). A conceptual hybrid project management model for construction projects. Procedia Computer Science, 181, 921-930.

Ridlo, A. F. (2019, August 3rd). Effectiveness Analysis of the Application of the Failure Mode and Effect Analysis Method with Failure Defense Task for Reliability Management Improvement in Sea Water Desalination System of PLTU Paiton Baru (1 X 660 MW). IPTEK Journal of Proceedings Series, 5, 2354-6026.

Sebastian, N. (2008). The Definitive Guide to Project Management (2nd edition). London: Ft. Pr.

Špundak, M. (2014). Mixed Agile/ Traditional project management methodology – reality or illusion? Procedia - Social and Behavioral Sciences, 119, 939 – 948.

Streule, T., Miserini, N., Bartlome, O., Klippel, M., & Garcia De Soto, B. (2016). Implementation of Scrum in the Construction Industry. Procedia Engineering, 164, 269-276.

Wysocki, R. (2019). Effective Project Management Traditional, Agile, Extreme, Hybrid (Eight Edition). Indianapolis, Indiana: John Wiley & Sons, Inc.

DEVELOPMENT OF E-GOVERNMENT PROCESS MODEL BASED ON SPECIFIC CHARACTERISTICS OF LOCAL GOVERNMENT ORGANIZATIONS

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ABSTRACT

The implementation of e-Government in Indonesia aims to realize clean, effective, transparent, and accountable governance as well as quality and reliable public services. However, until now, the implementation of e-Government at the local government level has a much lower index value compared to the central government. This local government has specific characteristics that distinguish it from other government organizations such as ministries or institutions. Previous studies have found that organizational characteristics influence e-Government adoption, but there is no study has been conducted to explore the specific characteristics of local government organizations in e-Government adoption. Therefore, this research focuses on developing an e-Government process model based on exploration of specific characteristics of local government organizations. The novelty of this research lies in the specific characteristics of local government organizations that make up the e-Government process model. This study uses an exploratory qualitative method for the identification of the e-Government process model; the identification of specific characteristics of local government organizations; and the development of local e-Government process models. The results of the local e-Government process model indicate that the number of local government affairs affects the amount of data, the number of services, the number of applications, and the complexity of data integration between affairs in the service link system. In addition, the diverse geographic areas of local governments have an effect on variations of intra-network infrastructure that is built.

Keywords: E-Government, Process Model, Local Government Characteristics.

1. INTRODUCTION

The constant demand for quality standards of public service delivery and greater government transparency by citizens, communities, and other partners has encouraged governments to leverage information and communication technology through the implementation of e-Government to meet the evolving needs of citizens, businesses, and public. E-Government promotes transparent and effective governance (Tolbert and Mossberger, 2006; Bal et al., 2015), and provides faster and more efficient services at minimum cost (Agangiba & Kabanda, 2016). In Indonesia, the implementation of e-Government aims to realize clean, effective, transparent, and accountable governance as well as quality and reliable public services (Presidential Regulation of the Republic of Indonesia No. 95 concerning Electronic-Based Government Systems, 2018).

Government organizations in Indonesia, such as ministries, institutions, and local governments, have specific characteristics that distinguish them from each other. This can be seen in local government organizations that have specific characteristics like territory, authority and power, finance, and organizational structure. This organizational characteristic can affect the adoption of e-Government in local governments, as in previous studies which state that one of the main categories that influence IT adoption is organizational factors (Hameed & Counsell, 2014), government size is one of the main factors related to IT adoption, organizational characteristics like government size and professionalism are the main determinants of computer technology adoption, and also demographic characteristics of local government, type & form of government, city size, metropolitan status, & region are significant institutional factors in the implementation and development of e-Government (Moon & Norris, 2005).

In a comprehensive review of e-Government studies, Titah and Barki conclude that most e-Government studies fall into five distinct categories exploring influence; a) managerial practice, b) individual and organizational characteristics, c) IT characteristics, d) e-Government measurement, and e) government subculture; on e-Government adoption (Patel & Jacobson, 2008). However, until now there has been no study that explores the specific characteristics of local government organizations in e-Government adoption.

In addition, the implementation of e-Government at the local government level has a much lower value index compared to the central government until now. Ugi Cahyo Setiono, coordinator for the coordination and evaluation of the implementation of e-Government policies at the State Apparatus Empowerment and Bureaucratic Reform Ministry, conveyed the results of the e-Government evaluation in 2019 where only 23 percent of regency/city governments received good predicate (SPBE, 2020). On the other hand, the Administrative Reform and Bureaucratic Reform Ministry noted that the e-Government implementation index in 2019 at the local government level was still at 2.07, an increase of 0.2 compared to 2018 which was 1.87 (Bayu, 2020). Therefore, this research will focus on developing an e-Government process model based on the exploration of the specific characteristics of local government organizations.

2. LITERATURE REVIEW

2.1 E-Government

Presidential Regulation No. 95 of 2018 concerning Electronic-Based Government Systems states that electronic-based government systems are government administrations that utilize information and communication technology to provide services to electronic-based government system users (Presidential Regulation of the Republic of Indonesia No. 95 concerning Electronic-Based Government Systems, 2018). Within the framework of the electronic-based government system, there is a domain structure consisting of business process domains, data and information domains, infrastructure domains, application domains, security domains and service domains.

2.2 E-Government Process Model

The Regulation of the Minister of State Apparatus Empowerment and Bureaucratic Reform No. 19 of 2018 concerning the Preparation of Business Process Maps for Government Agencies, states that process modeling is the creation of a business process map formulation with flow-drawing techniques either manually or using application programs (Regulation of the Minister for Empowerment of State Apparatus and Bureaucratic Reform of the Republic of Indonesia Number 19 concerning the Preparation of the Business Process Map of Government Agencies, 2018). The results of Silke Palkovit's research stated that the holistic framework for electronic public service

modeling – the process in e-Government consists of 3 levels, namely the strategic level (business model); business level (administrative service model, process map, business process model, and organizational model); and IT level (portal interaction model, information system configuration, and IT infrastructure model) (Palkovits & Wimmer, 2003). In addition, in modeling e-Government business processes, Hafedh Chourabi uses a combined approach of The Business Process Mapping modeling technique and UN/CEFACT modeling methodology (BPMapping-UMM) for transparent and efficient performance (Chourabi et al., 2009).

2.3 Organizational Characteristic

In studies related to organizational characteristics, some stated that organizational characteristics could consist of culture, top management support, rewards & incentives, organizational structure (Said et al., 2014); structure, organizational size, knowledge, culture, and inter-organizational relationships (Ko et al., 2008). Hameed identified 10 organizational characteristics from various IT literatures, which consist of organizational size, IT expertise, top management support, resources, IS department size, IS infrastructure, formalization, centralization, organizational readiness, and product champion (Hameed & Counsell, 2014).

2.4 Local Government

Local government can be described as some government bodies elected by the people that have administrative, legislative and executive functions on the territories under their jurisdiction. It is defined as an authority that decides or determines certain measures within a given territory (Ndreu, 2016). Local governments usually only have control over a specific geographic area and cannot pass or enforce laws that would affect the wider area (Thapa, 2020).

3. METHODS

This study uses a qualitative exploratory approach with 3 main stages, namely: identification of e-Government process models, identification of specific characteristics of local government organizations, and development of local e-Government process models. To identify the e-Government process model, a literature study was conducted on previous research on the e-Government process model and Indonesian regulations regarding the development of business process matrices of government institutions and e-government. To identify the specific characteristics of local government organizations, a literature study was conducted on previous research on local government, a documentation study on government documents, and interviews with local government officials. Furthermore, the results of the identification of the e-Government process model and the specific characteristics of local government organizations are used as input for modeling the local e-Government process. And finally, validation of the local e-Government process model was carried out using the expert judgment method.

4. RESULTS

4.1 E-Government Process Model

From this research, 11 model components and 6 domains are obtained in 3 levels of e-Government process model as shown in Figure 1.

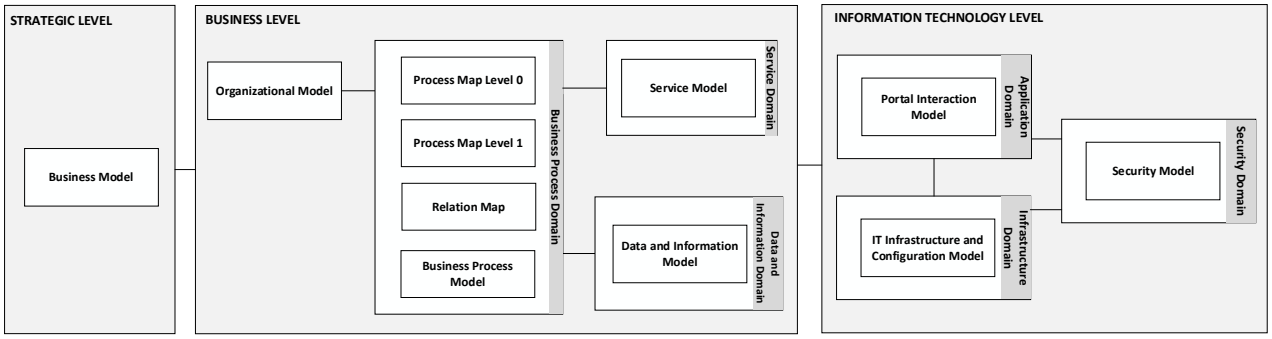


Figure 1. E-Government Process Model

4.2 Specific Characteristics of Local Government Organizations

This study found five aspects of the specific characteristics of regency/city local government organizations that distinguish them from other government organizations like ministries or institutions. Some specific characteristics of regency/city local government organizations can be found in regional characteristics aspects which are divided into districts and sub-districts/villages and authority characteristics aspects that carries out many affairs so it has a large and fat organizational model. Details of the specific characteristics of regency/city local government organizations are shown in Table 1.

Table 1. Specific Characteristics of Regency/City Local Government Organizations

Characteristic Aspect	Organizational Characteristics Findings		Justification of Findings
	Regency/City Government	Ministries/Institutions	
Region	The regency/city government is divided into districts and districts are divided into sub-district and/or villages to carry out government affairs, empowerment and community services	The region of ministry/institution is not divided, but has representative offices spread across Indonesia for certain public services and has simple business processes	The regency/city government organizational model has sub-districts and urban village /villages spread over one district/city
	Mapped by island or coastal areas, mountainous areas, industrial trade areas, and agricultural areas.	There is no mapping of geographical area characteristics	The IT infrastructure and configuration model (regency/city intra-government networks) consist of various network infrastructures according to regional characteristics
Authority	Organizing mandatory government affairs and elective government affairs consisting of 32 affairs, such as education; health; public works and spatial planning; public housing and residential areas; social; labor; population administration and civil registration; to transmigration.	In charge of one to three specific affairs in government	The regency/city government organizational model and process map are divided into affairs in accordance with mandatory government affairs and optional government affairs under their authority.
	Serving the citizens or the community directly	Coordinate provincial governments	The regency/city government business model has customers from local citizen or the community of the regency/city

Characteristic Aspect	Organizational Characteristics Findings		Justification of Findings
	Regency/City Government	**Ministries/Institutions**	
	Cooperate in carrying out the affairs that are within their authority according to the field of affairs Example of education affairs: the ministry in charge of education affairs cooperate with the department in charge of education affairs in the district/city government		The IT infrastructure and configuration model (regency/city government service link system) have integration between ministry/ institution data and regency/city government data according to their respective fields of affairs
Resource	The funding needed to accelerate the electronic-based government system in local governments is charged to the local budget revenue and expenditure / APBD	The funding needed for the acceleration of an electronic-based government system in the central agency is charged to the state budget revenue and expenditure. In general, this budget is larger than the local government or equivalent to a large regional government	The regency/city government business model has a regional revenue and expenditure budget that comes from retribution and taxes, so in the implementation of e-Government at local will vary according to the size of their respective budget
IS Infrastructure	The number of applications is higher, it is more complex because it carries out various government affairs	The number of applications for the ministry tends to be less than the local government because the ministry focuses on a particular field of affairs.	The regency /city government application portal interaction model consists of many applications, so it affects the number of applications that will be built and maintained by the regency/city government
	Data and information are more diverse in type and have close cross-relationships between one data and another because they carry out various government affairs	Data and information only consist of 1 to 3 types because they focus on certain fields of affairs, but the volume of data is larger because it covers data throughout Indonesia	• The regency/city government data model consists of various types of data • The IT infrastructure and configuration model (regency/city government service link system) has high data integration, which is cross-linked between the affairs within the regency/city government.
	Network infrastructure is more complex due to scattered regional factors such as departnments buildings, sub-districts, and urban village/ villages that need to be connected. In addition, it is influenced by geographical factors such as islands or coasts and mountains so to connect them, various infrastructures are needed.	The network infrastructure is simpler because office locations tend not to be widely spread, while representative offices do not handle many public services such as district/city governments.	The IT infrastructure and configuration model (regency/city intra-government network) consists of various network devices or several alternative system devices according to regional characteristics

Characteristic Aspect	Organizational Characteristics Findings		Justification of Findings
	Regency/City Government	Ministries/Institutions	
Centralization	The organizational structure of the regency/city government has a shorter level because it only reaches the second echelon so it affects the shorter level of administrative matters	The organizational structure of the ministry/institution has a longer level because it reaches the first echelon so that it affects a longer level of administrative matters	The regency/city government application portal interaction model for administrative matters, such as authorization, disposition, and verification, there are short levels consisting of section heads/sub-coordinators, heads of fields, heads of department, and regent/ mayor

In addition to the 5 aspects of organizational characteristics above, the results of this study also discuss 5 other characteristic aspects such as IT expertise, top management support, formalization, organizational readiness, and culture. However, in these 5 aspects, there are no specific characteristics that distinguish regency/city local governments from other government organizations such as ministries or institutions. IT expertise, top management support, formalization, organizational readiness, and culture are highly dependent on the respective organizations, both regency/city, provincial, ministries and institutions. Therefore, to implement optimal e-Government, all government organizations need to improve IT expertise, develop technology policies and strategies agreed by the leader as a form of top management support and formalization, conduct socialization and training related to the benefits of e-Government, as well as implementing a reward and punishment system in the e-Government implementation.

4.3 Local E-Government Process Model

Referring to the E-Business model proposed by Peter (Weill; & Vitale, 2001), Figure 2 show the strategic level business model for regency/city local e-Government. Regency/city government has specific characteristics namely the authority to serve the citizens or the community directly, so in the regency/city local e-Government business model, citizen are one of the customers. Based on the perspective of e-Government beneficiaries, regency/city local e-Government has two types of service products, namely electronic-based government administration services to support internal bureaucracy management whose beneficiaries can consist of employees or government agencies, and electronic-based public services to support the implementation of public services whose beneficiaries are the community. As previously mentioned, regency/city government has specific characteristics of funding resources originating from the local budget revenue and expenditure, so the regency/city local e-Government business model has cash flow consisting of local retribution and local tax from citizen or public.

Based on the specific characteristic of the regency/city government authority, at the business level, it shows that the regency/city government carries out many affairs (32 affairs) so it affects business processes, services, applications and data which is also large in number as shown in Figure 3.

To accommodate the specific characteristics of regency/city government areas, which consist of island or coastal areas, mountainous areas, industrial trade areas, and agricultural areas, various types of devices are needed in the regency/city intra-government network infrastructure. Each local government can use intra-network device with a choice of fiber optic, VSAT satellite, and wireless radio or a combination of the three as shown in Figure 4. The choice of the network system depends on the characteristics of the region and the characteristics of the funding resources of each regency/city. To get the maximum connection speed, regency/city governments can use a

fiber optic network system, but in general this device is optimal for use in urban areas with a lot of electromagnetic interference. Archipelagic or coastal areas whose regions are far apart by the sea (>20km) can use a satellite network system to connect their departments, districts, and sub-districts/villages. If it is not possible to use a fiber optic network system, mountainous or rural areas or peatlands whose departments, districts, and sub-districts/villages areas are separated from the center of government can use a wireless fidelity network system as long as there are no difractions. All types of network systems are attempted to use a closed connection or use a Virtual Private Network (VPN).

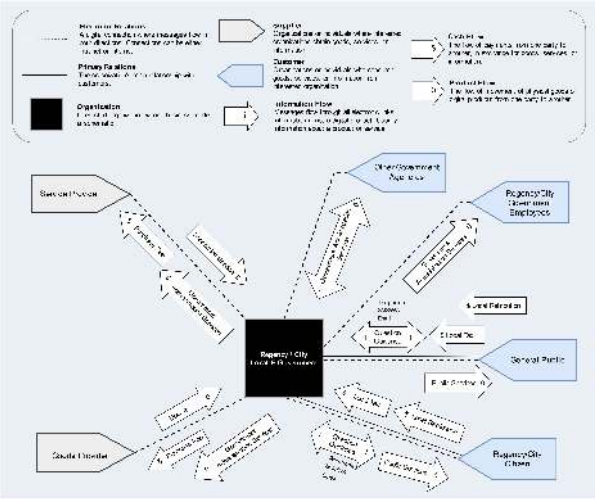


Figure 2 Regency/City Local E-Government Business Model – Strategic Level

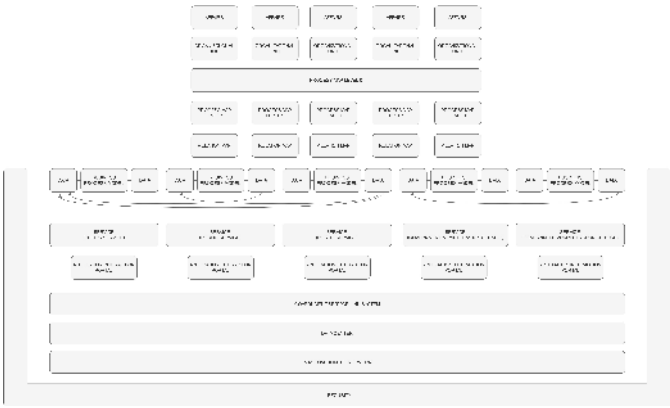


Figure 3 Regency/City Local E-Government Business Level Model

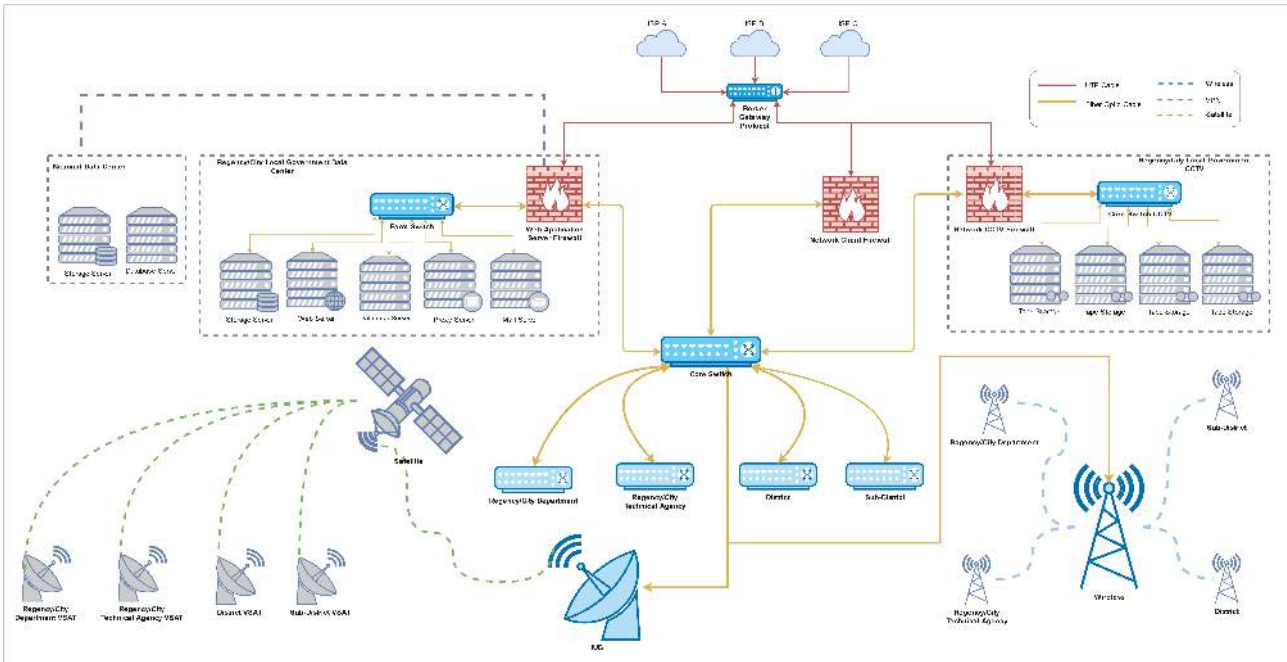


Figure 4 IT Infrastructure and Configuration Model – Regency/City Intra-Government Network

In order to connect data and information, application systems, services, and other various device channels from various government affairs in regency/city local governments, a service link system is needed. This service link system is expected to increase efficiency in the development of

e-Government services. The regency /city government service link system can consist of a system similar to an enterprise service bus so it can be called a government service bus or use API management. As shown in Figure 5, in the service link system there is a unified component consisting of adapters to connect each application to API adapter repositories, API adapter repositories or API groups as gateways for authentication, business/services process management as an application for directing the intended business process/services, function/data services to connect or access certain targeted databases/functions, proxy services as a link to and from the external connection lines of the regency/city government.

Referring to the specific characteristics of the regency/city government, the utilization of the service link system is divided into 2 types, namely cross-linked data integration between various affairs in the regency/city and integration of regency/city data with ministry/institutions data according to their respective affairs. Examples of cross-linked data integration between various affairs in a regency/city are: data on resident affairs (birth) are used for education affairs in new student admissions applications and student assistance fund management application; and data on resident affairs (deaths) are used for funeral affairs in cemetery land use permit application. While examples of data integration between ministries/institutions and regency/city government according to their respective affairs is: in educational affairs, the national student data (national student number) managed by the ministry of education is used in new student admissions applications managed by the regency/city education department.

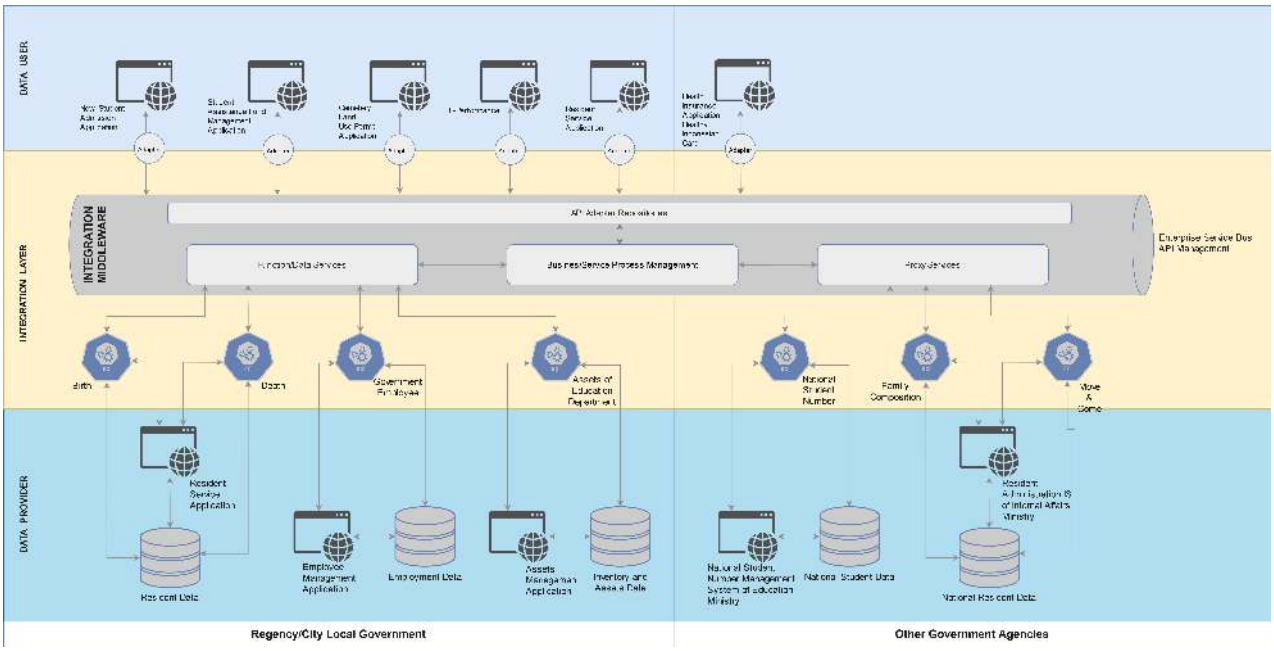


Figure 5 IT Infrastructure and Configuration Model – Regency/City Government Service Link System

6. CONCLUSIONS

Based on this research, it can be concluded that in the regency/city local e-Government process model, there are many affairs, so it affects business processes, services, applications, and data, which are large in number as well. In addition, regency/city governments have cross-linked data between various affairs and related to ministries/institutions, so a service link system is needed. To accommodate various area of regency/city, various network systems can be built. The managerial implication of this research is that regency/city local governments can compile an e-Government adoption strategy document which approved by the leaders by referring to the

process model that has been produced such as building intra networks, building service link systems, building applications derived from business affairs and processes, improving IT expertise, conducting e-Government socialization and training, also implementing a reward and punishment system in e-Government implementation.

REFERENCES

Agangiba, M., & Kabanda, S. (2016). E-Government Accessibility Research Trends in Developing Countries. *Mediterranean Conference on Information Systems*. http://aisel.aisnet.org/mcis2016/8

Bayu, D. J. (2020). *Skor Indeks Sistem Pemerintahan Berbasis Elektronik Nasional Baru Sebesar 2,18*. https://databoks.katadata.co.id/datapublish/2020/10/02/skor-indeks-sistem-pemerintahan-berbasis-elektronik-nasional-baru-sebesar-218

Chourabi, H., Mellouli, S., & Bouslama, F. (2009). Modeling e-government business processes : New approaches to transparent and efficient performance. *Information Polity*, *14*(1–2), 91–109. https://doi.org/10.3233/IP-2009-0168

Hameed, M. A., & Counsell, S. (2014). Establishing relationships between innovation characteristics and it innovation adoption in organisations: A meta-analysis approach. *International Journal of Innovation Management*, *18*(1), 1–32. https://doi.org/10.1142/S1363919614500078

Peraturan Presiden Republik Indonesia No. 95 Tahun 2018 Tentang Sistem Pemerintahan Berbasis Elektronik, (2018).

Peraturan Menteri Pendayagunaan Aparatur Negara Dan Reformasi Birokrasi Republik Indonesia Nomor 19 Tahun 2018 Tentang Penyusunan Peta Proses Bisnis Instansi Pemerintah, 53 (2018).

Ko, E., Kim, S. H., Kim, M., & Woo, J. Y. (2008). Organizational characteristics and the CRM adoption process. *Journal of Business Research*, *61*(1), 65–74. https://doi.org/10.1016/j.jbusres.2006.05.011

Moon, M. J., & Norris, D. F. (2005). Does managerial orientation matter? the adoption of reinventing government and e-government at the municipal level. *Information Systems Journal*, *15*(1), 43–60. https://doi.org/10.1111/j.1365-2575.2005.00185.x

Ndreu, A. (2016). the Definition and Importance of Local Governance. *Social and Natural Sciences Journal*, *10*(1). https://doi.org/10.12955/snsj.v10i1.730

Palkovits, S., & Wimmer, M. A. (2003). Processes in E-Government – A Holistic Framework for Modelling Electronic Public Services. *Electronic Government*, 213–219. https://doi.org/10.1007/10929179_39

Patel, H., & Jacobson, D. (2008). Factors influencing citizen adoption of e-government: A review and critical assessment. *16th European Conference on Information Systems, ECIS 2008*.

Said, A. R., Abdullah, H., Uli, J., & Mohamed, Z. A. (2014). Relationship between Organizational Characteristics and Information Security Knowledge Management Implementation. *Procedia - Social and Behavioral Sciences*, *123*, 433–443. https://doi.org/10.1016/j.sbspro.2014.01.1442

SPBE, T. (2020). *Indeks e-Government Indonesia Naik 19 Peringkat di Level Internasional*. https://spbe.go.id/blog/indeks-e-government-indonesia-naik-19-peringkat-di-level-internasional

Thapa, I. (2020). *Local Government : Concept, Roles and Importance for Contemporary Society* (Issue July). https://doi.org/10.13140/RG.2.2.23009.33123

Tolbert, C. J., & Mossberger, K. (2006). The effects of E-government on trust and confidence in

government. *Public Administration Review*, *66*(3), 354–369. https://doi.org/10.1111/j.1540-6210.2006.00594.x

Weill;, P., & Vitale, M. R. (2001). *Place to Space: Migrating to eBusiness Models* (1st ed.). Harvard Business School Press.

PROJECT MANAGEMENT APPLICATION ANALYSIS ON SHIP X PROJECT IN PT. ABC

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ABSTRACT

In the implementation of construction projects, punctuality, cost and quality have a close relationship in supporting the success of the project. The precision of the operation of the ship's construction was also a matter of concern. Due to the delay, it could lead to a reverse payment process, which would obviously disrupt production. The research aims to analyze time and expense for the project ship X at PT. ABC through the use of the crashing project, with the limitation of the construction of the hull. The process of working on the ship X hull construction at requires 390 days, with analysis through the crashing project, a 39-day reduction in completion with an additional cost of Rp. 889.928.707,00. Crashing project has been used for total expenses by Rp. 14,090,537,853.00

Keywords: Project Management, Ship Building, Crashing Project.

1. INTRODUCTION

Project management plays a very important role in the performance of a project. Especially for big projects that are associated with large resources. Implementation of project management has more to do with traditional approaches. In running project management it will be able to reduce rework, minimise problems in coordination, communication will work better between the tender owner and the project owner, errors in documenting will be smaller, there will be fewer complaints from the owner, document reduction, time and cost effectiveness, and cycle cost reduction. Another advantage is that project management can integrate processes, increase the efficiency and effectiveness of projects, from the design stage to operation and maintenance (Pakhale & Pal, 2020).

The X is a ship that has been worked out by pt. ABC. In the process of building project x did not come apart from a few flaws and obstacles. Some of the obstacles that occur include material delays and inaccuracies in the timing of project implementation between the plan and the realization of implementation. In project management, it is necessary to pay attention to matters related to punctuality, budget or financial conditions, the quality of the project and the smooth implementation of the project to be carried out.

In the process of carrying out the construction of the BRS, the method of constructing the vessel was modern fobs (full outfitting block system). In this method it can be referred to as the area/zone/stage method. The X ship is made up of 121 blocks divided into six zones. The construction of each block on the BRS 'construction process thrived on payments on each terminal. Therefore, the duration of the construction time required on each block needs to be noticed.

he focus of this study is to analyze the time of acceleration and expense required in the process of constructing the ship, thereby shortening the tardiness and implementation time that could be consistent with planning particularly with the time spent in the implementation (scheduling). In the implementation of project activities, planning on project activities is necessary so that an analysis can be carried out related to the acceleration of the duration of the project to avoid delays in its implementation. By using the crashing duration method, it is hoped that it can get optimal time to analyze the implementation of the X ship construction project. Improvements in project management in ship construction are expected to reduce the risk of delays for the implementation of future projects.

2. LITERATURE REVIEW

2.1 Project

The project can be defined by its specifications. The project is divided into specific components or information related to the phases, iteration, activities, roles and work products (Martins & da Silva, 2006).

A project is a unique activity constrained by time and resources of both human, material, cost or tool, so it requires a project management from the initial phase to the completion phase, where a project manager is primarily responsible for the success of the project. The existence of significant time and cost deviations or the success of a project would demonstrate the management of the project by a contractor manager and be a major concern to the owner of the project /owner (Simanjuntak, Manlian Ronald, 2019).

2.2 Project Management

Project management is a combination of personnel, policies, procedures and systems (manuals or with computers), which enables the accomplishment of planning, organizing, directing, and controlling project costs, schedules, quality and performance." Project management consists of subsystems of the organization and management of human relationships, as well as technical (nonhuman) management. The management of technical aspects consists of the elements of planning systems, control systems, methodology systems and information systems management (Prianto et al., 2014).

The criteria for project success are twofold, namely Project Management Success (focusing on the project process, being able to achieve cost, time, and quality as needed, as well as how the project management process is carried out) and Product Success (related to the final project result))(Baccarini, 1999).

2.3 Period of Activity

According to Soeharto (1997) The time period during which activity in the work network is long would take for activity from beginning to end. There are several factors to consider in estimating the time period of activity, among other things:

1. Estimates should be free from consideration of the effects of any prior or subsequent activity.
2. Approximate time span of activities results from the assumption that normal amounts of resources are available.
3. In the early stages of this analysis of the figures, it was thought that there was no limit to the number of resources, so it made it possible for the activities to be carried out in parallel or parallel times.
4. Use a normal working day, avoid assuming overtime, unless those things are specifically planned for the project.
5. Free of consideration reaching the project's completion target.

2.4 Crush Project

Crashing project is a method of shortening the length of project time by reducing time from one or more essential project activities to less than normal times of activity. Crashing project is an act to reduce the overall duration of the project after analyzing existing alternatives. Aim to optimize work time at lower costs. Often in crashing comes "trade-off", which is an exchange of time for expense.

There are 3 (three) steps it takes to construct a time graph - a cost, that is:

1. Search total direct costs for the old selected project, for example: labor and equipment costs.
2. Find total indirect costs for the long-selected project, example: consultations and administration costs.
3. Add up the direct and indirect costs for the long-selected project.

Time components in the crashing project, there are two-time components:

1. Normal time, which is the completion of activity in normal conditions.
2. Acceleration time, which is the shortest time possible to complete the activity.

Of these two components can be obtained totals acceleration time, with equations:

$$Acceleration\ Total\ Time = Normal\ Time - Acceleration\ Time$$

Component expenses in the crashing project, there are three component expenses:

1. Normal costs, which is a direct cost to complete activity in normal conditions.
2. The acceleration cost, which is a direct cost of completing activity on acceleration /crash (the shortest time conditions most likely to complete activity). From these two components can be obtained totals: acceleration costs, with equations:
   $$Acceleration\ Total\ Time = Accelaration\ Cost - Normal\ Cost$$
3. The acceleration per unit of time (slope), which is a direct cost of completing activity in acceleration /crash (the shortest time conditions most likely to complete activity) in the smallest time units, using equations:

$$Acceleration\ Charges\ Per\ Unit\ of\ Time = \frac{Acceleration\ Total\ Cost}{Acceleration\ Total\ Time}$$

3. METHODS

The work of a project often raises the question of whether the predetermined time in the project arrangement is optimal. In this study, the condition of the implementation of the project is that there is a difference in duration (time) of project planning by the implementation of it. By optimizing time and costs is expected to accelerate the duration of projects (crashing) with a minimum of expense added. The crashing process will focus on the activities at a critical course.

With the research focused on the crashing project on x, the first step involved is identifying the scope of the work of the BRS project, then analyzing data using the crashing project that is expected to be able to determine the optimum time and expense for the implementation of the x ship project.

4. RESULTS

In the process of building the X ship in PT. ABC, the construction method used is the fobs method (full outfitting block system). In this method it is commonly called the building of the ship by using the area/zone/stage method. The x ship is made up of 121 blocks divided into six zones:

Table 1. Ship's Zone Division Data X Ship

Zona	Name	Total Block
1	Cargo Hold	23
2	Engine Room	28
3	Fore Part	14
4	After Part	21
5	Wheel House	22
6	Hanggar	15

The hull construction of the BRS project took 392 days. Here is the time duration of the construction of the hull on the x ship and the analysis results to shorten the time and expense required.

Table 2. Activity Time Duration

No	Block	Volume Pekerjaan (kg)	Total Jam Orang	Durasi Normal (Hari)	Jumlah Orang	Durasi Normal (Jam)	Biaya Normal	Crash Duration 1 Jam		Crash Duration 2 Jam	
								Maksimal Crashing	Total Biaya Crashing 1 jam	Maksimal Crashing	Biaya Crashin 2 jam
Hull Construction		3.435,15		392		3.136		352,36		326,67	
Cargo Hold/Midle Part (Zona 1)											
1	1 P	42,45	2574	61	7	488	169.609.440,00	54,83	181.043.784,27	50,83	220.845.62
2	1 S	33,32	2022	113	3	904	133.236.320,00	101,57	142.218.543,82	94,17	173.484.79
3	2 P	33,66	2044	63	5	504	134.685.973,33	56,63	143.765.926,59	52,50	175.372.36
4	2 S	24,68	1504	78	3	624	99.103.573,33	70,11	105.784.713,11	65,00	129.041.11
5	3	33,91	2060	107	3	856	135.740.266,67	96,18	144.891.295,88	89,17	176.745.13
6	1A P	66,72	3550	58	10	464	233.921.333,33	52,13	249.691.310,86	48,33	304.585.06
7	1A S	52,77	2812	109	4	872	185.292.053,33	97,98	197.783.652,43	90,83	241.265.69
8	2A P	52,53	3180	64	8	512	209.540.800,00	57,53	223.667.146,07	53,33	272.839.58
9	2A S	45,10	2734	122	4	976	180.152.373,33	109,66	192.297.477,15	101,67	234.573.40
10	3A P	45,56	2762	52	9	416	181.997.386,67	46,74	194.266.873,41	43,33	236.975.76

57 | Fore Part (Zona 3)

	A	B	C	G	H	I	J	K	N	R	T	X
17	3B S	31,14	1892	67	5	536	124.670.186,67	60,22	133.074.918,35	55,83	162.330.97
18	R1 P	21,54	1160	63	3	504	76.436.266,67	56,63	81.589.273,41	52,50	99.526.38
19	R1 S	18,36	991	104	2	832	65.300.293,33	93,48	69.702.560,30	86,67	85.026.42
20	R2 P	33,37	1784	66	5	528	117.553.706,67	59,33	125.478.675,66	55,00	153.064.72
21	R2 S	29,10	1556	90	3	720	102.530.026,67	80,90	109.442.163,30	75,00	133.502.63
22	R3 P	22,52	1209	38	5	304	79.665.040,00	34,16	85.035.716,85	31,67	103.730.52
23	R 3 S	19,97	1077	86	2	688	70.967.120,00	77,30	75.751.420,22	71,67	92.405.10
Engine Room (Zona 2)											
24	B1 P	45,01	2728	53	9	424	179.757.013,33	47,64	191.875.463,67	44,17	234.058.61
25	B1 S	36,06	2191	58	6	464	144.372.293,33	52,13	154.105.256,93	48,33	187.984.75
26	B2 P	54,34	3290	105	5	837	216.789.066,67	94,02	231.404.059,93	87,17	282.277.43
27	B2 S	43,86	2661	79	6	632	175.342.160,00	71,01	187.162.979,78	65,83	228.310.10
28	B3 P	37,57	2280	44	9	352	150.236.800,00	39,55	160.365.123,60	36,67	195.620.83
29	B3 S	27,86	1695	88	3	704	111.689.200,00	79,10	119.218.808,99	73,33	145.428.64

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	A	B	C	G	H	I	J	K	N	R	T	X
35	SA 2A S	41,87	2235	145	3	1.160	147.271.600,00	130,34	157.200.022,47	120,83	191.759.895
36	P	63,72	3394	121	5	968	223.641.973,33	108,76	238.718.960,30	100,83	291.200.486
37	S	55,29	2947	121	4	968	194.187.653,33	108,76	207.278.955,81	100,83	252.848.506
38	TR 1 P	43,08	2301	62	6	496	151.620.560,00	55,73	161.842.170,79	51,67	197.422.604
39	TR 1S	36,12	1932	165	2	1.320	127.305.920,00	148,31	135.888.341,57	137,50	165.762.916
40	SA 2B P	32,27	1729	75	4	600	113.929.573,33	67,42	121.610.218,73	62,50	148.345.798
41	SA 2B S	32,75	1753	154	2	1.232	115.511.013,33	138,43	123.298.272,66	128,33	150.404.965
42	S P	41,32	2206	61	6	488	145.360.693,33	54,83	155.160.290,64	50,83	189.271.736
43	S S	38,20	2040	79	4	632	134.422.400,00	71,01	143.484.584,27	65,83	175.029.166
44	TR 2 P	38,24	2043	71	5	568	134.620.080,00	63,82	143.695.591,01	59,17	175.286.562
45	TR 2 S	32,24	1726	194	1	1.552	113.731.893,33	174,38	121.399.211,99	161,67	148.088.402
46	TR 3 P	32,49	1739	44	7	352	114.588.506,67	39,55	122.313.574,53	36,67	149.203.784
47	TR 3 S	27,65	1484	84	3	672	97.785.706,67	75,51	104.378.001,50	70,00	127.325.138
48	MD P	10,59	770	55	2	440	50.737.866,67	49,44	54.158.397,00	45,83	66.064.930

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	A	B	C	G	H	I	J	K	N	R	T	X
54	4A S	21,74	1328	109	2	872	87.506.346,67	97,98	93.405.650,94	90,83	113.940.555
55	BB	47,00	3609	202	3	1.616	237.809.040,00	181,57	253.841.110,11	168,33	309.647.187
56	4B P	27,84	1691	49	6	392	111.425.626,67	44,04	118.937.466,67	40,83	145.085.451
57	4B S	27,69	1684	97	3	776	110.964.373,33	87,19	118.445.117,60	80,83	144.484.861
58	P P	44,74	3260	63	9	504	214.812.266,67	56,63	229.293.992,51	52,50	279.703.472
59	P S	31,38	2310	301	1	2.408	152.213.600,00	270,56	162.475.191,01	250,83	198.194.791
60	R4 P	24,24	1475	93	3	744	97.192.666,67	83,60	103.744.981,27	77,50	126.552.951
61	R4 S	20,24	1236	124	2	992	81.444.160,00	111,46	86.934.777,53	103,33	106.047.083
62	U1 P	1,98	137	181	0	1.448	9.027.386,67	162,70	9.635.974,53	150,83	11.754.409
63	U1 S	1,98	137	181	0	1.448	9.027.386,67	162,70	9.635.974,53	150,83	11.754.409
64	U2 P	5,78	364	170	0	1.360	23.985.173,33	152,81	25.602.151,31	141,67	31.230.694
65	U2 S	5,78	364	170	0	1.360	23.985.173,33	152,81	25.602.151,31	141,67	31.230.694
After Part (Zona 4)											
66	K	12,25	754	102	1	816	49.683.573,33	91,69	53.033.027,72	85,00	64.692.152

	A	B	C	G	H	I	J	K	N	R	T	X
73	P1 P	27,05	1451	49	5	392	95.611.226,67	44,04	102.056.927,34	40,83	124.493.784
74	P1 S	27,37	1469	94	3	752	96.797.306,67	84,49	103.322.967,79	78,33	126.038.159
75	P2 P	24,60	1319	47	5	376	86.913.306,67	42,25	92.772.630,71	39,17	113.168.368
76	P2 S	24,60	1319	75	3	600	86.913.306,67	67,42	92.772.630,71	62,50	113.168.368
77	P3 P	36,99	1976	69	5	552	130.205.226,67	62,02	138.983.107,12	57,50	169.538.055
78	P3 S	36,97	1974	96	3	768	130.073.440,00	86,29	138.842.435,96	80,00	169.366.458
79	PU 1 P	25,35	1359	56	4	448	89.549.040,00	50,34	95.586.053,93	46,67	116.600.312
80	PU 1 S	23,37	1255	71	3	568	82.696.133,33	63,82	88.271.153,56	59,17	107.677.256
81	PU 2 P	20,52	1106	58	3	464	72.878.026,67	52,13	77.791.152,06	48,33	94.893.263
82	PU 2 S	17,53	946	72	2	576	62.335.093,33	64,72	66.537.459,18	60,00	81.165.486
83	PU 3 P	32,61	1747	61	5	488	115.115.653,33	54,83	122.876.259,18	50,83	149.890.173
84	PU 3 S	28,63	1535	155	2	1.240	101.146.266,67	139,33	107.965.116,10	129,17	131.700.868
85	DP	2,20	172	168	0	1.344	11.333.653,33	151,01	12.097.719,85	140,00	14.757.361
86	DS	2,20	172	170	0	1.360	11.333.653,33	152,81	12.097.719,85	141,67	14.757.361

	A	B	C	G	H	I	J	K	N	R	T	X
92	O3 S	18,50	1130	93	2	744	74.459.466,67	83,60	79.479.205,99	77,50	96.952.430
93	B3 P	23,64	1441	58	4	464	94.952.293,33	52,13	101.353.571,54	48,33	123.635.798
94	B3 S	18,50	1130	95	2	760	74.459.466,67	85,39	79.479.205,99	79,17	96.952.430
95	O5 P	18,11	1109	101	2	808	73.075.706,67	90,79	78.002.158,80	84,17	95.150.659
96	O5 S	14,70	903	155	1	1.240	59.501.680,00	139,33	63.513.029,21	129,17	77.476.145
97	B5 P	18,11	1109	103	2	824	73.075.706,67	92,58	78.002.158,80	85,83	95.150.659
98	B5 S	14,70	903	142	1	1.136	59.501.680,00	127,64	63.513.029,21	118,33	77.476.145
99	R4 P	22,07	1348	138	2	1.104	88.824.213,33	124,04	94.812.362,55	115,00	115.656.527
100	R4 S	18,21	1114	179	1	1.432	73.405.173,33	160,90	78.353.836,70	149,17	95.579.652
101	R3 P	24,57	1497	107	2	856	98.642.320,00	96,18	105.292.364,04	89,17	128.440.520
102	R3 S	18,20	1114	147	1	1.176	73.405.173,33	132,13	78.353.836,70	122,50	95.579.652
103	R5 P	12,03	743	121	1	968	48.958.746,67	108,76	52.259.336,33	100,83	63.748.368
104	R5S	9,47	589	162	1	1.296	38.811.173,33	145,62	41.427.656,93	135,00	50.535.381
105	V2 P	15,84	971	103	2	824	63.982.426,67	92,58	68.295.848,69	85,83	83.310.451
109	P2 P	17,47	1070	96	2	768	70.505.866,67	86,29	75.259.071,16	80,00	91.804.513
110	P2 S	16,13	990	175	1	1.400	65.234.400,00	157,30	69.632.224,72	145,83	84.940.625
111	B2 P	17,47	1070	136	1	1.088	70.505.866,67	122,25	75.259.071,16	113,33	91.804.513
112	B2 S	16,13	990	163	1	1.304	65.234.400,00	146,52	69.632.224,72	135,83	84.940.625
113	P1 P	12,11	750	12	10	96	49.420.000,00	10,79	52.751.685,39	10,00	64.348.958
114	P1 S	13,58	834	172	1	1.376	54.955.040,00	154,61	58.659.874,16	143,33	71.556.041
115	B1 P	12,11	750	120	1	960	49.420.000,00	107,87	52.751.685,39	100,00	64.348.958
116	B1 S	13,58	834	174	1	1.392	54.955.040,00	156,40	58.659.874,16	145,00	71.556.041
117	B2 P	21,13	1289	117	2	936	84.936.506,67	105,17	90.662.563,30	97,50	110.594.409
118	B2 S	17,79	1090	154	1	1.232	71.823.733,33	138,43	76.665.782,77	128,33	93.520.486

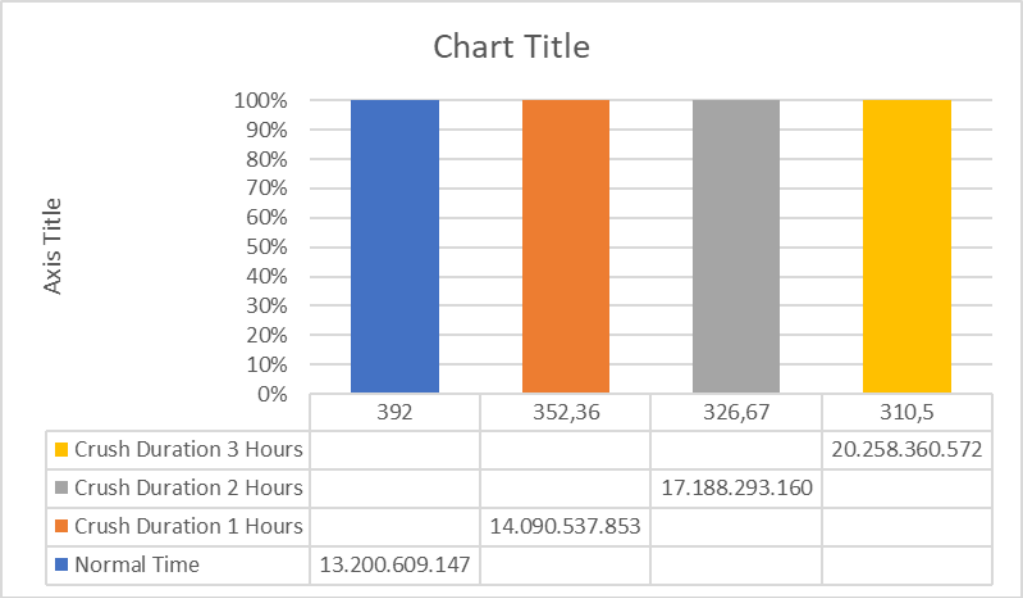


Figure 1. Total Time Cost Comparisons

From the above, it is known that in the process of constructing a hull construction project with an increased cost of the lowest would be an additional 1 hour of overtime of 352 days and the required additional costs of Rp. 889,928,707.00.

6. CONCLUSIONS

Under the method crush project, the fastest time for the completion of the hull construction work was 310 days with an additional three hours of overtime and a required additional cost of rp 7,057,71,424,00.

The lowest cost needed for increased hull construction was 352 days with an additional 1 hour of overtime and required additional costs of Rp. 889,928,707.00.

REFERENCES

Baccarini, D. (1999). The Logical Framework Method for Defining Project Success. *Project Management Journal*, *30*(4), 25–32.

Martins, P. V., & da Silva, A. R. (2006). A case study applying process and project alignment methodology. *Journal of the Brazilian Computer Society*, *12*(3), 65–82.

Pakhal, P. D., & Pal, A. (2020). Digital project management in infrastructure project: a case study of Nagpur Metro Rail Project. *Asian Journal of Civil Engineering*, *21*(4), 639–647.

Prianto, K., Dewi, S. M., & Pujiraharjo, A. (2014). Pengaruh Kompetensi Manajer Proyek Terhadap Keberhasilan Proyek Pada Perusahaan Kontraktor Di Kabupaten Malang. *Jurnal Media Teknik Sipil*, *10*(2), 156–168.

Simanjuntak, Manlian Ronald, G. H. S. (2019). Kajian Faktor-faktor Penting Manajer Proyek Dalam Proses Konstruksi Bangunan Gedung Tinggi Di Jakarta Pusat. *Seminar Nasional Teknik Sipil*, 299–308.

Soeharto, I. (1997). *Manajemen Proyek: Dari Konsepsual Sampai Operasional*. Jakarta: Erlangga.

OPTIMIZATION OF SMALL SCALE LNG DISTRIBUTION DESIGN FOR POWER PLANTS IN THE BALI AND NUSA TENGGARA

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ABSTRACT

The soaring prices of coal and oil have caused the operational costs of power plants to rise. The Indonesian government is currently implementing a program to utilize natural gas to replace fuel oil for supply to power plants. One of the obstacles in the distribution of LNG is the unavailability of infrastructure/ LNG receiving terminal in the generating area. In this study, the distribution design is limited to 9 power plants located in Bali and Nusa Tenggara. Seeing the characteristics of the demand that is not too large, then this LNG distribution can be categorized into a small-scale LNG distribution. One way to transport LNG on a small scale is to use ISO tanks which are transported by ship. There are five stages in the design of this LNG distribution, namely: (1) Determining the hub with a qualitative assessment which gives the results of the selected hub, namely Benoa Port and Labuan Bajo Port. (2) Selection of 3 alternative distribution schemes using AHP with the decision to choose alternative 1 (Using trucks to bring LNG to the plant). (3) Determine the power plant to be served from the selected hub using the Clustering Method which produces two clusters, namely the Benoa Cluster & Labuan Bajo Cluster. (4) Choosing the type and route for each ship using the set partitioning problem approach. (5) Conduct an economic study to analyze the feasibility of investing in the distribution pattern that has been generated. This research is expected to obtain the distribution design from the hub to the generator, the type and number of ships, routes, and the number of ISO tanks needed for LNG distribution in the Bali and Nusa Tenggara regions.

Keywords: Small Scale LNG, ISO Tank, Analytical Hierarchy Process, dan Set Partitioning Problem

1. INTRODUCTION

Increasing the price of coal and oil as fuel for power plants, the government makes efforts to replace these fuels with natural gas. These efforts will reduce production costs, fulfill electricity supply, increase national natural gas absorption which will have a major impact on national energy security and accelerate energy diversification. To accelerate the gasification of power plants in Indonesia, the Ministry of Energy and Mineral Resources assigned PT Pertamina (Persero) to carry out the supply and development of LNG infrastructure to provide natural gas to the State Gas Company (Persero). There are 52 power plants that are priority for this gasification program spread across the territory of Indonesia. The Minister of Energy and Mineral Resources assigned the State Electricity Company (PLN) to gasification of power plants and purchase LNG from PT Pertamina (Persero) for the conversion of the use of high speed diesel fuel to LNG.

In supporting the LNG distribution program, several things must be met, such as infrastructure and service support, such as the availability of LNG ships, the availability of LNG receiving terminals and LNG tank facilities as well as regasification units and other supporting facilities. Due to the limited facilities required, LNG distribution is planned to utilize the port managed by PT Pelindo Indonesia as a location where LNG supply will be distributed before being

distributed to the power plant. Of the 52 power plants that are prioritized for gasification, this study will only focus on power plants located in Bali and Nusa Tenggara.



Figure 1. Distribution of 9 power plants in Bali and West Nusa Tenggara

The 9 power plants in Bali and West Nusa Tenggara have special characteristics, namely they require small-scale gas needs and are also spread over several areas in Bali and Nusa Tenggara. An alternative solution that can be taken is to apply the concept of LNG distribution on a small scale. Small-scale LNG distribution is designed to supply gas with small gas supply requirements, spread over several areas over short distances, using small size vessels or barges and use C-type Tank or ISO Tank for LNG storage during distribution. For this study, an ISO Tank with a size of 20' will be chosen because it is considered more relevant for small scale LNG distribution.

No.	Power Plant	Capacity (MW)	BBTUD	ISO Tank Demand/days
1.	MPP Jeranjang Lombok	50	3.6	9
2.	PLTMG Sumbawa	50	6.13	14
3.	PLTMG Bima	50	6.13	14
4.	PLTMG Maumere	40	2.9	7
5.	PLTMG Alor	10	1.3	3
6.	PLTMG Kupang	40	2.9	7
7.	PLTMG Waingapu	10	1.3	3
8.	PLTG Gilimanuk	134	7.9	18
9.	PLTMG Rangko (Flores)	23	6.5	15

Table 1. The generator and the capacity and requirements of ISO Tank

2. LITERATURE REVIEW

a. Natural gas

The definition of natural gas is the result of a natural process in the form of hydrocarbons under conditions of atmospheric pressure and temperature in the form of a gas phase obtained from the oil and gas mining process, including conventional natural gas and gas flares (ESDM, 2016). Natural gas contains several types of gas such as Liquefied Petroleum Gas (LPG), Liquefied Natural Gas (LNG) and Compressed Natural Gas.

b. Liquefied Natural Gas *(LNG)*

The definition of LNG is natural gas that cooled to 162 °C at atmospheric pressure and is liquefied (600-fold volume reduction) and stored in LNG storage tanks (Laleh et al. 2019). LNG carried by ships is received by the main liquefied natural gas terminal facilities (Abdillah et al, 2020).

c. LNG Distribution

LNG supply chain has components of natural gas reserves / production wells (gas wells), liquefaction plants (liquefaction plants), loading terminals with storage tanks (loading terminals), LNG carriers (LNG carriers), receiving terminals and receiving terminals), regasification unit (regasification unit), and Gas Consumer (Artana, et al 2016).

d. LNG Carrier

The means of transportation used to distribute LNG from the LNG refinery to the LNG receiving terminal (receiving terminal). LNG carriers usually use a steam turbine for the main engine, because the LNG in the tank will always produce Boiled off gas. To keep the LNG temperature low, LNG carriers use mild steel. LNG carriers have large capacities so they are the right choice to distribute LNG over long distances.

e. Small scale LNG distribution

LNG transportation using small LNG vessels is still rare, with gas demand from small power plants scattered at several points (Bittate et al. 2018). Small-scale LNG distribution does not require extensive pipelines as transportation where most of the distribution is transported by ships and trucks. Therefore, smaller and infrequent requests can be served economically without the substantial investment cost of spreading gas in the pipeline. The small-scale LNG distribution process will use ISO Tanks to distribute LNG. Small-scale LNG regasification and cold utilization systems can be a sustainable solution in the LNG trade.

f. Receiving Terminal LNG

This receiving terminal consists of a storage unit, a processing unit for LNG regasification and an LNG distribution unit to the factory (Putra et al. 2018). At the receiving terminal there are several systems, namely: Berthing System, Storage System and Regasification System.

3. METHODS

The methodology in this research consists of stages with the aim that the design of small-scale LNG distribution can meet the fulfillment of power plants in Bali and Nusa Tenggara. Small-scale LNG distribution design is carried out through five stages.

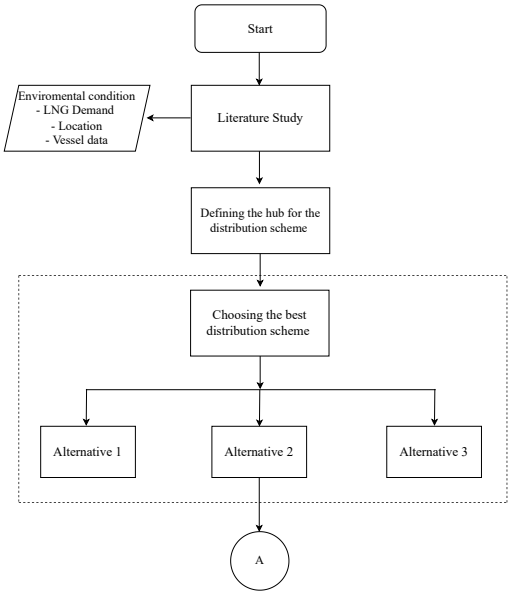


Figure 3. Research stages

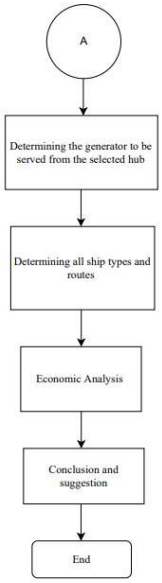


Figure 4. Research stages

As can be seen in figure 3 and figure 4, the first stage is to determine the hub in the distribution scheme. The second stage is to determine the LNG distribution scheme from the hub to the power plant that will be used. The third stage is to determine which plants will be served by the hub in the Bali and Nusa Tenggara regions. Next in the fourth stage is to determine all types, capacities, numbers and routes of ships in the Small Scale LNG distribution. The fifth stage is to conduct an economic study of the resulting LNG distribution design

4. RESULTS

a. Defining the hub for the distribution scheme

The selection of the hub is carried out by considering four factors including geographical location, generating capacity and development potential, supporting equipment at the port, as well as the conditions and available transportation infrastructure. Qualitative research was conducted by considering the parameters above, so the selected hubs were Benoa Port, Bali and PMLB Labuan Bajo Flores Port.

Consideration	Bali	Lombok	Bima	Sumbawa	Flores	Kupang	Maumere	Waingapu	Alor
Port strategic location	√	√	√	√	√	√			√
LNG *Demand*	√	√			√	√			
Loading unloading facilities									
Reach stacker	√	√	√	√		√	√	√	√
Crane	√	√				√		√	√
Forklift	√	√					√	√	√
Truk trailer	√								√
Infrastructure readiness									
Jetty	√	√	√	√	√	√		√	
Container yard	√	√		√	√	√	√		√
Road Acces	√			√	√	√	√	√	√
Shipping Lane	√	√		√	√	√	√	√	√

Table 1 Recapitulation of hub selection from several ports

b. Choosing the best distribution scheme

This stage is carried out by implementing the AHP (Analytical Hierarchy Process) method through expert choice software. Each attribute and alternative involved in the selection process will be compared by looking at the importance of each of the existing attributes, sub attributes and alternatives. The AHP method will be used to select several alternatives based on the attributes. The following are attributes, sub-attributes and alternatives in the stage of selecting the best distribution scheme.

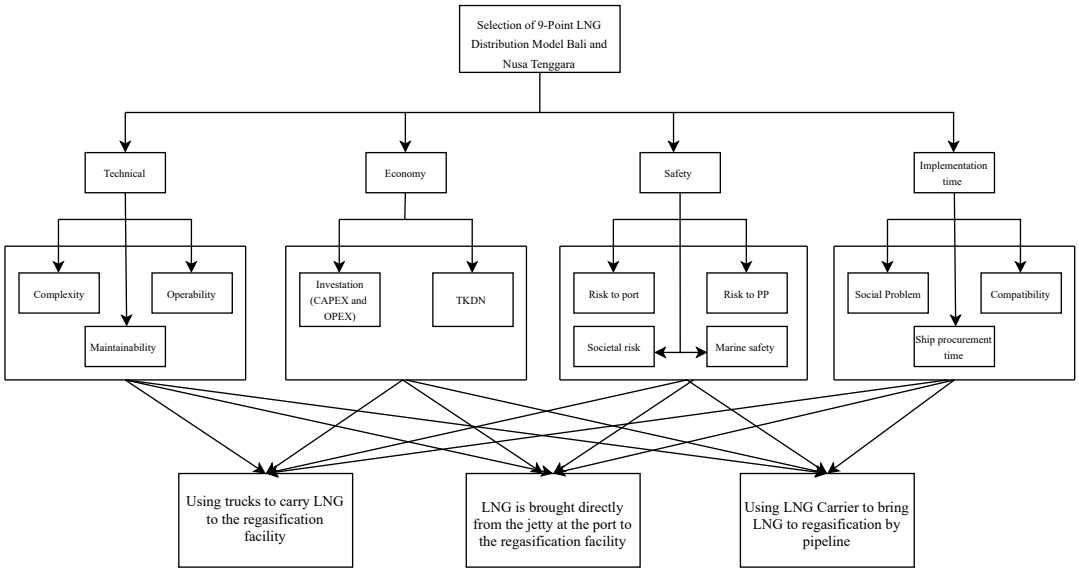


Figure 5. distribution model selection hierarchy

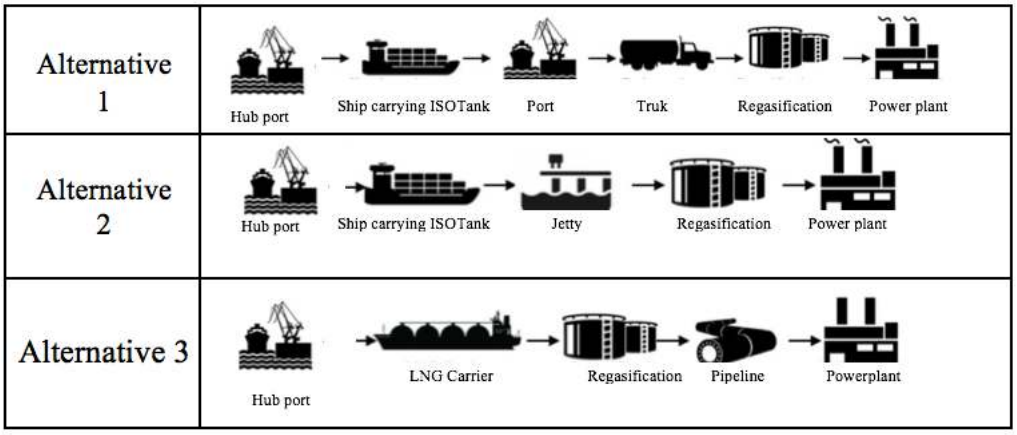


Figure 6. Alternative LNG distribution options to be used

Based on the assessment of each of the alternatives above, an assessment of the profit weight of each alternative is obtained. It can be seen that the 1st alternative is the alternative that has the highest weight of 0.532.

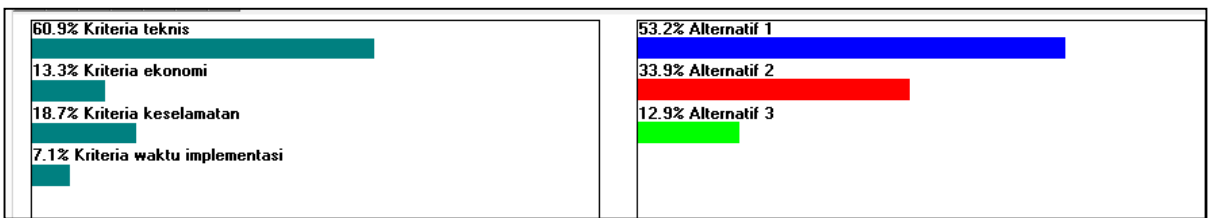


Figure 7. the results of the weighting of the 9-point LNG distribution model

Considering that the model selection scheme with the AHP approach uses an approximation approach, then the next step is sensitivity analysis to re-examine the selection results. Figure 8 shows the condition of the base case where the selection results are based on the previous weighting. For example, the sensitivity test for the first is carried out by increasing the weight of economic criteria up to 60% (impact on the reduction of other criteria). It can be seen in Figure 9 that changes in economic criteria will still result in the selection of alternative 1. Thus, if one day there is a change in conditions that results in changes in the weight of the economic criteria, this will not be enough to fail the selection of alternative 1 as the best alternative.

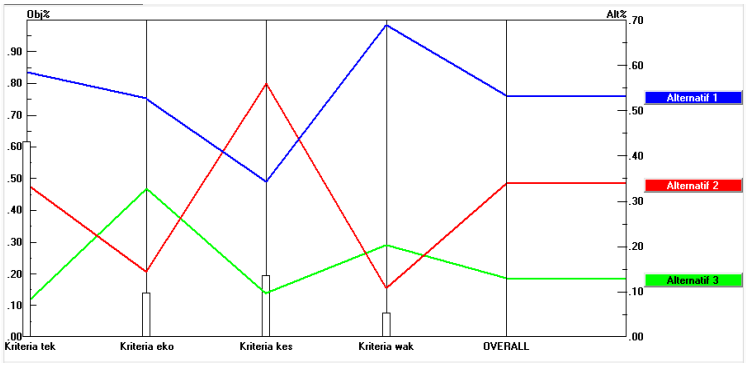


Figure 8. Sensitivity Analysis (Base case)

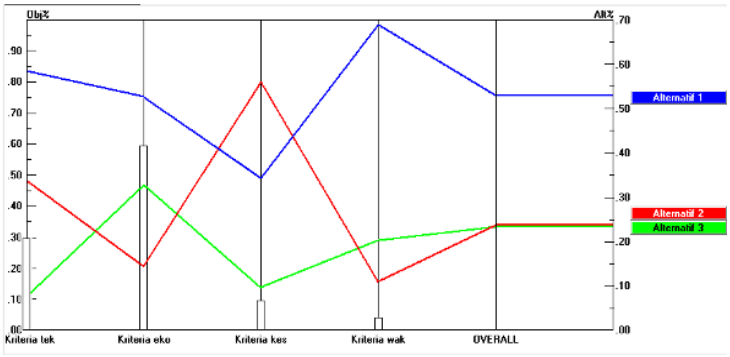


Figure 9. Sensitivity Analysis (increase implementation time weight)

c. Determine the generators to be served from the selected hub

Based on the number of hubs that have been obtained from the first stage, further clustering is carried out which ports will be served from each hub. The determination of this port cluster is carried out using the K-Means Clustering method. The input in the K-Means Clustering method is the position or location of each landing point on the ISO Tank. The input will be given in the form of latitude and longitude coordinates. In this study, the central point of the cluster has been determined where the center point of the cluster has a function as a hub terminal that will supply LNG to the nearest port.

	Centroid 1	**Centroid 2**
X (Longitude)	115,21	119,87
y (Latitude)	-8.73	-8,49

Table 2. The centroid point for the Benoa-Flores hub

After determining the centroid for each alternative, the next step is to calculate the Euclidean distance. This method is done by calculating the distance of each port to each centroid point. The following is Euclid's theorem that will be used for this step.

$$D(i,j) = \sqrt{(X_{1i} - X_{1j})^2 + (X_{2i} - X_{2j})^2 + \cdots + (X_{ki} - X_{kj})^2 \ldots} \quad (1.1)$$

The result of this stage is that the distance from each port to each centroid is obtained. The distance from the port to the centroid that has the lowest value will be included in the cluster. The following is the result of the calculation of the Ecludian distance.

Port	Euclidean Distance	Euclidean Distance		Cluster
		1	2	
Gilimanuk	0.9656	0.9656	5.4508	1
Lembar	0.8594	0.8594	3.8102	1
Badas, Sumbawa	2.1776	2.1776	2.5026	1
Bima	1.1624	3.5133	1.1624	2
Maumere	2.3485	7.0090	2.3485	2
Waingapu	1.2040	5.1180	1.2040	2
Alor (Kalabahi)	4.6524	9.3211	4.6524	2
Kupang	4.0287	8.4419	4.0287	2

Table 3. Result of the calculation of the Euclidian Distance

The following is the result of grouping 9 port points into two clusters on each alternative hub:

Cluster	Receiving Terminal
Cluster 1 (Hub Benoa, Bali)	Gilimanuk Port
	Lembar Port
	Badas Port
Cluster 2 (Hub Flores)	Bima Port
	Flores Port
	Maumere Port
	Waingapu Port
	Alor Port
	Kupang Port

Table 4. Clustering Result

d. Determine all ship types and route

Determining the route and capacity of the ship is done by making multiple routes (multiple routes) are feasible where the route can meet the needs of the generator and does not exceed the capacity of the ship. This stage uses the method of determining the route and type of ship for LNG distribution which was developed with a combination of web-based applications and the use of optimization-based software. In general, this application was developed with the following stages:

1. establish possible routes

2. calculate the number and cost of trips per year for each route
3. determine the combination of routes that provide minimal transportation costs based on all routes that have been formed through approach integer linear programming,

Phase I and Phase II are route generation stages that can be done using a web-based application that has been developed (figure 10). There are several characteristics of ship routes that form the basis for route formation in Phase I and Phase II. Furthermore, in Phase III, the combination of routes is carried out through the integer linear programming, where the output given in Phase I and Phase II is translated into an integer programming model and solved using commercial software (figure 11)

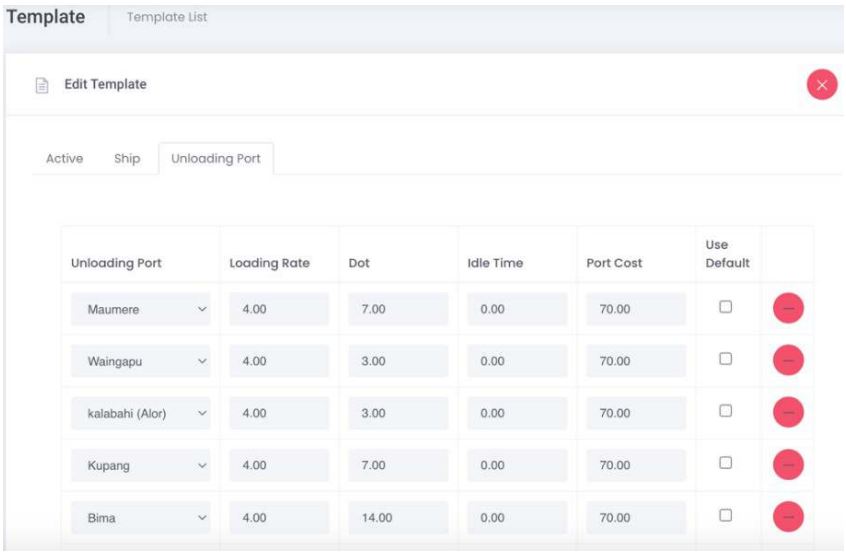


Figure 10. Interface of softwaere

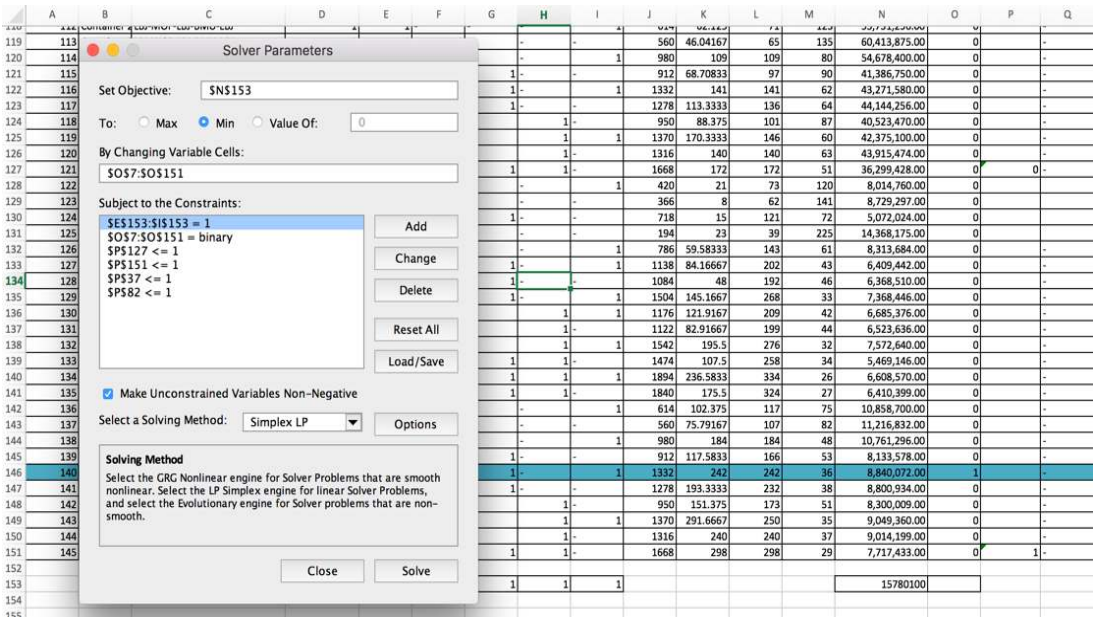


Figure 11. Interface of solver in excel

The objective function model, decision variables, and constraints are translated into a spreadsheet model, the next step is to perform computations using the Solver Add-in Excel or other optimization software. The following is a summary of the results of the selection of ships and LPG transportation routes.

No.	Route	Ship	Route time	Number of round trip	Total cost
1	BOA–SWQ-BOA-GIL-BOA-LBR- BOA (Cluster 1)	LCT 200	149	59	14,647,883
2	LBJ-WGP–LBJ–KOE–LBJ (Cluster 2)	LCT 200	199	44	6,940,028
3	LBJ-MOF-LBJ-ARD-LBJ-BMU-LBJ (Cluster 2)	LCT 150	242	36	8,840,072

Table 5. results of the selection of ships and LPG transportation routes

e. Economic Analysis

The results of the analysis on the optimization of LNG distribution are used to develop an economic analysis related to the investment feasibility of the project. Several methods are used to measure investment feasibility, namely IRR (Internal Rate of Return) and PBP (Payback Period) to determine the investment payback period. In this document, the three methods are calculated by assuming a project duration of 20 years. Costs will be calculated based on Capital Expenditure (CAPEX) where the CAPEX component is divided into 3 groups according to location in the LNG supply chain, namely LNG Hub Terminals, Ports, and Power Plants. Operational expenses (OPEX) where opex consists of operating and maintenance costs for ports and plants, trucks and trailers to transport ISO LNG Tanks to plants, and ships transporting ISO LNG Tanks. The following are the results of CAPEX, OPEX, Revenue estimation with IRR and PBP values for each cluster.

DATA BASIS					
Cost Component	**Unit**	**Total Cost**			
CAPEX	USD	51,577,734			
OPEX	USD/Year	19,295,494			
Project Duration	Years	20			
Disposal/Salvage Value	USD	2,578,887			
Annual Depreciation	USD/Year	2,449,942			
Tax Cost	%/Year	22%			
Inflation Rate	%/Year	3%			
REVENUE ESTIMATION					
GAS TOTAL	bbtu day	10			
	mmbtu day	10,050			
	mmbtu year	3,668,250			
Revenue from *Tolling Fee* (USD/mmbtu)	**Toll Fee Est.**	**Total**	**IRR**	**PBP**	
	8.451	30,998,803	8%	7.10	
	8.560	31,401,718	10%	6.19	
	8.762	32,142,698	12%	6.08	
	8.988	32,971,177	14%	5.22	

Table 6. results of Cluster

DATA BASIS					
Cost Component	**Unit**	**Total Cost**			
CAPEX	USD	41,181,231			
OPEX	USD/Year	17,309,714			
Project Duration	Years	20			
Disposal/Salvage Value	USD	2,059,062			
Annual Depreciation	USD/Year	1,956,108			
Tax Cost	%/Year	22%			
Inflation Rate	%/Year	3%			
REVENUE ESTIMATION					
GAS TOTAL	bbtu day	24			
	mmbtu day	23,800			
	mmbtu year	8,687,000			
Revenue from *Tolling Fee* (USD/mmbtu)	**Toll Fee Est.**	**Total**	**IRR**	**PBP**	
	3.131	27,196,192	8%	7.03	
	3.160	27,452,372	10%	6.13	
	3.224	28,004,608	12%	6.03	
	3.296	28,630,317	14%	5.17	

Table 7. Result of cluster

6. CONCLUSIONS

The conclusions that can be drawn from this study are:

1. Recommendations for hub terminal locations by utilizing Benoa Harbor and Labuan Bajo Flores Multipurpose Port
2. In determining the selection of the best LNG distribution scheme, there are three alternatives to choose from, namely:
   - Model 1: LNG Plant – Ship carrying ISO Tank – Port – Truck carrying ISO Tank – Regasification Facility – Generator
   - Model 2: LNG Plant – Ship carrying ISO Tank – Jetty at the plant- Regasification facility – Generator
   - Model 3: LNG Plant – LNG Carrier at the port – Regasification at the port – Pipeline – Generator
3. The results at the clustering stage using two hubs namely Benoa Port and Labuan Bajo Multipurpose Port resulted in 2 clusters serving several receiving terminals, namely:
   - **Cluster 1 (Hub Benoa, Bali) :**Gilimanuk Harbor, Lembar Harbor, Badas Harbor,
   - **Cluster 2 (Labuan Bajo Port Hub):** Bima Harbor**,** Flores Harbor**,** Maumere Harbor Waingapu Harbor, Kalabahi Harbor, Alor**,** Kupang Port.
4. Based on the results of the route determination application by combining the excel solver in processing data, the results obtained from route determination are:
   - **Cluster 1**: Using LCT 200 Ship by serving 1 route, namely: Benoa – Badas – Benoa – Gilimanuk – Benoa – Lembar – Benoa
   - **Cluster 2**: Using 2 ships, namely LCT 150 and LCT 200 by serving routes
     - Labuan Bajo – Waingapu - Labuan Bajo – Kupang - Labuan Bajo
     - Labuan Bajo - Merauke - Labuan Bajo – Alor - Labuan Bajo
5. The results of the calculation taking into account the costs at the hub, port, power plant and transportation process:
   - cluster 1 produces a CAPEX value of USD 41,181,231 and an OPEX of USD 17,309,714. Meanwhile, for cluster 2, the CAPEX values were USD 51,577,734 and USD 19,295,494.
   - The scenario in cluster 1, there is an estimated Tolling Fee along with the value of the IRR and Payback Period. By referring to the WACC limit of 11%, the ideal decision that can be taken is with an IRR of 12% which results in a total tolling fee of 28.004,608. This value will result in a return on investment within 6.03 years. And this also happens in cluster 2. Where the ideal decision that can be taken is with an IRR value of 12% with a total tolling fee of 32,142,698. This value will result in a return on investment within 6.08 years.

REFERENCES

Abdillah, H. N., Artana, K. B., Dinariyana, A. A. B., Handani, D. W., & Aprilia, P. W. (2021). Study on the LNG Distribution to Bali-Nusa Tenggara Power Plants Utilizing Mini LNG Carriers. IOP Conference Series: Materials Science and Engineering, 1–12. https://doi.org/10.1088/1757- 899x/1052/1/012055

Artana, K. B., Fajar N, T., Mulyadi, Y., & SA, G. B. D. (2016). Kajian Pemilihan Metode Distribusi LNG ke Pembangkit Listrik Tenaga Gas Bintuni. CINIA: The 2 end Conference on Innovation and Industrial Appplications, 138–144. https://doi.org/10.12962/j23546026.y2018i1.3362

Bittante, A., Jokinen, R., Krooks, J., Pettersson, F., & Saxén, H. (2017). Optimal Design of a Small-Scale LNG Supply Chain Combining Sea and Land Transports. Industrial and Engineering Chemistry Research, 1–33. https://doi.org/10.1021/acs.iecr.7b01061

Budiyanto, M. A., Pamitran, A. S., & Yusman, T. (2019). Optimization of the Route of Distribution of LNG Using Small Scale LNG Carrier: A Case Study of a Gas Power Plant in the Sumatra Region, Indonesia. International Journal of Energy Economics and Policy, 9(6), 179–187. https://doi.org/10.32479/ijeep.8103

Budiyanto, M. A., Riadi, A., Buana, I. G. N. S., & Kurnia, G. (2020). Study on the LNG Distribution to Mobile Power Plants Utilizing Small-Scale LNG Carriers. Heliyon, 6, 1–7. https://doi.org/10.1016/j.heliyon.2020.e04538

Fikri, M. H. C., Hendrarsakti, J., Sambodho, K., Felayati, F. M., Octaviani, N. S., Giranza, M. J., & Hutomo, G. A. (2018). Estimating Capital Cost of Small Scale LNG Carrier. SENTA, 225–229. https://doi.org/10.5220/0008542102250229

Jokinen, R., Pettersson, F., & Saxén, H. (2015). An MILP Model for Optimization of a Small-Scale LNG Supply Chain Along a Coastline. Applied Energy, 138, 423–431. https://doi.org/10.1016/j.apenergy.2014.10.039

Katili, A. M. F., Artana, K. B., & Dinariyana, A. A. B. (2017). Kajian Teknis dan Ekonomis Distribusi Gas Alam dari FSRU Menuju Superblok. Jurnal Teknik ITS, 5(2), 522–527. https://doi.org/10.12962/j23373539.v5i2.19519

Shirazi, L., Sarmad, M., Rostami, R. M., Moein, P., Zare, M., & Mohammadbeigy, K. (2019). Feasibility Study of the Small Scale LNG Plant Infrastructure for Gas Supply in North of Iran (Case Study). Sustainable Energy Technologies and Assessments, 35, 220–229. https://doi.org/10.1016/j.seta.2019.07.010

Soegiono, K.B.A. (2006). Transportasi LNG Indonesia. Airlangga University Press

PROCUREMENT RISK MANAGEMENT OF MINING SERVICES IN A MINING COMPANY USING HOUSE OF RISK (HOR) METHOD

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ABSTRACT

This paper presents a case study of risk mitigation of the procurement of mining services in PT XYZ. PT XYZ is a mining company engaged in the extraction and processing of nickel ore that produces nickel in matte (78% nickel content) in South Sulawesi. In running its business, PT XYZ cannot fulfill all its own needs, so it needs to cooperate with mining service contractors to support its operation. During the process of procuring such services, there are several related risks that may occur in terms of time, cost, and quality that could impact to the operation of the company such as production target not achieved. The method used is the House of Risk (HOR) method. HOR1 is used to identify risk events, risk agents, and the correlation between risk agents and risk events. HOR1 resulting a shortlisted risk agents that need to be considered in HOR2. In HOR2, preventive actions are identified, the correlation between the preventive actions and the risk agents, the difficulty of implementing the preventive actions, and the ratio of its total effectiveness to the difficulty. HOR2 resulting a shortlisted preventive action to reduce the occurrence of the risk agents. From the results of the analysis and evaluation on HOR1, it is obtained thirteen risk agents that need to be prioritized, namely the Scope and specifications of the contract requisition are not clear, Lack of awareness/care of users to make Contract requisition (CR) on time, The workload of the procurement department is too large, Budget are limited, the Procurement Analyst does not have sufficient time to understand the scope of work, the Contract Management Team sometimes forgets to take into account the cost component as part of the company's normative obligations, Dependence on one contractor, CR approval at the User is too long, Procurement Analyst is lacking in determining the negotiation target, Users do not understand the procurement process, Contracts handled by one user are too many, Clarification of proposals takes a long time, and project manager (PM) Changes on the user's side. Risk mitigation in HOR2 resulted in eight preventive actions that need to be prioritized, namely Coordination of user needs more intensively and regularly, Making procurement plans early, Making SoW that are easy to understand, Better Collaboration with Contractors, Leveraging procurement load to be evenly distributed, Assigning Procurement employees to the User department to better understand business processes, Make contracts with a longer duration (3-5 years), and Consolidate contracts for similar works.

Keywords: Risk management, House of Risk, risk event, risk agent, preventive action.

1. INTRODUCTION

Mining is an activity of extracting valuable and economically valuable mineral deposits from the earth's crust, below the earth's surface, and below the water surface (BPS, 2022). PT XYZ is a mining company engaged in the extraction and processing of nickel ore. Nickel ore is a mineral or mineral aggregate containing nickel (BPS, 2022). PT XYZ produces nickel in matte (78% nickel grade), which is an intermediate, lateritic ore at its integrated mining and processing facilities in South Sulawesi. All of its production is sold under long-term contracts to a refinery in Japan.

In running its business, PT XYZ cannot fulfill all its own needs, so it needs to cooperate with mining service contractors. The procurement process at PT XYZ consists of purchasing planning in the form of making a procurement strategy or requisition, selecting contractors, Request for Proposals (RFP) and receiving proposals, evaluation of safety, technical, and commercial, negotiation, determination of the awarded contractor, and execution or follow-up. The output of the procurement process is a Contract or Agreement with a Contractor.

Mining Services include construction of mining infrastructure, construction and maintenance of settling ponds, transportation of slag for mine road backfill, hydrogeological studies, preparation of exploration samples, quarry drilling, geotechnical investigation and monitoring, replanting and maintenance of post-mining area plants, land reclamation arrangements, exploration drilling, filling mine blast holes and quarry, mine effluent, tree bucking, land clearing, preparation and delivery services for mining material samples, and dredging sediments in settling ponds.

During the procurement process for mining services, there are risks that may arise in terms of time, cost, and quality. Risk in terms of time, for example, the procurement process is too long so that it does not meet the schedule of user needs. The unavailability of mining service contractors in a timely manner can cause operational activities to be delayed. An example of a case in the procurement of mining services for Mining Road Construction in 2019, there was a delay due to the tender process being too long, more than 3 (three) months from the user's expectation of 2.5 (two and a half) months. This delay was caused by lengthy technical evaluations, lengthy price evaluations and negotiations, and lengthy approval of the tender result. A similar case also occurred in 2021 because the contractor participating in the tender was a new contractor, so they were not too familiar with the procurement process for PT XYZ.

The risk from the cost side can be in the form of excessive use of resources due to an inefficient process, for example the procurement process must be repeated because there is no proposal from the bidder that matches the user's needs. This often occur because the number of proposals received is not competitive (less than 3), so the tender process needs to be repeated. In addition to having an impact on costs, this event also has an impact to the time.

In terms of quality, the risk that may occur is that the quality of the contractors who are invited to participate in the tender or are selected as winner are not in accordance with user expectations. This risk can occur during the procurement process, but the impact is greater during the contract execution. Risks during the procurement process, for example, the quality of the proposal is not appropriate, incomplete or does not meet the tender requirements. Risks during work execution, for example, the contractor does not have the ability to complete the work as expected.

Based on the description above, it can be concluded that there is a phenomenon that occurs in the Procurement Section of PT XYZ in the form of risks related to the procurement process for mining services. To avoid the adverse effects of these risks, PT XYZ needs to mitigate the risks in the Procurement Section.

The selection of risk assessment method needs to consider several things such as suitability to the situation or organization to be assessed, can increase understanding of the nature of risk and how to prevent it, can be used in a traceable, repeatable, and verifiable way (ISO 31010, 2009). Risk assessment includes three main processes, namely risk identification, risk analysis, and risk evaluation. There are several risk assessment methods described in ISO 31010, such as Hazard and Operability Studies (HAZOP), Failure Mode and Effect Analysis (FMEA), and Fault Tree Analysis (FTA). Another method was introduced by Pujawan and Geraldin (2009), House of Risk (HOR). The HOR model aims to identify risks and design mitigation strategies to reduce the probability of occurrence of the risk agents by implementing preventive actions to risk agents.

Based on the above background, the problems that will be discussed in this study are the identification of potential risks in the Procurement Section of PT XYZ and its causes, and how to mitigate risks in the Procurement Section of PT XYZ by using the House of Risk (HOR) method.

2. LITERATURE REVIEW

Supply chain is a network of companies that work together to create and deliver a product into the end users. These companies usually include suppliers, manufacturers, distributors, stores or retailers, as well as supporting companies such as logistics service companies. Supply chain is an effort to transform raw materials from producers into products or services needed by consumers. If the supply chain is a physical network, namely companies that are involved in supplying raw materials, producing goods, or sending them to end users, Supply Chain Management (SCM) is a method, tool, or management approach. The main activities included in the SCM classification are (i) Product development activities, (ii) Procurement, purchasing, or supply activities, (iii) Production and inventory planning activities (planning and control), (iv) Production planning activities (production), (v) Delivery/distribution activities, and (vi) Product/goods return management activities (Pujawan and Mahendrawati, 2017)

According to Guo in Oliveira et al (2017), the supply chain involves many areas and participants, including various networks, making the supply chain vulnerable to the uncertain influence of endogenous and exogenous factors from all involved in the chain. This can affect the business activities of a company, so planning is needed to avoid breaking the chain. Supply chain risk can be broadly defined as exposure to an event that causes disruption, which affects supply chain management. These risks can be classified as quantitative or qualitative. Quantitative risks include inventory shortages, overstocks, obsolescence and insufficient availability of components and materials. Qualitative risks include lack of precision or reliability of components and materials in the supply chain (Oliveira et al, 2017).

Sources of risk can be divided into supply risk, operation risk, demand risk, information security risk, macroeconomic risk, political risk, competition risk, and resource risk. The first four (supply, operations, demand and information security) are specifically related to the supply chain, as they can disrupt supply and/or distribution operations (Manuj and Mentzer in Oliveira et al, 2017). According to Baz and Ruel (2021), Supply Chain Risk Management (SCRM) practices can be conceptualized as capabilities/resources that are learned, disseminated, shared, and developed by the company. The purpose of SCRM is to improve company performance, by maintaining supply chain robustness and increasing supply chain resilience. The same thing was also stated by Pujawan and Geraldin (2009) that the overall goal of SCRM is to increase supply chain resilience.

Oliveira et al (2017) summarize the SCRM model from several previous researchers for the purpose of managing risk in the supply chain, by reducing vulnerabilities and ensuring the continuity of supply chain functions. The model basically consists of i) risk identification; ii) risk

evaluation; iii) proposed strategies for accepting, transferring, reducing or mitigating risks; and iv) risk monitoring.

Based on the description above, it can be concluded that procurement is one of the main activities of SCM. The procurement of mining services for PT XYZ can thus be considered as a main activity of SCM. The risk associated with the procurement process can be analyzed under the SCRM framework.

House of Risk (HOR) is a SCRM model developed by Pujawan and Geraldin (2009). HoR integrates the Failure Mode and Effect Analysis (FMEA) model with the House of Quality (HOQ) model. FMEA is a systematic and structured method for identifying failure modes of a system and assessing the effects or consequences of those failure modes (Juran, 1999). The purpose of FMEA is to provide a systematic approach to identify priority risk prevention that should be prioritized to reduce the risk of failure (Christopher, 2005). The HOR model aims to identify risks and design mitigation strategies to reduce the probability of occurrence of risk agents by providing preventive actions to risk agents. The risk agent is the causative factor that drives the risk event. One risk agent can cause more than one risk event. Reducing the occurrence of risk agents will usually prevent some risks from occurring so it is necessary to identify the relationship between risk agents and risk events.

The HOR model determines the selection of risk agent that will be given priority for prevention based on the Aggregate Risk Potential (ARP) value. The ARP value is calculated from the severity level of the risk event, the probability or occurrence of the risk agent, and the level of correlation between the risk agent and the risk event. HOR has two phases, namely the risk identification phase (HOR1) and the risk mitigation phase (HOR2).

3. METHODS

HOR1 aims to determine which risk agent will be prioritized for risk prevention measures. The HOR1 steps are described as follows:

1) Identify risk events that can occur in each business process. In order to identify risk events as a whole, it is necessary to identify existing business processes. Identification of business processes can be done using the SCOR (Supply Chain Operation Reference) model that include five main processes namely plan, source, make, deliver, and return.
2) Assess the severity of the impact caused by the risk event. The scale used is 1-10 where 10 represents a very severe or catastrophic impact.
3) Identify risk agents and assess the likelihood of occurrence of each risk agent. The scale used is 1-10 where 1 means it almost never happens and 10 means it almost certainly happens.
4) Define the correlation between risk agents and risk events. The values are 0, 1, 3, or 9, where 0 means no correlation and 1, 3, and 9 represent low, medium, and high correlation, respectively.
5) Calculating Aggregate Risk Potential, ARP_j, from risk agent with Equation 1 as follows:

$$ARPj = O_j \sum_i S_i R_{ij} \qquad \text{(Equation 1)}$$

Where:
O_j : likelihood of occurrence of the risk agents j
S_i : severity of the risk events i
R_{ij} : correlation between risk agents j and risk events i

6) Ranking the risk agents based on the *ARPj* value from the largest A*RPj* value to the smallest.

HOR2 aims to determine the priority of preventive actions that are considered effective and not too difficult to do to reduce the likelihood of occurrence of the risk agents. The HOR2 steps are described as follows:

1) Select the risk agents with a high priority rating to be analyzed in HOR2. This priority selection can be done using Pareto's law. Pareto's law states that in a population that contributes to a general effect, relatively few causes account for most of the effect (Juran and Godfrey, 1999), or also known as the 80/20 principle, i.e., 80% of the effects are due to 20% of the causes.
2) Identify actions that are considered relevant to prevent the occurrence of risk agents. One risk agent can be handled by more than one action and one action simultaneously can reduce the possibility of more than one risk agent occurring.
3) Determine the correlation between preventive actions and risk agents. The values are 0, 1, 3, or 9, where 0 means no correlation and 1, 3, and 9 represent low, medium, and high correlations, respectively. This correlation is considered as the level of effectiveness of action *k* in reducing the possibility of occurrence of risk agents *j*.
4) Calculating the total effectiveness of each preventive action, TE_k, with Equation 2 as follows:

$$TE_k = \sum_j ARP_j E_{jk} \qquad \text{(Equation 2)}$$

Where:
ARP_j : Aggregate Risk Potential of the shortlisted risk agents *j*
E_{jk} : correlation between preventive actions *k* with risk agents *j*

5) Define the difficulty to implement the preventive actions. The scale is 3, 4, and 5 where 3 means low (easy), 4 means moderate, and 5 means high (difficult). This level of difficulty indicates the cost or effort required to take preventive action (Pujawan and Geraldin, 2009).
6) Calculating the ratio of the total effectiveness to the difficulty to implement preventive action, ETD_k, with Equation 3 as follows:

$$ETD_k = \frac{TE_k}{D_k} \qquad \text{(Equation 3)}$$

Where:
TEk : total effectiveness of preventive action *k*
Dk : difficulty) to implement preventive action *k*

7) Assign a priority rating for each action, R_k, where a rating of 1 is given to the action with the highest *ETD*k.

Data collection was done through a Focus Group Discussion (FGD) involving key persons related to the procurement of mining services. The participants are manager procurement (1 person), supervisor procurement (2 persons), and procurement analyst (2 persons) of PT XYZ. Prior to the FGS, a preliminary list of business process, risk events, risk agents, and preventive actions were distributed to the participants.

4. RESULTS

From the FGD, it was confirmed by the participants the business process of PT XYZ mining services procurement process. Business process identification refer to SCOR model, for PT XYZ context, only one process applicable namely source (procurement). The preliminary list

was discussed on the FGD and in conclusion it was defined the business process as per Table 1 in the Appendices.

Table 1 also indicates the list of identified risk events associated with each business process and its severity. To identify the risk events, the main discussion was focused on what can go wrong in each sub-process and how severe the impact will be. There are 21 identified risk events with severity ranging from four to eight.

The next step was to identify the risk agents. Table 2 also indicates the list of identified risk agents that potentially causes the risk events its likelihood of occurrence. To identify the risk events, the main discussion was focused on what can trigger the occurrence of the risk events. There are 25 identified risk agents with occurrence ranging from one to nine.

After getting the risk events and risk agent, then defined the correlation between risk agents and risk events. The correlation indicate scenario of what risk events will happen if a risk agent occurs. One risk agent may cause more than one risk events, and vise versa. The correlation scale is used as input to HOR1 analysis. Using HOR1 procedure, the ARP' was calculated using Equation 1 with the input of three parameter namely the severity of the risk events, occurrence of the risk agents, and correlation between risk agents and risk events. The calculation resulted *ARP*j of each risk agents as shown in Table 3.

Arranging the ARP_j into pareto diagram visually indicate the ranking and cumulative ARP_j of the risk agents (Figure 1). Figure 1 presents the results of the HOR1 analysis that thirteen of the twenty-five risk agents have a cumulative ARP_j value of 79.54% (rounded to 80%). The thirteen risk agents are presented in Table 4. The thirteen selected risk agents will then be entered into HOR2 to determine the appropriate risk mitigation.

The analysis continued to identify the preventive actions to mitigate the selected risk agents. The same approach was done through FGD to identify the appropriate preventive actions, correlation with selected risk agents, and difficulty to implement the preventive actions. Using the procedure of HOR2, TE_k was calculated using Equation 2 from two parameters namely ARP_j of the selected risk agents and correlation between preventive actions and selected risk agents. TEk then divided by difficulty (Equation 3) to obtain the total effectiveness to difficulty ratio, ETD_k, of the preventive actions. The value if TE_k, D_k, and ETD_k is shown on Table 5.

Arranging the ETD_k into pareto diagram visually indicate the ranking and cumulative ETD_k of the preventive actions (Figure 2). Figure 2 presents the results of the HOR2 analysis that eight of the fourteen preventive actions have a cumulative ETD_k value of 82.04%. The eight preventive actions are presented in Table 6. The eight selected preventive action is the output of HOR2 that shall be prioritized to mitigate the risk.

The eight preventive action can be grouped into three main strategies namely Collaboration, Partnership, and Planning (Table 7). Collaboration includes the preventive actions of Routine and intense coordination with user, Leverage procurement analyst workload, and Assign procurement analyst to user department to understand the business process. Partnership includes the preventive actions of Consolidate similar works into one contract, and better collaboration with contractor. Planning includes the preventive actions of develop procurement plan earlier and create SoW to be easy to understand.

6. CONCLUSIONS

The study reveals that from twenty-one identified risk events in Procurement Section of PT XYZ, there are thirteen risk agents potentially cause the risk event with ARPj of 79.54%. they are (1) Scope and specification are not clear (2) Lack of ownership of the user to speed up the CR, (3) Workload of procurement is too high, (4) Limited budget, (5) Procurement analyst does not have

enough time to understand the scope of work, (6) CMT missed to consider some cost component in the owner estimate, (7) Dependence to one contractor, (8) CR approval is too long, (9) Procurement Analyst less autonomy in defining the negotiation target, (10) User does not understand well the procurement process, (11) Too many contracts handled by one user, (12) Proposal clarification take long time, and (13) PM replacement in user side.

The further analysis or HOR resulting eight of fourteen identified preventive action has cumulative ETD_k of 82.04%. They are (1) Routine and intense coordination with user, (2) Develop procurement plan earlier, (3) Create SoW to be easy to understand, (4) Better collaboration with contractor, (5) Leverage procurement analyst workload, (6) Assign procurement analyst to user department to understand the business process, (7) Create longer contract duration (3-5 years), and (8) Consolidate similar works into one contract.

The implementation of three strategies implies a managerial implication. Collaboration, Partnership, and Planning strategies need commitment from all stakeholders to implement and meet the agreed plan. It also need support from management in term of resources and budget allocation.

REFERENCES

Badan Pusat Statistik (2022), *"Statistik Indonesia 2022",* Badan Pusat Statistik, Jakarta.

Badan Pusat Statistik (2021), *"Statistik Pertambangan Non Minyak dan Gas Bumi 2015-2020",* Badan Pusat Statistik, Jakarta.

Baz, J.E. dan Ruel, S. (2021), "Can Supply Chain Risk Management Practices Mitigate the Disruption Impacts on Supply Chains' Resilience and Robustness? Evidence From an Empirical Survey in A COVID-19 Outbreak Era", *International Journal of Production Economics 233, Elsevier,* 107972.

Juran, J.M and Godfrey, A.B. (1999), *Juran's Quality Handbook*, 5th Edition, McGraw-Hill, New York.

Oliveira, U.R.de, Marin, F.A.S., Rocha, H.M., dan Salomon, V.A.P. (2017), "Review the ISO 31000 standard in supply chain risk management", *Journal of Cleaner Production 151, Elsevier.* hal. 616-633.

Pujawan, I. N., Geraldin, L. H. (2009), "House of Risk: a Model for Proactive Supply Chain Risk Management", *Journal of Business Process Manajement,* Vol. 15 No. 6, hal. 953-967.

Pujawan, I.N dan Mahendrawati (2017), *Supply Chain Management*, Edisi 3. Penerbit Andi, Yogyakarta.

Utari, R. (2015), *Perancangan Strategi Mitigasi Resiko Supply Chain di PT Atlas Copco Nusantara Dengan Metoda House of Risk,* Tesis Magister, Institut Teknologi Sepuluh Nopember, Surabaya.

Vale (2021a), *PNR-00078 Business Risk Management, Rev. 02*. Vale, Rio de Janeiro.

Vale (2021), *POL-0009-G Risk Management Policy, Rev. 06*. Vale, Rio de Janeiro.

APPENDICES

Tables:

Table 1. Business Process, Risk Events, and Severity

No.	Major Process	Sub-processes	Risk Events (Ei)	Code	S_i
1	Source: Procurement of mining services	Contract Requisition (CR)	Delay in receiving CR	E1	7
			CR approval is too long	E2	5
		Tender strategy	Tender strategy is not suitable	E3	7
		Bidder List	Process is not competitive	E4	8
		Bidder qualification	Invited contract does match with the requirement	E5	8
		Baseline	Baseline is too high	E6	5
		RFP issuance	Delay in sending the RFP	E7	5
		Pre-bid Meeting and site visit	Tender explanation is not clear	E8	7
		Q&A of the tender	Q&A take too long time	E9	4
		Proposal receiving	Received proposal is less than 3	E10	6
		Safety evaluation	Delay in conducting safety evaluation	E11	4
		Technical evaluation	Delay in conducting technical evaluation	E12	5
			Too many changes in the tender scope	E13	6
			Technical evaluation approval is too long	E14	5
		Commercial evaluation	Delay in conducting commercial evaluation	E15	5
		Negotiation	Negotiation saving does not meet the target	E16	5
		Procurement Award Report (PAR)	PAR approval is too long	E17	5
		Contract signing	Contract signing is too long	E18	5
		Create contract in ERP (SAP)	Approval in SAP is too long	E19	5
		Contract handover	User does not understand the contract	E20	7
		Contract change	Misunderstanding regarding the contract	E21	6

Table 2. Risk Agents, and Occurrence

No.	Risk Agents	Code	O_j
1	Contractor capacity is not adequate	A1	2
2	Price reference is not accurate	A2	2
3	Urgent CR from users	A3	7
4	Scope and specification are not clear	A4	6
5	Dependence to one contractor	A5	7
6	Exchange rate fluctuation	A6	4
7	Proposal clarification take long time	A7	4
8	Natural disaster	A8	1
9	Bankruptcy of the contractor	A9	2
10	IT problem occur	A10	4
11	User does not understand well the procurement process	A11	5
12	Lack of ownership of the user to speed up the CR	A12	8
13	Workload of procurement is too high	A13	7
14	Procurement analyst does not have enough time to understand the scope of work	A14	9
15	CR approval is too long	A15	6
16	Procurement Analyst less autonomy in defining the negotiation target	A16	6
17	Less reference of market price	A17	4
18	Technical team has less reference in doing the technical evaluation	A18	4
19	Bidder list approval is too long	A19	3
20	Limited budget	A20	8
21	PM replacement in user side	A21	4
22	Too many contracts handled by one user	A22	4
23	New assigned user has limited knowledge to handle the contract	A23	3

No.	Risk Agents	Code	O_j
24	Lead time and sourcing time KPI become more difficult from year to year (2022: 42 days, 2021: 55 days, 2020: 65 days)	A24	9
25	*Contract Management Team* (CMT) missed to consider some cost component in the owner estimate	A25	9

Table 3. Aggregate Risk Potential *(ARPj)* of the Risk Agents

No.	Code	Risk Agents	ARP_j
1	A1	Contractor capacity is not adequate	202
2	A2	Price reference is not accurate	180
3	A3	Urgent CR from users	469
4	A4	Scope and specification are not clear	2118
5	A5	Dependence to one contractor	1036
6	A6	Exchange rate fluctuation	252
7	A7	Proposal clarification take long time	864
8	A8	Natural disaster	109
9	A9	Bankruptcy of the contractor	92
10	A10	IT problem occur	680
11	A11	User does not understand well the procurement process	920
12	A12	Lack of ownership of the user to speed up the CR	1488
13	A13	Workload of procurement is too high	1477
14	A14	Procurement analyst does not have enough time to understand the scope of work	1251
15	A15	CR approval is too long	960
16	A16	Procurement Analyst less autonomy in defining the negotiation target	960
17	A17	Less reference of market price	364
18	A18	Technical team has less reference in doing the technical evaluation	704
19	A19	Bidder list approval is too long	231
20	A20	Limited budget	1256
21	A21	PM replacement in user side	756
22	A22	Too many contracts handled by one user	868
23	A23	New assigned user has limited knowledge to handle the contract	336
24	A24	Lead time and sourcing time KPI become more difficult from year to year (2022: 42 days, 2021: 55 days, 2020: 65 days)	270
25	A25	Contract Management Team (CMT) missed to consider some cost component in the owner estimate	1161

Table 4. Shortlisted Risk Agents

No.	Code	Risk Agents	ARPj
1	A4	Scope and specification are not clear	2118
2	A12	Lack of ownership of the user to speed up the CR	1488
3	A13	Workload of procurement is too high	1477
4	A20	Limited budget	1256
5	A14	Procurement analyst does not have enough time to understand the scope of work	1251
6	A25	CMT missed to consider some cost component in the owner estimate	1161
7	A5	Dependence to one contractor	1036
8	A15	CR approval is too long	960
9	A16	Procurement Analyst less autonomy in defining the negotiation target	960
10	A11	User does not understand well the procurement process	920
11	A22	Too many contracts handled by one user	868
12	A7	Proposal clarification take long time	864
13	A21	PM replacement in user side	756

Table 5. Preventive Actions, TE_k, D_k, and ETD_k

No.	Preventive Actions	Code	TE_k	D_k	ETD_k
1	Routine and intense coordination with user	PA1	73829	4	18457,3
2	Better collaboration with contractor	PA2	21869	4	5467,3
3	Better implementation of the SOP, apply reward and punishment	PA3	14360	4	3590,0
4	Develop procurement plan earlier	PA4	28081	3	9360,3
5	Empower the employee to work multitasking	PA5	10764	4	2691,0
6	Create longer contract duration (3-5 years)	PA6	20474	4	5118,5
7	Simplify tender proposal	PA7	13854	4	3463,5
8	Provide training to contractor	PA8	7818	5	1563,6
9	Assign procurement analyst to user department to understand the business process	PA9	20928	4	5232,0
10	Create SoW to be easy to understand	PA10	32058	4	8014,5
11	Obtain mor market price reference (market intelligence)	PA11	7412	5	1482,4
12	Asses financial capability of the contractor prior to tender	PA12	3972	5	794,4
13	Consolidate similar works into one contract	PA13	20100	4	5025,0
14	Leverage procurement analyst workload	PA14	16173	3	5391,0

Table 6. Shortlisted Preventive Actions

No.	Code	Preventive Actions	ETD_k
1	PA1	Routine and intense coordination with user	18,457.25
2	PA4	Develop procurement plan earlier	9,360.33
3	PA10	Create SoW to be easy to understand	8,014.50
4	PA2	Better collaboration with contractor	5,467.25
5	PA14	Leverage procurement analyst workload	5,391.00
6	PA9	Assign procurement analyst to user department to understand the business process	5,232.00
7	PA6	Create longer contract duration (3-5 years)	5,118.50
8	PA13	Consolidate similar works into one contract	5,025.00

Table 7. Mitigation Strategy

No.	Strategy	Code	Preventive Action
1	Collaboration	PA1	Routine and intense coordination with user
		PA14	Leverage procurement analyst workload
		PA9	Assign procurement analyst to user department to understand the business process
		PA13	Consolidate similar works into one contract
2	Partnership	PA2	Better collaboration with contractor
		PA6	Create longer contract duration (3-5 years)
3	Planning	PA4	Develop procurement plan earlier
		PA10	Create SoW to be easy to understand

Figures:

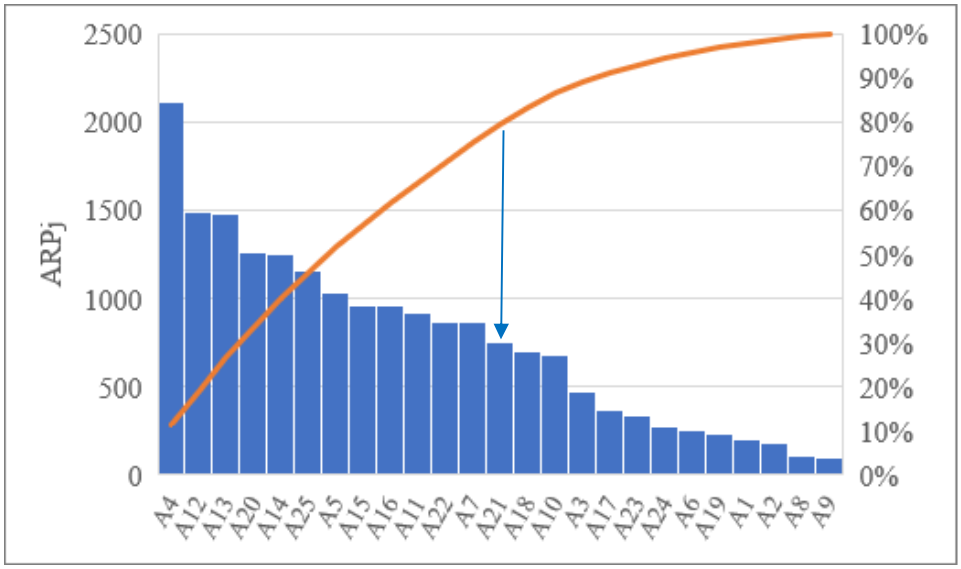


Figure 1. Pareto Diagram of ARP_j

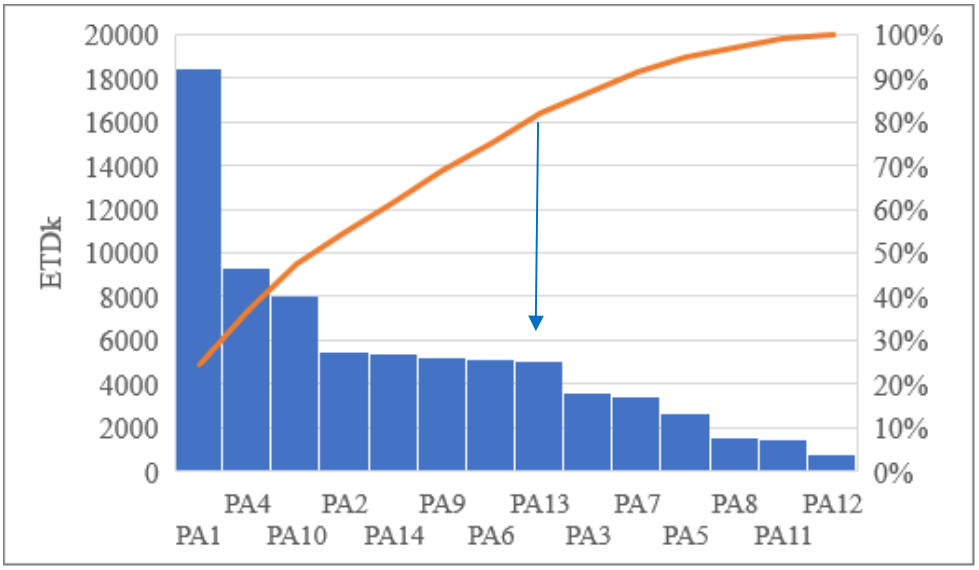


Figure 2. Pareto Diagram of ETD_k

PREDICTIVE ANALYTICS MODEL DEVELOPMENT TO EVALUATE MAINTAINABILITY OF OPEN SOURCE PROJECT IN GITHUB

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ABSTRACT

The development of software projects nowadays cannot be separated from open-source libraries or products. There are millions of open-source products with specific functionality that can be used when developing software. But choosing a good open-source product that has good maintainability is not an easy task. Github is one of the git-based open-source repositories and currently stores more than 46 million open-source projects. Lots of Github's repository features can be analyzed the repository quality. But manually assessing a repository's quality by analyzing its features needs skills and experience. Previous research used the Random Forest method to automatically assess the level of maintainability of a Github repository. This study will use more features from the repository and then compare the Random Forest and Extreme Gradient Boosting methods in assessing Github's repository maintainability. The result has shown that XGBoost model has a highest accuracy (89.03%) by a tiny margin compared to the Random Forest model (88.38%). Thus, both models are generally very good in assessing open-source project's maintainability.

Keywords: maintainability, software, Github, open-source, machine learning.

1. INTRODUCTION

The current software development process is inseparable from the use of open-source software. In a survey by Synapsys, more than 90% of software projects in various sectors use open-source technology (Synopsys, 2021). These open-source technologies range from operating systems such as Linux, database technologies such as PostgreSQL, tools to assist development such as Jenkins for build automation and Jest for testing, to libraries or frameworks such as Svelte. Open source can be interpreted as something that can be accessed by the public and changed as needed (Dahlander & Magnusson, 2005). In software terms, open source refers to software whose code is publicly accessible and can be altered or improved as needed. For example, a contributor can access and improve open-source software by adding new features or fixing features that do not work correctly (Altenhöner, 2005).

The rose of open-source usage is associated with the existence of code-sharing platforms. Github is one of them; by far, it has been the largest, with more than 46 million public repositories (Github, 2022). Github allows software developers to collaborate on the development of open-source projects by accessing, forking, and modifying code in the developer's local environment, then submitting pull requests to be reviewed by other contributors (Jiang et al., 2017). All these processes are made available because of git technology (Kalliamvakou et al., 2015; Vasilescu et al., 2015). Apart from code contribution, a contributor can also help by creating issues and responding to them,

reviewing pull requests, and adding and modifying documentation or other files outside the project's code file.

Due to the nature of open-source projects that rely on voluntary contributions, there is a risk of low maintenance activity, which can even lead to an unmaintained or abandoned project (Coelho et al., 2020). Github does not provide instruments or functions to determine whether a project is still actively developed. However, chronological data and elements from a repository can be used to determine the development activity. These chronological data from a repository includes commits, pull requests, issues, and releases. At the same time, the non-chronological elements that can be used to evaluate maintainability include the number of stars, the number of forks, the number of sponsors, and the number of watchers.

The selection of the proper library or technology to be used in software development is critical in ensuring good software quality. One of the characteristics of good software quality is the software lifetime in the context of the easiness of maintenance (Tamai & Torimitsu, 1992). In other words, an excellent open-source library has an acceptable level of maintainability (Perez-Riverol et al., 2016). Libraries with poor maintainability can cause the quality of the developed software to decline and become hard to maintain.

In 2013, Jymit Khondhu researched the factors that could affect the open-source project's maintainability on Sourceforge. The outcome of this research is an analysis of factors based on repository features at Sourceforge, which potentially cause maintainability problems. Developers can consider these factors to decide whether to use open-source software (Khondhu et al., 2013). Jailton Coelho then used the results of Khondhu's research to predict the maintainability level of software projects on Github. Coelho used the Random Forest method to create a model that predicts whether a repository is still actively developed (Coelho et al., 2020).

This study will use more elements from the open-source project repository on Github. The classification techniques used in this research are Random Forest and Extreme Gradient Boosting. The resulting models will be compared to determine the best model with the highest accuracy to predict the maintainability status of open-source projects on Github.

2. LITERATURE REVIEW

2.1 Software Maintainability

McCall formulated one of the classic references that define the determinants of software quality in 1977. 11 factors can be used to assess software quality, one of which is maintainability. McCall describes maintainability as the ease of identifying errors and correcting and verifying improvements (McCall et al., 1977). This description has evolved along with the development of the software.

One of the most recent descriptions of maintainability is the ease with which a software system or a software component can be modified, repaired, improved performance or other attributes, and the ability to adapt to environmental changes (C. Chen et al., 2017). According to the Consortium for Information and Software Quality, maintainability incorporates the concepts of changeability, modularity, understandability, testability, and reusability. Meanwhile, based on ISO/IEC 25010:2011, maintainability has sub-characteristics of modularity, analyzability, modifiability, reusability, and testability.

The maintainability level of open-source libraries closely affects the software's maintainability level. Let us take an example of the Android application development. The selected open-source library must have an acceptable level of maintainability so that when Google releases the latest Android version, application developers can easily update the library version without any changes to the application code. Suppose the maintainability level of the library is poor or even not

maintained by the contributors. In that case, it will pose a risk of having to make significant changes to the application code. In the worst case, developers must find a new library or alternative libraries and modify hundreds of lines of code that use the old ones.

2.2 Github

Github is a repository service for git-based version control. Git is a version control that monitors file changes and has been used by programmers to coordinate individual and teamwork software work. Git was first developed and introduced by Linus Torvalds, also the Linux operating system developer. Github allows git users to collaborate faster than by creating their own hosted repository.

In a simple contribution flow, contributors will fork the main repository. Then they can modify the contents of files in the repository and then send a pull request. Other contributors will then review this pull request. Other contributors can leave comments, change the code in the pull request and reject or accept the pull request to be merged to the main repository. Sometimes a repository has special rules such as who has access to modify files to the main branch, pull request format and descriptions, issues format and descriptions, commit messages format, and so on. These rules will be embedded in the repository's documentation, and contributors must follow them.

2.3 Previous Studies

Table 1. Previous studies

	Research Title	**Methods**	**Author(s)**
1	Is This Github Project Maintained? Measuring The Level of Maintenance Activity of Open-Source Projects	Random Forest	Jailton Coelho, Marco Tulio Valente, Luciano Milen, Luciana L. Silva (2020)
	The authors developed a model based on the Random Forest method to assess the maintainability of open-source software on Github. The resulting model has an accuracy of 92% by assessing the historical elements of the repository for two years and collecting chronological data in 3 months range.		
2	Open-Source Software in the Classroom: Empowering Students to Self-Select Projects to Contribute	Features matrix of Github repositories.	Juanan Pereira dan Óscar Díaz (2022)
	The authors developed an application called GitMate that can discover similar repositories to the one the student chose. The result has shown that 80% of the students change their choice after using GitMate. In conclusion, GitMate helps students to discover Github repositories with better quality.		

3	Predicting long-time contributors for GitHub projects using machine learning	Naive bayes, k-Nearest Neighbors (kNN), Logistic Regression, Decision Tree, Random Forest	Vijaya Kumar Eluri, Thomas A. Mazzuchi, Shahram Sarkani (2021)
	Minimum or no contribution has been one of the risks of an open-source project. This research used machine learning methods to predict the number of contributors who will become longtime contributors. The outcome is expected to help developers in choosing the right open-source project.		
4	Toward Using Package Centrality Trend to Identify Packages in Decline	Dependency analysis on Javascript packages in node package manager.	Suhaib Mujahid, Diego Elias Costa, Rabe Abdalkareem, Emad Shihab, Mohamed Aymen Saied, dan Bram Adams (2021)
	The authors used dependency analysis, which analyzes the number of other packages dependent on the analyzed package. This analysis was utilized to determine the usage trend. The authors also utilized the least square regression method to produce a model with an 87% accuracy rate in predicting usage.		
6	Predicting Health Indicators for Open-Source Projects (using Hyperparameter Optimization)	k-Nearest Neighbors (kNN), Support Vector Regression, Random Forest, Linear Regression, Regression Tree and error rate reduction using hyperparameter	Tianpei Xia, Wei Fu, Rui Shu, Rishabh Agrawal, Tim Menzies (2020)
	Much research has been done to determine the health of a software project. Unfortunately, most of the produced models had a high error rate. Hyperparameter optimization was studied in this research to help reduce this error rate. In this research, the authors proved that using hyperparameters reduced the error rates in all previous models.		

3. METHODS

This study uses a quantitative approach emphasizing numerical data processing and statistical analysis. The data needed in this study is numerical, so data conversion is not needed. This data will then be processed using Random Forest and XGBoost. The models from these methods are then compared, and the best model with the highest accuracy is selected.

3.1 Research Flow

After collecting and analyzing previous studies, problem identification, research objectives, and methodology, we begin collecting data to be used as input. For this research, 516 repositories from various programming languages will be used as input. The repository elements are collected

using GraphQL API provided by Github. To make the data split more straightforward and balanced, we pick the same quantity of unmaintained and maintained repositories.

Next, the data preprocessing is started. This preprocessing includes replacing NaN values with zero, change the status to numerical category and splitting the data for training and testing. We used 70:30 for the split ratio. As stated before, we did not apply any balancing method as we already have balanced input. Then we began the model training. Changing the status values to numerical was necessary especially for XGBoost, because the python library was unable to automatically convert string or text category to numerical one. In this conversion the maintained status was converted to 1, and the unmaintained status was converted to 0.

The model training for Random Forest and XGBoost was done simultaneously. The model validation for the resulting models was also done in parallel. After we had the accuracy data, we picked the model with the highest accuracy and wrote the conclusion of this research.

3.2 Data Features

There are 18 features used for this study. Status is the only feature used as a dependent feature, while the other 17 are independent features. The project's status was determined by reading the project README file or project's tag or exploring the project's issues. These 18 features are described in Table 2.

Table 2. Data features

No	Feature	Description
1	status	Maintained/unmaintained status
2	total_commit_in_24m	Number of commits in 24 months
3	total_star	Total number of stars
4	total_contributor	Total number of collaborators
5	total_opened_issue	Total number of open issues
6	total_closed_issues	Total number of closed issues
7	avg_time_open_issue	Average time of open issue in 24 months, since creation until today
8	avg_time_closed_issue	Average time of closed issue in 24 months, since creation until closed
9	total_open_pr	Total number of open pull requests in 24 months
10	total_closed_pr	Total number of closed pull requests in 24 months
11	avg_time_to_close_pr	Average time of closed pull requests in 24 months, since creation until closed
12	avg_time_to_open_pr	Average time of open pull requests in 24 months, since creation until today
13	merged_pr	Total number of merged pull requests in 24 months
14	avg_time_to_merge_pr	Average time of merged pull requests in 24 months, since creation until merged
15	total_watchers	Total number of repository's watchers
16	total_releases	Total number of releases
17	total_forks	Total number of forks
18	max_contributions	Maximum contributions from all of contributors

4. RESULTS

We obtained chronological data over a range of 24 months. All 516 data were selected manually, and the status was determined by checking the information on the repository's main page, maintained or unmaintained tag, and issues. These tags include unmaintained, obsolete, deprecated, do not use, and abandoned. The maintained repositories were selected from the package manager, NPM for javascript and typescript packages, and Rubygems for ruby libraries. We sorted the libraries by popularity and dependencies. 51% of 516 data are unmaintained repositories, and the rest are maintained repositories. Therefore, the data is already balanced.

After the model training processes were finished, the model validation processes began. The result can be seen in Table 3, the confusion matrices can be seen in Figure 1 and the ROC for both models can been in Figure 2. The feature importance for both Random Forest and XGBoost can be seen in Figure 3.

Table 3. Model validation results

Methods	Accuracy	Precision	Recall
Random Forest	0.8838	0.9054	0.8589
XGBoost	0.8903	0.8961	0.8846

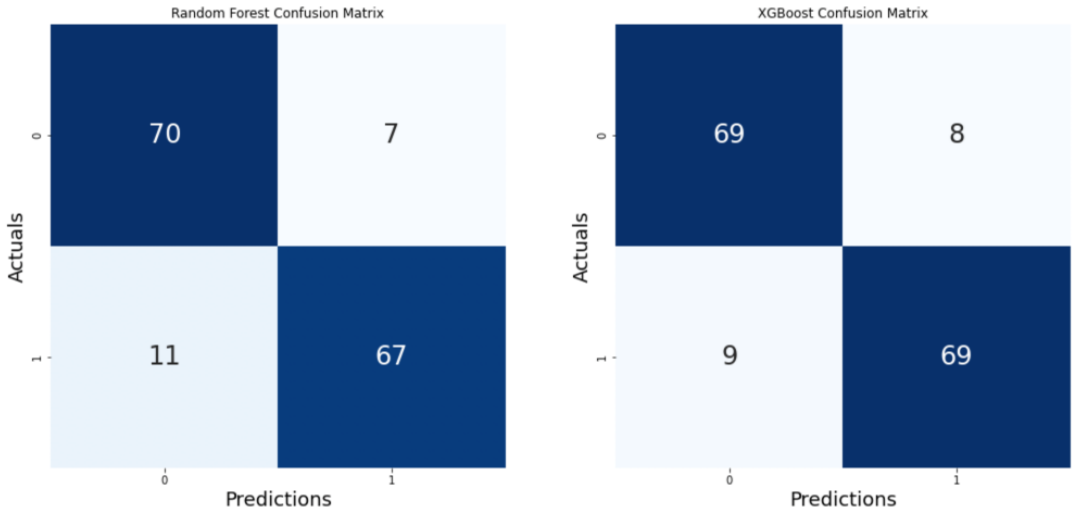


Figure 1. Model confusion matrices

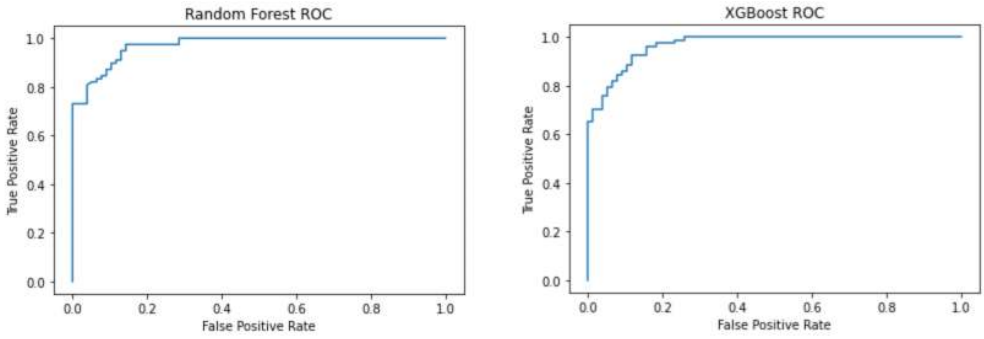


Figure 2. Model ROC curves

Random Forest

variable	importance
total_closed_issues	0.202092
total_commit_in_24_months	0.150158
total_merged_pr	0.128186
total_contributors	0.112293
total_stars	0.091328

XGBoost

variable	importance
total_closed_issues	0.630907
total_commit_in_24_months	0.055929
total_merged_pr	0.043889
average_closed_pr	0.034654
total_contributors	0.032600

Figure 3. Model feature importances

6. CONCLUSIONS

Even though the XGBoost model produced higher accuracy than the Random Forest model, it only leads by a tiny margin. This means that both models are pretty good at predicting the maintainability level of a Github project.

As for the feature importance that can be seen in Figure 3, top three of the most importance features for both models are the same, they are total_closed_issues, total_commit_in_24_months and total_merged_pr. The other features are varied in the order. Using this feature importance data, we can also conclude that developers should look for these three elements when they want to manually assess the maintainability of an open-source project in Github.

Although the data collection and input are different from the previous study, our data collection approach can be interpreted as a different perspective for collecting chronological elements of a Github project. Further research could use a larger or smaller range of time to analyze the project as this research and the previous are collecting data within 24 months. Moreover, this study uses almost the default settings, hyperparameter tuning can be used in further study to find the best configuration so the model can achieve higher accuracy. Further study could also collect more data and gather data from other repositories like Gitlab and Bitbucket.

We also hope that in the future study, authors can create an app or a browser extension that utilizes the generated model, making it easier for software developers to view the maintenance status when exploring Github repositories.

REFERENCES

Altenhöner, R. (2005). Open-Source Software—Definition, licensing models and organizational consequences (introduction). 71, 6.

Breiman, L. (2001). Random Forests. Machine Learning, 45(1), 5–32.

Chen, C., Alfayez, R., Srisopha, K., Boehm, B., & Shi, L. (2017). Why Is It Important to Measure Maintainability and What Are the Best Ways to Do It? 2017 IEEE/ACM 39th International Conference on Software Engineering Companion (ICSE-C), 377–378.

Chen, T., & Guestrin, C. (2016). XGBoost: A Scalable Tree Boosting System. *Proceedings of the 22nd ACM SIGKDD International Conference on Knowledge Discovery and Data Mining*, 785–794.

Coelho, J., Valente, M. T., Milen, L., & Silva, L. L. (2020). Is this GitHub project maintained? Measuring the level of maintenance activity of open-source projects. *Information and Software Technology*, 122.

Cristianini, N., & Shawe-Taylor, J. (2000). An Introduction to Support Vector Machines and Other Kernel-based Learning Methods. *Cambridge University Press*.

Dahlander, L., & Magnusson, M. G. (2005). Relationships between open-source software companies and communities: Observations from Nordic firms. *Research Policy*, 34(4), 481–493.

Dietterich, T. G. (2000). Ensemble Methods in Machine Learning. *Multiple Classifier Systems*, 1–15.

Genuer, R., Poggi, J.-M., & Tuleau, C. (2008). Random Forests: Some methodological insights (arXiv:0811.3619). arXiv. https://doi.org/10.48550/arXiv.0811.3619

Github. (2022). *Google Public Repository Search*.

Goller, C., Löning, J., Will, T., & Wolff, W. (2000). Automatic Document Classification—A thorough Evaluation of various Methods. *ISI*.

Hsu, C.-W., Chang, C.-C., & Lin, C.-J. (2008). A Practical Guide to Support Vector Classication. https://www.semanticscholar.org/paper/A-Practical-Guide-to-Support-Vector-Classication-Hsu-Chang/7abeda3a20c13bfee416d94efa313ff870656fec

Jiang, J., Lo, D., He, J., Xia, X., Kochhar, P. S., & Zhang, L. (2017). Why and how developers fork what from whom in GitHub. *Empirical Software Engineering*, 22(1), 547–578.

Kalliamvakou, E., Damian, D., Blincoe, K., Singer, L., & German, D. M. (2015). Open Source-Style Collaborative Development Practices in Commercial Projects Using GitHub. *2015 IEEE/ACM 37th IEEE International Conference on Software Engineering*, 1, 574–585.

Khondhu, J., Capiluppi, A., & Stol, K. J. (2013). Is it all lost? 9th IFIP WG 2.13 International Conference, OSS 2013. In E. Petrinja, G. Succi G, N. El Ioini, & A. Sillitti (Eds.), *IFIP Advances in Information and Communication Technology* (pp. 61–79). Springer New York LLC.

Kotu, V., & Deshpande, B. (2015). Chapter 8—Model Evaluation. In V. Kotu & B. Deshpande (Eds.), *Predictive Analytics and Data Mining* (pp. 257–273). Morgan Kaufmann.

McCall, J., Richards, P. A., & Walters, G. (1977). Factors in software quality: Concept and definitions of software quality.

Perez-Riverol, Y., Gatto, L., Wang, R., Sachsenberg, T., Uszkoreit, J., Leprevost, F. da V., Fufezan, C., Ternent, T., Eglen, S. J., Katz, D. S., Pollard, T. J., Konovalov, A., Flight, R. M., Blin, K., & Vizcaíno, J. A. (2016). Ten Simple Rules for Taking Advantage of Git and GitHub. *PLOS Computational Biology*, 12(7), e1004947.

Software Maintainability Standard | CISQ - Consortium for Information & Software Quality. (n.d.). Retrieved April 24, 2022, from https://www.it-cisq.org/standards/code-quality-standards/maintainability/index.htm

Synopsys. (2021, April 13). 2021 OSSRA report on the state of open source in commercial software. Software Integrity Blog. https://www.synopsys.com/blogs/software-security/open-source-trends-ossra-report/

Tamai, T., & Torimitsu, Y. (1992). Software lifetime and its evolution process over generations. *Proceedings Conference on Software Maintenance* 1992, 63–69.

Vasilescu, B., Yu, Y., Wang, H., Devanbu, P., & Filkov, V. (2015). Quality and productivity outcomes relating to continuous integration in GitHub. *Proceedings of the 2015 10th Joint Meeting on Foundations of Software Engineering*, 805–816.

Zhou, Z.-H. (2012). Ensemble Methods: Foundations and Algorithms. *CRC Press*.

FACTORS IN DISPUTE HANDLING PROCESS AFFECTING PERFORMANCE IN POWER PLANT PROJECTS

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ABSTRACT

The power plant development project is a national strategic project, but in the implementation of it, there were disputes between project actors. The dispute will affecting the project's net. Fifty-seven percent of project failures are caused by poor communication between project actors. Based on this, it is necessary to conduct research to determine the factors in the dispute resolution process that affect the performance of the power plant development project. This research will be carried out using the SEM-PLS method by analyzing the loading factor of each indicator to find significant indicators that affect project performance. The absence of a defect handling solution in the contract contributed 89% of the total. The most affected for handling dispute is the additional time and cost on the project with contributed up to 92%.

Keywords: Project Management, Dispute Management, Dispute Resolution, etc.

1. INTRODUCTION

There are several reasons why projects fail to be implemented, 57% of the total are poor communication between project elements and conflict for resolution process (Bull Survey, 1998). The opinion differences, conflicts or disputes may occured due to various factors in electricity development projects. Thirty-seven main reasons of dispute found in international construction projects and can be categorized into 4; 1. Owner related, 2. Contractor Related, 3. Contract related and 4. External factor. The 2 most dominant are unfair risk allocation and data errors that provided by owners to contractors. (Juanting Liu, Huiling Li, 2019).



Figure 1.1 The causes of Project Failure Source: Bull Survey, 1998

Conflicts that occur in projects that have become disputes will not only have an impact on the direct costs incurred in resolving disputes, but also have an impact on project delays, reduced quality of work, costs incurred due to delays and also greatly impact on reputation. In general, dispute resolution by negotiation is the best way and minimizes the direct and indirect impacts that will arise (Wenxue Lu, Lihan Zhang, 2015). So it is necessary to analyze in the dispute resolution process what are the factors that can affect Project Performance, so that it can mitigate the handling of conflicts that occur in the project so as not to affect Project Performance. The previous research was carried out by Wenxue Lu, Lihan Zhang, Jing Pan in 2015 with the research title "Identification and analysis of hidden transaction costs in project dispute resolutions". Furthermore, there is a research conducted by Wenxue Lu, Jian Liu in 2013 “Research into the moderating effects of progress and quality performance in project dispute negotiation”, in which the research examines how the most effective method is to minimize the impact of a dispute on progress and quality. work in the project.

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2. LITERATURE REVIEW

2.1. Dispute

The dispute begins with an opinion difference by the parties, it is the lowest level in the conflict, it can be resolved by discussing the existing differences and trying to resolve together. If this of opinion differences cannot be solved, it will enter the level of arguments where the parties who have differences of opinion will form supporting arguments from their respective arguments, at this level the problem begins to warm up and there needs to be a deeper solution can be done by formal negotiation or mediation with preparation and openness to this argument, the problem can be resolved immediately. The third level is a Dispute where there is a fundamental conflict of interest. At this level the differences that have arisen have become increasingly complex and the parties have their own views in order to defend their own interests. In this phase, there needs to be further treatment where mediation is the first alternative that can be done. And if it cannot be resolved, it is necessary to have an award imposed for the resolution of this conflict which can be done through arbitration or litigation. (Eilenberg, I. M. 2003).

In construction projects there are two types of conflict / disputes, Cognitive Conflict and emotional conflict. Cognitive conflict is a conflict related to project and project completion such as differences in project results perception, contract interpretation, work methods, project position and other matters related to construction projects. Emotional Conflict or commonly called affective conflict is related to personal conflicts between individual characters, interpersonal relationships and misunderstandings between individuals. (Guangdong, 2017)

2.2. Factors That Cause Dispute

There are several main areas that cause conflicts in construction projects, regardless of the legal aspects of the disputes submitted and the core of the claims can be categorized in various ways including (Eilenberg, 2003).

- Defective Work

  The contractor performs the work with the result not in accordance with the specified standards or carries the specified tolerance limit.
- Variation or work add

Variation is an additional work that has not previously been listed in the scope of the contract and is instructed by the owner to the contractor to be able to carry out the added work.

- Delays and overtimes
  Quite a few contracts can be started and completed according to the initial planning, the slowness of this work can be caused by many factors such as natural conditions, project management errors, the existence of additional work, contractual conflicts and others.
- Unforeseen project site conditions
  In general, the condition of the project site that appears on the surface will be able to quickly how the conditions and methods such as what should be carried out in the implementation of the project, but the conditions that exist in the soil or other conditions that require special and thorough inspections that have not been known before such as underground water conditions, the presence of large stones are asked, soil conditions and so on.
- Failed to represent the Contract
  Failure to represent a contract in general begins with the content of the contract document that is less detailed, causing confusion from the contractor in defining the contract.
- Fact-Keeping Differences
  Many of the conflicts that occur are related to failures in recording fact data on the ground. Data recording / data documentation that occurs in the field is important in conflict resolution.

2.3. Management Conflict

Many opinions think that conflict is something bad and should be avoided, according to Mary Parker Fallet (1925) effectively conflict management does not consider that conflict is a futile thing, but according to the normal process of socializing which gives rise to differences in perceptions and points of view. There are three methods that are generally used in handling conflicts, domination in this concept will cause victory by one side and one side feels defeated (win-lose situatuin), the second is compromise where both sides give up on the running process (lose - lose situation), and the most important thing is integration where both sides understand each other's interests and re-focus to get a middle ground where both sides overcome defeat and both sides gain an advantage (win-win situation) (Lowe, D., & Leiringer, R. 2006)

2.4. Stages of conflict handling.

In the process of discussing contract changes, it is necessary to have a formal procedure used to obtain agreement between the parties for a change or adjustment to the contract, in general, the settlement of claims in contract adjustments is as follows (Levin, P. 2016):

1. Identifying the Contract: In the initial phase the parties need to identify the contract.
2. Notification: Once a basis is obtained on the contract and a factor is obtained that causes the project not to reach the stipulated constrain, the parties can submit a notification.
3. Systematic and accurate documentation: in submitting this claim, evidence is needed that can strengthen the claim submitted.

4. Evaluation: Based on the final claim submitted along with the evidence and impact of the claim on the contract and the clauses contained in the contract, based on the final claim, the project owner evaluates the claim submitted.
5. Negotiation: The parties have conducted a review of several matters that are the point of claim, at this point the parties have obtained the position or judgment expected by each contractor and owner.
6. Dispute Resolution: In the negotiation process, the parties still have not found an agreement, and have their respective positions that are strong enough, so that the settlement process is completed in the next stage according to what is stated in the contract or mutual agreement in the selection of the Alternative Dispute Resolution (ADR) method

2.5. Alternative Dispute Resolution

Dispute Resolution has the primary emphasis on avoiding disputes, however, there are where the parties have disputes that arise lawfully, and a method is needed to resolve the dispute in order to produce the best conclusions and alternative avenues in dispute resolution (Lowe, D., & Leiringer, R. 2006). In the work contract of the dispute resolution construction project, it prioritizes the principle of deliberation, where all parties to the dispute conduct deliberations to obtain agreement in dispute resolution.
Alternative dispute resolution is carried out referring to the cooperation contract used by the severe parties, or the written agreement agreed by both parties. Alternative dispute resolution that can be done by mediation, conciliation and arbitrate. In addition to these alternative efforts, the parties can form a dispute board formed by all parties on the principle of professionalism and is not part of one party's. (UUJK 2017).

In general, there are three stages in dispute resolution including the following (Lowe, D., & Leiringer, R. 2006):

- Stage 1: Negotiation
- Stage 2: Alternative settlement by non-binding
- Phase 3: Alternative settlement by binding on all parties.

METHOD	COMMON LAW/ STATUTE BASIS	FREQUENCY OF USE	SPEED	COST	CONFIDENTIALITY	BINDING	ADVERSARIAL	SPECIAL FEATURES
Stage 1								
Negotiation	No	Very common ubiquitous	Varies	Low	Yes	No	No	Can continue throughout the dispute
Stage 2								
Mediation	No	Common	Fast	Low	Yes	No (unless agreed)	No	
Conciliation	No	Fairly common	Fast	Low	Yes	No (unless agreed)	No	Often included with mediation
Neutral evaluation	No	Infrequent	Fast	Low	Yes	No	No	
Adjudication	Yes	Common	Fast	Low	Yes	Yes (until completion or Arb/Lit)	Yes	Statutory adjudication is construction specific
Stage 3								
Arbitration	Yes	Common	Contingent	Contingent	Yes	Yes	Yes	
Expert determination	No	Fairly common	Fast	Moderate	Yes	Yes	Yes	
Litigation	Yes	Common	Slow	High	No	Yes	Yes	

Gambar 2 Conflict continuum Source: David Lowe, 2006

3. METHODS.

In this study, several procedures were planned in this study divided into several stages:

1. Literature study for the determination of variables and indicators
   Based on the phenomena described previously, a literature study was conducted to be able to formulate any variables in the dispute resolution process that affect Project Performance, as well as what indicators can be used to measure these variables..
2. Data Colection
   Data was collected using a questionnaire with a Likert scale of 1-5, where 1 strongly disagree to 5 strongly agree, where this questionnaire is composed of indicators for each variable. Respondents were taken using purposive sampling. The number of respondents is 50 people where the respondents are actors in the construction of power plants in several projects in Indonesia, consisting of project owners, contractors and consultants.
3. Data Analysis and Discussion
   Data processing is carried out using SEM-PLS where the outer model is carried out, to determine the validity and reliability of the data. Followed by the iner model to see the significance and correlation value of each variable on the success of the project..
4. Conclusion
   From the results of the analysis obtained, conclusions are drawn on the results of the research obtained.

3. 1. Research Variabel.

Table 1. Variable and Indicator

Variabel	No	Indicator	Reference
Procedure Handling	TP 1	Evidence	(Levin, P. 2016)
	TP 2	Evaluation Duration	
	TP 3	Proposal	
	TP 4	Decision Making	
	TP 5	Notification	
Contract	KT 1	Interpretation	(Eilenberg, I. M. 2003)
	KT 2	Defect Handling	
	KT 3	Calculation Method	
	KT 4	Risk Allocation	
	KT 5	Cost and Time Estimate	
	KT 6	Proses tender	
Communication	KM 1	Procedure Communication	(Guangdong, W., et al. 2017)
	KM 2	Frequency Communication	
	KM 3	Formal Communication	
	KM 4	Informal Communication	
	KM 5	Direct Communication	
	KM 6	Open Communication	
	KM 7	Negotiation Skil	
Project Condition	KP 1	Project Stop	(Levin, P. 2016)
	KP 2	Project Cash Flow	(Liu, J., et all. 2019)

	KP 3	Progress Plan	
	KP 4	Specification	
	KP 5	Actual cost	
	KP 6	Unforeseeable difficulties	
Alternative Dispute Resolution	ADR 1	Commitment	(Lowe, D., & Leiringer, R. 2006)
	ADR 2	Agreement dispute resolution	
	ADR 3	Third party involvement	
	ADR 4	dispute council	
	ADR 5	Fees during dispute resolution	
Project Performance	KPI 1	Cost and Time	(Suanda,B. 2017)
	KPI 2	Quality	
	KPI 3	Trust and Good Relationship	

3. 2. Data Processing With Sem-PLS

The questionnaire that has been filled out by the respondent is then processed using Partial Least Square (PLS). PLS is a data analysis technique to analyze the relationship between a set of variable blocks. This is based on the assumption that the relationship between the specified blocks refers to and considers a clear knowledge base (theory). Each variable block is assumed to represent a theoretical concept which is represented in the form of a latent variable

1. Evaluation of Measurement Model (Outer Model)
   Evaluation of the measurement model or outer model is carried out to assess the validity and reliability of the model. The outer model with reflective indicators is evaluated through convergent and discriminant validity of latent construct forming indicators and composite reliability and Cronbach alpha for the indicator block. While the outer model with formative indicators is evaluated through its substantive content, namely by comparing the relative weight and seeing the significance of the construct indicators
   a. Convergent validity
      Convergent validity can be evaluated in three stages, namely indicators of validity, construct reliability, and the AVE value. The validity indicator can be seen from the loading factor value. If the value of the outer loading of an indicator is more than 0.7 then it is accepted.
   b. Discriminant validity
      Evaluation of discriminant validity is carried out in two stages, namely by looking at the cross-loading value for each variable that must be more than 0.7 and comparing the squared value of the correlation between the construct and the AVE value or the correlation between the construct and the AVE root. The criterion in cross loading is that each indicator that measures its construct must be correlated higher with its construct than with other constructs.
   c. Reliability
      Reliability evaluation, a construct reliability test was carried out which was measured by two criteria, namely composite reliability and Cronbach alpha. The construct is declared reliable if the value of composite reliability and Cronbach's alpha is more than 0.6.
2. Structural Model Evaluation (Inner Model)

Structural model evaluation describes the relationship between latent variables in a research model. Testing of the structural model is carried out by looking at the R-square value square

4. RESULTS

The number of respondents to the questionnaire obtained in this research is as many as 53 respondents, who filled in the data by respondents for approximately 2 weeks. Sampling of respondents is used by purposive sampling method so that respondents who fill in the data are respondents who have met the criteria, namely, respondents who have or are currently carrying out as actors in power plant development projects, either contractors, project owners or consultants. After the examination process was carried out, there were 3 questionnaires that were declared inappropriate, so there were 50 questionnaires which were analyzed further. Respondents consist of 50% Project Owners, 30% contractors and 20% project supervisory consultants, and all respondents are project implementers.

4. 1. Validity Test Results

Table.1 Loading Factor Analysis

Indicator	Loading Factor	Indicator	Loading Factor	Indicator	Loading Factor
ADR.1	0,595	KM.7	0,739	KT.2	0,800
ADR.2	0,768	KP.1	0,668	KT.3	0,657
ADR.3	0,746	KP.2	0,721	KT.4	0,561
ADR.4	0,496	KP.3	0,666	KT.5	0,833
ADR.5	0,769	KP.4	0,615	KT.6	0,577
KM.1	0,706	KP.5	0,740	TP.1	0,533
KM.2	0,546	KP.6	0,382	TP.2	0,535
KM.3	0,492	KPI.1	0,920	TP.3	0,472
KM.4	-0,328	KPI.2	0,904	TP.4	0,834
KM.5	-0,203	KPI.3	0,768	TP.5	0,831
KM.6	-0,426	KT.1	0,583		

From the simulation results using SEM PLS, the loading factor results can be seen in table 4.1. In the first simulation results obtained from 32 indicators contained in the research, there are 18 indicators that are not valid because the loading factor value shows the criteria <0.7. Among them are ADR 1 and ADR 4 with a loading factor value of <0.6 where a dispute board can be formed before or after a dispute with an agreement by the parties (Lowe, D., & Leiringer, R. 2006), KM indicators 2,3,4, 5 and 6 the existence of cultural differences Communication between individuals needs to be supported by negotiation skills in dispute resolution (Ock, & Han, 2003), KP indicators 1,3,4 and 6 with a value of <0.7 Project Condition can be analyzed using Earn Value with look at the financial performance of a project (Suanda, B. 2017), and Indicators in ContractKT variables 1.3 and 4 with a value of <0.7 The calculation method in evaluating Contract changes can be done by mutual agreement (Levin, P. 2016). Based on the loading results, further data validity testing is needed by eliminating invalid indicators (<0.7).

Table.2 Loading Factor Analysis after elimination

Indicator	Loading Factor
ADR.2	0,801
ADR.3	0,721
ADR.5	0,828
KM.7	1,000
KP.2	0,867
KP.5	0,838
KPI.1	0,921

Indicator	Loading Factor
KPI.2	0,897
KPI.3	0,779
KT.2	0,898
KT.5	0,955
TP.4	0,829
TP.5	0,892

Elimination has been carried out on the KM 1 indicator because it has a value of <0.7, so re-elimination is carried out according to so that the results of the Loading Factor value can be seen in table 2, where it can be seen that all factor loading values on each indicator are >0.7, so it can be said that the indicator valid and can be done in the next test..

4. 2. Average Variance Extracted (AVE)

Table.3 Average Variance Extracted Result

Variable	AVE	Description
Dispute Resolution	0,603	Valid
Project Performance	0,753	Valid
Communication	1,000	Valid
Project Condition	0,726	Valid
Contract	0,859	Valid
Procedure	0,742	Valid

Validity test results can be seen in Table 3, it can be seen that the AVE value is above 0.5 so that it can be said that all variables are declared valid and can measure the diversity of manifest variables in each variable.

4. 3. Discriminant Validity

Discriminant Validity is used to measure the discriminatory validity of a measurement model (Outer Model) by comparing the AVE route of each variable with the correlation between one variable in the model and other variables. If the AVE route is greater than the correlation of other latent variables, then the variable is said to be valid. The results of the Discriminant validity test can be seen in Table 4 where the results of the comparison of the discriminant validity variable from the Dispute resolution variable with discriminant validity have a greater value (0.777) when compared to the results of the discriminant validity variable dispute resolution with other variables, the discriminant validity value of the Project Performance variable. also has a greater value when compared to the relationship of its own variable compared to other variables. And it can be seen in Table 4.4 that all discriminant validity values in each variable have a greater value when compared to discriminant validity by other variables, so it can be ascertained if the variable

has relevant observations to measure its own variable compared to measuring other variables and it can be said that the variable valid.

Table.4 Discriminant Validity

Discriminant Validity	Dispute Resolution	Project Performance	Communication	Project Condition	Contract	Procedure
Dispute Resolution	**0,777**					
Project Performance	0,528	**0,868**				
Communication	0,615	0,491	**1,000**			
Project Condition	0,438	0,322	0,451	**0,852**		
Contract	0,560	0,299	0,401	0,373	**0,927**	
Procedure	0,488	0,459	0,426	0,044	0,462	**0,861**

4. 4. Structural Model Test (Inner Model)

Table.5 Result R Square

	R Square
Dispute Resolution	0,515
Project Performance	0,289
Project Condition	0,247

The results of the R^2 value in Table 4.8 show that there are 3 endogenous variables tested in this research. Looking at the results of R^2, it shows that Dispute Resolution is influenced by the variables "Procedure", "Contract" and "Communication" by 51.5% and it can be said that these variables are quite representative of "Dispute Resolution" and can be said to have a moderate relationship. The Project Condition variable is only affected by 24.7% by the "Communication" and "Contract" variables so that it can be said that the influence of Communication and Contract is weak on Project Condition and Project Condition can be explained by 65.3% by other variables. Project Performance Variables that are influenced by Dispute Resolution and Project Conditions have an R^2 value of 28.9% so that there are still 71.1% of other variables that affect Project Performance, so that the handling of disputes in projects is said to be weak in influencing Project Performance..

4. 5. Discussion

The value of r-square on the endogenous variable "Project Condition" is weak (0.247) this shows that there are still 75% of other variables that can affect the Project Condition, such as the project's financial condition, the project's external environment, changing regulations, unknown conditions, force majeur and so on, and the handling of disputes has a weak effect on the condition of the project.

In determining the dispute resolution will be positively and significantly influenced by the Contract variable, where the Contract which explains the method of dispute resolution in the event of a dispute, and can be interpreted clearly by the project actors, then the dispute resolution will be carried out properly. (Eilenberg, I. M. 2003). In this condition, the Contract, which clearly defines the dispute resolution method, will be a reference and clear procedure for settlement, so that disputes that occur do not drag on for long and there is a clear path to resolving disputes. In contracts such as this, the duration of time in each procedure that must be taken and the distribution of costs when entering into dispute settlement is explained in the next procedure, for example in one of the contracts for a power plant construction project where it is stated that when a dispute occurs, negotiations must immediately be carried out and must be completed within a short period of time. 30 days, if more than that, a dispute board shall be immediately formed for each party to mediate the dispute that occurs and a deadline of 60 days is given, and if more than that there is still a dispute then the dispute will be resolved through arbitration, and all parties are required to agree with the results of the arbitration decision, in accordance with the agreed Contract. The moderate r-square value (0.515) indicates that the dispute resolution is positively influenced by contracts, communications, and procedures. And significantly influenced by contracts and communications between parties.

From the results of the analysis, it can be seen that the P-values Project Condition on Project Performance has a value of 0.497, this shows that Project Performance is not significantly affected by Project Conditions, project financial conditions and good project cash flow performance will affect Project Performance (Juanying Liu, & Huiling Li, 2019), where in the course of the Project Condition project repairs and improvements can be made and the existence of a dispute does not have a significant impact on the Project Condition so it will not fully affect Project Performance. From the respondent's profile Some of the projects handled by respondents during dispute resolution did not significantly affect Project Conditions, such as job suspensions, termination of payments to termination of agreements, so that Project Conditions on respondents did not affect Project Performance.

The weak R-square value of Project Performance (0.289) indicates that although dispute resolution significantly affects Project Performance, there are 71% of other variables that affect Project Condition.

5. CONCLUSIONS

In handling disputes on power plant projects that affect Project Performance, the method that will be used in dispute resolution, the method of dispute resolution by negotiation that can be carried out quickly and at minimal cost will have a positive impact on Project Performance. Dispute resolution methods that require the existence of a third party or litigation which will require considerable time and cost to settle will have a negative effect on Project Performance. Dispute resolution will be carried out properly if the communication process between the project actors can be carried out properly, where open communication is supported by good negotiation skills, which will affect the dispute resolution to be resolved at stage one (negotiation). In addition to good communication, dispute resolution will be resolved at the negotiation stage if the Contract itself has stated an agreement on the dispute resolution to be taken, as well as the duration of time as a reference in handling disputes and an agreement on the costs that will arise during the dispute resolution procedure. will be executed. clarity regarding the handling of defects and the accuracy of estimates of the cost and duration of good work in the contract agreement.

REFERENCES

A.T.w. Yu, G.Q.P. Shen,. (2015), Critical success factors of the briefing process for construction projects

Eilenberg, I. M. (2003). Dispute *Resolution* In Construction Management (Vol. 1st). New South Wales: National Library of Australia.

Guangdong, W., Cong, L, & Xianbo, Z. (2017). Investigating the relationship between communication-conflict interaction and project success among construction project teams. International Journal of Project Management 35, 1466-1482.

Jui-Sheng Chou, Shu-Chien Hsu., (2016). Classifying Influential Information to Discover Rule Sets for Project Disputes and Possible *Resolution*s, Taiwan: National Taiwan University of Science and Technology

Latan, H., & Ghozali, I. (2012). Partial Least Squares Konsep, Teknik dan Aplikasi menggunakan Program SmartPLS 2.0 M3. Semarang: Badan Penerbit Universitas Diponegoro.

Levin, P. (2016). Third Edition Construction Contract Claims, Changes, and Dispute *Resolution*.

Liu, J., Li, H., Skitmore, M., & Zhang, Y. (2019). Experience mining based on case-based reasoning for dispute settlement of international construction projects. Automation in Construction, 97, 181–191. https://doi.org/10.1016/j.autcon.2018.11.006

Lowe, D., & Leiringer, R. (2006). Commercial Management of Projects Defining the Discipline.

Lu, W., & Liu, J. (2014). Research into the moderating effects of progress and quality performance in project dispute negotiation. International Journal of Project Management, 32(4), 654–662. https://doi.org/10.1016/j.ijproman.2013.09.008

Lu, W., Zhang, L., & Pan, J. (2015). Identification and analyses of hidden transaction costs in project dispute *resolution*s. International Journal of Project Management, 711–718.

Suanda, B. (2016). Advance & Effective Project Management. Jakarta: PT. PP Construction and Investment.

Wenxue Lu, Lihan Zhang., (2015). Identification and analyses of hidden transaction costs in project dispute *resolution*s, : Tianjin University.

DETERMINATION OF CRITERIA IN SOCIAL SUSTAINABILITY ASSESSMENT OF CONSTRUCTION FIELD WORKERS

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ABSTRACT

The principle of sustainable development is developed to provide benefits to the society by balancing three pillars, namely economic, social and environment. Heterogeneity in social and culture encourages different criteria for measuring sustainability. Characteristics of the social aspects of a project have a high degree of uncertainty. Involvement in the implementation of social sustainability depends on the interaction of each stakeholder. One of the important stakeholders are field construction workers who play important role in achieving project success. This study examines social sustainability criteria of construction project field workers. Data were collected from the literature study that was obtained regarding social sustainability in construction workers. Where in the literature study obtained, it is also necessary to analyze the relevant tests from the literature study to be used as assessment criteria. Mean analysis was used to analyze the data. According to the analysis, 20 social sustainability variables were found relevant in this study. This study provides a reference for determining criteria in the social sustainability assessment model for construction project field workers.

Keywords: criteria, social sustainability, workers

1. INTRODUCTION

Social sustainability is a condition of improving life in a community (McKenzi, 2004). Social sustainability has been characterized by being a key element in the construction industry, increasing interaction between stakeholders to meet the current and future needs of populations and communities (Valdes-Vasquez and Klotz, 2013). All social sustainability impacts of business decisions and costs to bring about impacts, which are identified first which then allows quantification of project's social welfare. Social costs and benefits of a construction project are then involved to determine net benefits of project (Doloi, 2012). Social sustainability aspects are very important to be realized in project implementation so that it can provide short-term and long-term benefits for all stakeholders involved. Involvement in implementation of social sustainability depends on interaction of each stakeholder involved. Stakeholders are parties, individuals or organizations that are actively involved in project or who have an interest that is affected, both positively and negatively, on implementation of project (Santoso, 2009). In general, perception of project success depends on several perspectives, which are based on type of stakeholder, time horizon, and level of project hierarchy (Rohman et al, 2017). One of stakeholders involved is contractor, where there are construction field workers who play an important role in achieving project success.

There are several stages in a construction project, such as planning stage of construction work, scheduling and control depending on workforce, design stage, and construction stage are influenced by field workers (Kumarasinghe and Hadiwattege, 2018). Implementation of social sustainability of a construction project is carried out at the design and construction stages. Since this stage is influenced by field workers, implementation of social sustainability in construction is also influenced by performance of field workers. To date, workers' perspectives when measuring social sustainability in projects have been largely ignored and in fact workers are also relevant stakeholders for project success (Staniškienė and Stankevičiūtė, 2018). Social impact assessment began in the early 1970s. The assessment is in the form of a set of formal practices and procedures called the Social Impact Assessment (SIA), an extension of the Environmental Impact Assessment (EIA). Social Impact Assessment (SIA) is used to document and/or predict socio-economic impacts of the large-scale project (Jacquet, 2014). However, Social Impact Assessment (SIA) is considered inappropriate because it does not consider positive impact on development (Rohman et al, 2017).

In assessment activities, criteria are needed in assessing this. Criteria for assessing social sustainability aspects may change over time and their importance. (Almahmoud and Doloi, 2016) to assess a social sustainability condition from project side, first thing to do is to find these criteria (Karji et al, 2019). To develop a comprehensive evaluation system, social sustainability criteria must be identified first (Karji et al, 2019). Related literature studies identify social sustainability variables to be used as assessment criteria in social sustainability for field workers.

Therefore, this paper presents a method of determining assessment criteria to evaluate construction field workers from perspective of social sustainability, using mean score method. Followed by presenting a discussion of discussion of this paper and a summary for further research topics.

2. LITERATURE REVIEW

a. Sustainable Development Concept

In general, sustainability has emerged from global political process that tries to bring together most powerful time requirements at the same time (Newman, Kenworthy, 1999), namely need for economic development to address poverty; need for environmental protection of air, water, soil and biodiversity, dependency; and the need for social justice and cultural diversity to enable local communities to express their values in solving problems.

Terms related to sustainability such as sustainable, enduring and constant (Murray and Cotgrave, 2007) discussion of construction industry, sustainable development is expressed as green construction (Green Building) or as sustainable construction, buildings that follow sustainable principles are referred to as buildings with high performance, ecological buildings, green buildings or sustainable buildings (Ali and Al-Nsairat, 2009; Korkmaz et al, 2010; Häkkinen and Belloni, 2011). Terms of this understanding can sometimes be used interchangeably, but strictly speaking, terms such as greenery or high-performance focus on environmental dimensions, while sustainable construction and sustainable buildings cover environmental, economic and social aspects more comprehensively.

Sustainable development is relationship between humans and their environment by having factors in them (Du-Plessis, 2007). In initial factor position, "quality of life" adopted by a particular community is interpreted. This is the main determinant of needs that must be met. The second factor is choices made in terms of technology, politics, economy, and other systems adopted by society. Both of these factors are informed by certain value systems adopted by society.

Sustainable construction should be considered in a global context and should move away from traditional construction processes, which focus on time, cost, and quality (Houvila and Koskela, 1998). These activities involve and create synergistic relationships between environmental, economic, and social aspects of sustainability (Adetunji et al, 2008). To achieve sustainable construction, it is important to apply a balanced and harmonious approach that integrates various aspects of sustainability including the previous three aspects (Whang and Kim, 2015).

From above discussion, sustainable construction in this study is defined as a holistic and balanced process that aims to meet functional requirements of a building throughout its life cycle in a resource efficient manner and at the same time, minimize negative environmental impacts, increase economic acceptance, and increase human welfare through the protection of occupant satisfaction and the rights of other stakeholders. This definition of concept of sustainability needs to be considered, and a balance of three-dimensional sustainability performance and multi-stakeholder interests needs to be achieved.

b. Social sustainability in construction projects

Socially sustainable projects can create a harmonious living environment, while reducing social inequality and improving the quality of life in general (Enyedi G., 2002). Based on the notion of social itself, according to Cambridge Dictionary (2021), this understanding of social relates to society and living together in an organized manner. Social issues are a consequence of competing interests and values, uncertain causes and effects, and their implications in many areas of life (Boyer et al, 2016). Social sustainability is the ability to ensure welfare, security, health, education and provide all these issues equally without separating social class and gender. “In an area, social sustainability means capacity of various social actors (Stakeholders), to interact efficiently, to achieve same goal, driven by close interaction of institutions, at all levels” (Edward, 2000). At a basic level, sustainable community members realize that individual well-being is linked to the well-being of the larger community, of course the other way around (Hurol, 2014).

In general, social sustainability is described as engagement between employees, local communities, clients, and supply chains to ensure the fulfillment of current and future needs of populations and communities (Almahmoud and Doloi, 2016), a definition that more fully reflects the different perspectives of stakeholders. project. The concept of social sustainability has various interpretations in the construction industry depending on the stakeholder perspective and the phase of the project life cycle. This design perspective also includes understanding the social interrelationships embedded in the process of designing, constructing, and operating construction projects (Rohracher 2001). Based on the research of Yang et al. (2010) pointed out that social responsibility is the most important for stakeholders in construction projects. It is worth paying attention to social sustainability performance during feasibility studies of construction projects (Shen et al, 2011).

As the concept of social sustainability is still developing, this is an important time to start defining the social sustainability processes that should be integrated during planning and design phases of a construction project. Understanding of social sustainability processes can be enhanced by involving experts in developing a common framework, literature study, and an important first step in creating awareness about this topic in construction projects. In particular, concept can serve as a framework for applying social sustainability to construction.

c. Construction worker

Construction projects always require workers to work using their physique to work in the open field in any weather and conditions (Ervianto, 2002). One of the human resources that determines success in construction projects is construction workers. According to Sondari in Prasetyono (2015) the workforce contained in a contractor is categorized into two parts, namely:

1. Company workers are company staff who have a permanent work bond between the workforce and the company and have a fixed income that is paid every month. This workforce consists of several levels, namely the supervisor level, other field implementers to the highest managerial level, namely the project manager,
2. Casual workers are non-staff workers who do not have a permanent work bond between the company and the workforce. The income is in the form of wages, the amount of which is not fixed, depending on the form of work carried out or calculated based on working days.

Based on Constitution No. 13 of 2003 concerning manpower, Chapter I article 1 paragraph 2 of the definition related to manpower is anyone who is able to do work to produce goods and/or services both to meet their own needs and for the community.

There are several stages in a construction project, such as the planning stage of construction work, scheduling and control depending on the workforce, the design stage and the construction stage are influenced by field workers (Kumarasinghe and Hadiwattege, 2018). In the opinion of Staniškienė and Stankevičiūtė in 2018 the congruence between workers' perceptions of social sustainability practices leads to the creation of awareness value for the community. Many aspects of social sustainability that requires active efforts on the part of the organization and employee encouragement.

3. METHODS

This research study focuses on how to determine criteria that are relevant and can be used in social sustainability assessments for construction project field workers. Here is a flow chart for conducting a research study through the steps required when conducting research. Each stage will be explained in this section.

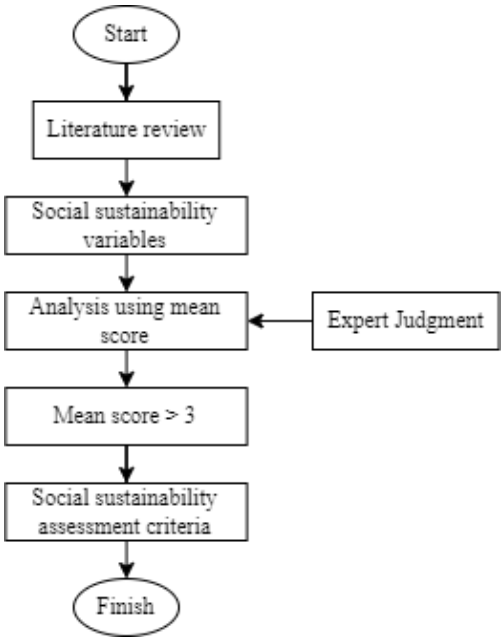


Figure 1. Research flow chart

a. Selection of social sustainability variables
   Based on previous literature studies that have been obtained. This variable is related to social sustainability of construction project field workers. Because the previous research has not been applied in Indonesia. It is required for further selection and analysis.
b. Analysis using the mean score method
   In determining the assessment criteria in social sustainability for construction field workers which were previously obtained through variable selection. These variables are needed to verify the research variables are relevant or not. In this analysis using a questionnaire. This research survey is through an assessment from expert judgment where the respondent is involved in construction projects. Using a Likert scale of 1-5 to measure the relevance of these variables, a score of 5 is for very relevant and 1 is not relevant. In this study, a value of 3.00 (three) is used as the cut-off value to determine the relevance of the attribute because this value is the middle value between values 1 to 5. It can be said to be relevant if the mean score obtained exceeds 3 (≥ 3) (Utomo, 2019).
c. Determination of social sustainability assessment criteria
   Based on the results of the analysis obtained. Social sustainability variables for construction project field workers that have been assessed as relevant, so that they can be used as criteria for assessing social sustainability for construction project field workers.

4. RESULTS

The selection of social sustainability variables in this study was based on previous literature studies. Based on several sources related to social sustainability of construction project field workers. Obtained as many as 21 variables variables. The following is a table for social sustainability variables in construction project field workers:

Table 1. Social sustainability assessment criteria for construction project field workers

No.	Category	Variable	Source
1	Indoor environmental quality (Worker barracks)	Proper lighting quality in workers' barracks	Ardda et al. (2018), Almahmoud dan Doloi (2015), Fatourehchi dan Zarghami (2020), Karji et al. (2019)
		Proper air quality in worker barracks (temperature and ventilation conditions)	Ardda et al. (2018), Almahmoud dan Doloi (2015), Fatourehchi dan Zarghami (2020), Karji et al. (2019)
		Acoustic comfort	Ardda et al. (2018), Almahmoud dan Doloi (2015), Fatourehchi dan Zarghami (2020), Karji et al. (2019)
		Reduction of environmental pollution	Rohman et al. (2017), Almahmoud dan Doloi (2015), Karji et al. (2019)
2	Workers' health and welfare	Ensuring equality and professional status	Oyebanji et al. (2017), Almahmoud dan Doloi (2015), Kamaruddin et al. (2020)
		Providing open space	Rohman et al. (2017), Almahmoud dan Doloi (2015)
		Provision of essential facilities (first aid, places of worship, toilets, etc.)	Almahmoud dan Doloi (2015), Whang dan Kim (2015), Kamaruddin et al. (2020), Bai et al. (2019)
		Providing feedback	Oyebanji et al. (2017), Whang dan Kim (2015)

No.	Category	Variable	Source
3	Safety and quality of service to workers	Safety in the work environment	Ardda et al. (2018), Almahmoud dan Doloi (2015), Fatourehchi dan Zarghami (2020), Karji et al. (2019), Shen et al. (2011), Whang dan Kim (2015), Kamaruddin et al. (2020), Sierra et al. (2018)
		Safety in the work environment	Ardda et al. (2018), Almahmoud dan Doloi (2015), Fatourehchi dan Zarghami (2020), Karji et al. (2019), Shen et al (2011), Whang dan Kim (2015), Kamaruddin et al. (2020), Sierra et al. (2018)
		Safety of life and property	Oyebanji et al. (2017)
		Providing safe public facilities	Rohman et al. (2017), Shen et al. (2011), Whang dan Kim (2015)
4	Accessibility	Accessibility to public transportation, which is meant is from the workers' barracks to public transportation.	Ardda et al. (2018), Sierra et al. (2017), Oyebanji et al. (2017), Almahmoud dan Doloi (2015), Karji et al. (2019)
		Accessibility to the workplace from the workers' barracks.	Ardda et al. (2018)
		Accessibility to public services (health clinic, police, market, etc.)	Ardda et al. (2018), Sierra et al. (2017), Sierra et al. (2018), Oyebanji et al. (2017), Karji et al. (2019)
5	Communication and cooperation	Get information that gets feedback (feedback) and ease of communication	Sierra et al. (2017), Almahmoud dan Doloi (2015), Rivai et al. (2020)
		Involvement in decision-making and integration activities	Sierra et al. (2017), Sierra et al. (2018), Oyebanji et al. (2017), Rohman et al. (2017), Almahmoud dan Doloi (2015), Karji et al. (2019), Kamaruddin et al. (2020), Fatourehchi dan Zarghami (2020), Whang dan Kim (2015)
		Social conflict can be solved	Rivai et al. (2020), Valdes-Vasquez dan Klotz (2013)
6	Employee commitment and performance	Development of skills and knowledge (training) received by workers	Sierra et al. (2018), Almahmoud dan Doloi (2015), Domingo et al. (2020), Karji et al. (2019), Shen et al. (2011), Whang dan Kim (2015), Kamaruddin et al. (2020), Bai et al. (2019)
		Workers comply with regulations	Rohman et al. (2017)
		Protecting workers' interests and rights	Bai et al. (2019), Kamaruddin et al. (2020)

The method used in this study uses a questionnaire, where the scoring is done by expert judgment who was previously an expert in the field of construction projects. These respondents were 3 people. The number of respondents in this preliminary survey was also carried out in several previous studies (Arumugam et al., 2015; Budayan et al., 2015; Tripathi and Jha, 2018), so that the number of respondents as many as three people is considered sufficient in determining the variables because this research is an early stage.

Table 2. Respondent profile

No.	Respondent	Institution	Education Level	Length of Engagement in the Project	Length of Engagement on Building Projects
1.	Respondent 1	Academician	Doktor	15 - 20 years	> 10 Projects
2.	Respondent 2	Academician	Magister	15 - 20 years	> 10 Projects
3.	Respondent 3	Academician	Doktor	> 20 years	3 - 4 Projects

In this study, the results of the selection of social sustainability variables were obtained from previous research literature studies. Where for the variables obtained as many as 21 social sustainability variables on construction project field workers, there is one variable, namely providing opinion input has an average value of 2,667 where the value is less than 3,000 (2,667 < 3,000) so that the variable is said to be irrelevant in this study. In addition, the results of filling out the questionnaire in the preliminary survey contained input variables to be added, namely the adequacy of rest time for workers, but these variables have been accommodated in the variables protected by the rights and interests of workers. So that 20 variables are obtained which will later become criteria in the assessment of social sustainability for construction project field workers. The results of the assessment given by the respondents and the results of the average values obtained can be seen in the following **Table 3**:

Table 3. Results of determining social sustainable's criteria

No.	Criteria	R1	R2	R3	Mean	St. Dev	Desc.
7	Provision of essential facilities (first, places of worship, toilets, etc.)	5.000	3.000	5.000	4.333	1.155	Relevant
9	Safety in the work environment	5.000	3.000	5.000	4.333	1.155	Relevant
10	Safety in the work environment	5.000	3.000	5.000	4.333	1.155	Relevant
14	Accessibility to the workplace from the workers' barracks.	4.000	5.000	4.000	4.333	0.577	Relevant
20	Workers comply with regulations	5.000	3.000	5.000	4.333	1.155	Relevant
2	Proper air quality in worker barracks (temperature and ventilation conditions)	5.000	2.000	5.000	4.000	1.732	Relevant
4	Reduction of environmental pollution	5.000	2.000	5.000	4.000	1.732	Relevant
11	Safety of life and property	5.000	2.000	5.000	4.000	1.732	Relevant
12	Providing safe public facilities	5.000	2.000	5.000	4.000	1.732	Relevant
18	Social conflict can be solved	5.000	3.000	4.000	4.000	1.000	Relevant
21	Protecting workers' interests and rights	5.000	2.000	5.000	4.000	1.732	Relevant
1	Proper lighting quality in workers' barracks	5.000	2.000	4.000	3.667	1.528	Relevant
3	Acoustic comfort	5.000	2.000	4.000	3.667	1.528	Relevant
19	Development of skills and knowledge (training) received by workers	4.000	3.000	4.000	3.667	0.577	Relevant
5	Ensuring equality and professional status	4.000	2.000	4.000	3.333	1.155	Relevant
16	Get information that gets feedback (feedback) and ease of communication	3.000	2.000	5.000	3.333	1.528	Relevant
17	Involvement in decision-making and integration activities	3.000	2.000	5.000	3.333	1.528	Relevant

No.	Criteria	R1	R2	R3	Mean	St. Dev	Desc.
6	Providing open space	3.000	2.000	4.000	3.000	1.000	Relevant
13	Accessibility to public transportation, which is meant is from the workers' barracks to public transportation.	3.000	2.000	4.000	3.000	1.000	Relevant
15	Accessibility to public services (health clinic, police, market, etc.)	3.000	2.000	4.000	3.000	1.000	Relevant
8	Providing feedback	3.000	2.000	3.000	2.667	0.577	Irrelevan

6. CONCLUSIONS

Based on the research and discussion that has been carried out, conclusions can be drawn in determining the relevant criteria for the assessment of social sustainability in construction project field workers using the average value. These scores are assigned by experts to the relevant assessors of social sustainability. The results obtained were 20 criteria for the assessment of social sustainability on construction project field workers.

REFERENCES

Adetunji, I., Price, A.D.F. and Fleming, P. (2008). Achieving sustainability in the construction supply chain. *Proceedings of the Institution of Civil Engineers-Engineering Sustainability* 161 (3), 161-172

Ali, H.H. and Al-Nsairat, S.F. (2011). Developing a green building assessment tool for developing countries–Case of Jordan. *Building and environment* 44 (5), 1053-1064

Almahmoud, E. and Doloi, H.K. (2015). Assessment of social sustainability in construction projects using social network analysis. *Facilities*

Ardda, N., Mateus, R. and Bragança, L. (2018). Methodology to identify and prioritise the social aspects to be considered in the design of more sustainable residential buildings—application to a developing country. *Buildings* 8 (10), 130

Arumugam, S., Perera, B. A. K. S., and Sumanarathna, D. M. G. A. N. M. (2015). Transaction costs of green office building construction in Sri Lanka.Bai, C., Kusi-Sarpong, S., Badri Ahmadi, H. and Sarkis, J. (2019). Social sustainable supplier evaluation and selection: a group decision-support approach. *International Journal of Production Research* 57 (22), 7046-7067

Budayan, C., Dikmen, I., dan Birgonul, M. T., (2015). "Alignment of project management with business strategy in construction: evidence from the Turkish contractors", *Journal of Civil Engineering and Management*, Vol. 21, No. 1, Hal. 94-106.Delgado, A. and Romero, I. (2016). Environmental conflict analysis using an integrated grey clustering and entropy-weight method: A case study of a mining project in Peru. *Environmental Modelling & Software* 77, 108-121

Doloi, H. (2012). Assessing stakeholders' influence on social performance of infrastructure projects. *Facilities*

Du Plessis, C. (2007). A strategic framework for sustainable construction in developing countries. *Construction management and economics* 25 (1), 67-76.

Enyedi, G. (2002). Social sustainability of large cities. *Ekistics*, 142-144

Ervianto, W.I.(2005). Manajemen proyek konstruksi, Yogyakarta: Andi

Fatourehchi, D. and Zarghami, E. (2020). Social sustainability assessment framework for managing sustainable construction in residential buildings. Journal of building engineering, 32, 101761

Häkkinen, T. and Belloni, K. (2011). Barriers and drivers for sustainable building. *Building Research & Information* 39 (3), 239-255

Hürol, H.Y. (2014). A study on social sustainability: The case of Doğanbey urban renewal project in Bursa. Middle East Technical University

Jacquet, J.B. (2014). A Short History of Social Impact Assessment, Department of Sociology and Rural Studies. Montana: South Dakota State University.

Kamaruddin, T., Hamid, R.A. and Abd Ghani, S. (2020). Social aspect implementation in sustainable construction. *IOP conference series: materials science and engineering* 849 (1), 012036.

Karji, A., Woldesenbet, A., Khanzadi, M. and Tafazzoli, M. (2019). Assessment of social sustainability indicators in mass housing construction: a case study of Mehr housing project. *Sustainable Cities and Society* 50 (101697)

Korkmaz, S., Riley, D. and Horman, M. (2011). Assessing project delivery for sustainable, high-performance buildings through mixed methods. *Architectural Engineering and Design Management* 7 (4), 266-274

Kumarasinghe, K.I.D. and Hadiwattege, C. (2018). The significance of labour factor in integrating sustainability concept into construction industry practice. The 7th World Construction Symposium, Built Asset Sustainability: Rethinking Design, Construction and Operations, Colombo, Sri-Lanka.

Li, W., Liang, W., Zhang, L. and Tang, Q. (2015). Performance assessment system of health, safety and environment based on experts' weights and fuzzy comprehensive evaluation. *Journal of Loss Prevention in the Process Industries* 35, 95-103

McKenzie, S. (2004). Social sustainability: towards some definitions. Hawke Research Institute University of South Australia, Australia

Montalbán-Domingo, L., Aguilar-Morocho, M., García-Segura, T. and Pellicer, E. (2020). Study of Social and Environmental Needs for the Selection of Sustainable Criteria in the Procurement of Public Works. *Sustainability* 12 (18), 7756

Murray, P.E. and Cotgrave, A.J. (2007). Sustainability literacy: the future paradigm for construction education?. *Structural survey*.

Newman, P. and Kenworthy, J. (1999). Sustainability and cities: overcoming automobile dependence, Island press.

Oyebanji, A.O., Liyanage, C. and Akintoye, A. (2017). Critical Success Factors (CSFs) for achieving sustainable social housing (SSH). *International Journal of Sustainable Built Environment* 6 (1), 216-227.

Prasetyono, P.N. (2015). Faktor Penyebab Stres Kerja Karyawan Kontraktor di Surabaya. Surabaya: Institut Teknologi Sepuluh Nopember.

R. H. P. N. D. A. P. &. C. K. Boyer, (2016). Five approaches to social sustainability and an integrated way forward. *Sustainability* 8 (9), 878

Rivai, F.R. and Rohman, M.A. (2020). A framework for mapping stakeholders interests related social sustainability in residential building. *IOP Conference Series: Materials Science and Engineering* 930 (1), 012003

Rohman, M.A., Doloi, H. and C. A. Heywood, (2017). Success criteria of toll road projects from a community societal perspective. *Built environment project and asset management*

Rohracher, H. (2001). Managing the technological transition to sustainable construction of buildings: a socio-technical perspective. *Technology Analysis & Strategic Management* 13 (1), 137-150.

Santoso, P.S. (2009). Analisis Faktor-Faktor Penyebab Terjadinya Cost Overrun Pada Proyek Konstruksi Di Yogyakarta. Doctoral dissertation, UAJY

Shen, L. Wu, Y. and Zhang, X. (2011). Key assessment indicators for the sustainability of infrastructure projects. *Journal of construction engineering and management* 137 (6), 441-451

Sierra, L.A., Pellicer, E. and Yepes, V. (2017). Method for estimating the social sustainability of infrastructure projects. *Environmental Impact Assessment Review* 65, 41-53.

Sierra, L.A., Yepes, V., García-Segura, T. and Pellicer, E. (2018). Bayesian network method for decision-making about the social sustainability of infrastructure projects. *Journal of Cleaner Production* 176, 521-534

Staniškienė, E. and Stankevičiūtė, Ž. (2018). Social sustainability measurement framework: The case of employee perspective in a CSR-committed organisation. *Journal of cleaner production* 188, 708-719

Tripathi, K. K., dan Jha, K. N. (2018), "Application of fuzzy preference relation for evaluating success factors of construction organisations", *Engineering, Construction and Architectural Management*.

Utomo, F.R. and Rohman, M.A. (2019). The barrier and driver factors of building information modelling (BIM) adoption in indonesia: a preliminary survey. *IPTEK Journal of Proceedings Series* 5, 133-139

Valdes-Vasquez, R. and Klotz, L.E. (2013). Social sustainability considerations during planning and design: Framework of processes for construction projects. *Journal of construction engineering and management* 139 (1), 80-89.

Whang, S.W. and Kim, S. (2015). Balanced sustainable implementation in the construction industry: The perspective of Korean contractors. *Energy and Buildings* 96, 76-85

MONITORING SYSTEM AND MULTI CONTROLING PROJECT CONSTRUCTION USING ANDROID-BASED HOUSE OF QUALITY METHOD

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ABSTRACT

This study intentded to model an android base multi-project real time monitoring system. The use of the android system is expected to make it easier for project managers to monitor multi projects in real time. The House of Quality method was used to interpet user demand into technical requirements, helping the interface design process for this APKs. This research starts with a literature study and interviews with respondents regarding the user expectations will later become input for determining attributes and technical responses for modeling APKs. The results of the House of Quality analysis concluded that all of the 35 customer requirement's attributes were considered important with a range score of 60-91. The use of the appropriate symbol selection for the first rank obtained with a value of 204.286 with 17.72% weight for the relative weight, for the second rank there is a notification from changes that occur with a value of 134,762 with a 11.69% weight and for the third rank is the S curve display of the plan and realization with a value of 107,619 with a 9.33% weight. The lowest rank is the feature of Location (google) with a value of 1,428 with 0.12% weight.

Keywords: Multi-project management, House of Quality (HoQ), Android App

1. INTRODUCTION

(Irawan & Syairudin (2015) that Multiple Project has more than one purposes eventhough happen in one same location, or different location. (Aritua, Smith, & Bower, 2009) claim that most part of the project serve a challange that fundamentally different from one single management project. According to Gray and Larson (2011) Evaluation and control is a part of every project manager with such a wide scope of work that must be controlled and monitored there fore they need an effective media to assist them and become a single information system for collecting and reporting data through cost progress, scheduling, and specification.

(Siswanto, Agus (2017) problem in multi management project is a time difference (*time schedule*) to each working package for each unmonitored project *schedule.* This study intended to design multi-project monitoring and controlling system according to the needs project manager needs. In this study House of Quality (HOQ) method is conducted. According (Tapke, Muller, Johnson, & Sieck, (1997) HoQ is the centre of the nerf from Quality Function Deployment (QFD) that having unique ability to translate user request into technical requirements.

For the process key issue regarding the system that about to design, combination of SWEEBOK Guide V.30 (2014) was used. The two theories above serve were made for the reason to design real-time system monitoring and multi project construction control Android base.

2. LITERATURE REVIEW

2.1 Multi Project Management

Pennypaker & Dye (2002) states that multiproject management project is different from portofolio managemen that more strategic, multi project management is the most talkable part to allocate resources, more focus to tactical decisions, and has a relatively short-term or dailty scope of planning, and the manager project who has responsibility. In this study that was conducted by Caniels and Bakens (2011) claims that in the multi project scope, a project manager had to use some of resources that centred managing, and should be divided to other manager project.

Dividing the limited resources to some project allow the organization to use the reseources efficiently.

2.2 Porject Control and Prorgress Evaluation

Control is the process of comparing actual performance against plans to identify deviatons, evaluate programs, and take appropriate corrective action. According to (Gray & Larson, 2011) evaluation and control is part of the job of every project manager. Controls with "Frequent inspections" and/or "involvement" can address issues in greater detail in small projects. But large projects require some form of formal control. Control by the person in charge, prevent small problems from turning into big problems, and stay focused. 2.3 House of Quality (HoQ)

Quality Function Deployment (QFD) according to (Akao, 1996) is a method for transforming requests from users into a design quality for deploying function forming quality and deploying methods for achieving design quality into systems, component parts, and specific elements in the process. manufacture. QFD is designed to help planners focus on the characteristics of an existing product or service from the point of view of market segmentation, enterprise, or technology development needs. QFD is also very useful for transforming Voice Of Customer (VOC) into engineering characteristics for a product or service by prioritizing the characteristics of each product or service along with setting development targets simultaneously for that product or service. (Akao, 1994) also stated that QFD has the unique ability to translate user requests into technical requirements.

2.4 Software Development Model

Rosa A.S. & M. Salahudin argues that software engineering is a development with engineering principles or concepts with the aim of producing software that has economic value, works efficiently using machines, and good software is software that can meet user or customer needs. (Rosa A.S & M. Salahudin, 2016:4). In addition, Pressman (2010) stated that software development consists of processes, methods and tools that enable professionals to develop high-quality computer software.

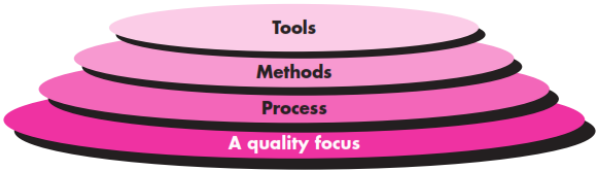


Figure 1. Step of Development Software (Presman, 2010)

2.5 Waterfall Process Model

The waterfall model uses a lifeflow approach to software that is being developed sequentially starting from requirements analysis and software specifications (communication), planning (planning), modeling (modeling), implementation or construction (construction), and delivery. software to users (deployment) (Pressman, 2010: 39). These stages can be seen in Figure 3 below.

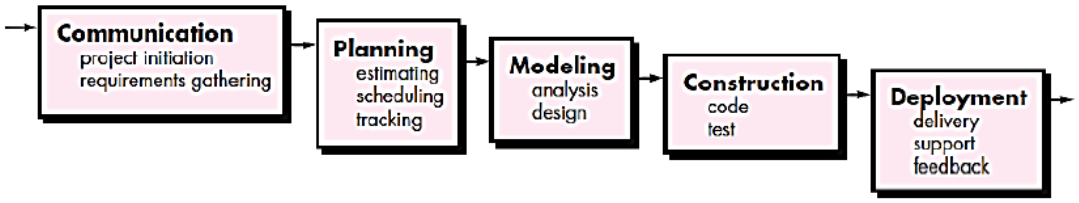


Figure 2. Waterfall Model of Software Development (Pressman, 2010)

3. METHODS

The flow of this research as the steps that will be used in research starting from the background of the problem, the formulation of the problem and the purpose of the research. The study of literature is used as a reference to research theory. Related to the project survey is the existing data input which is the data input for research variables on the management of the existing company until this research was conducted. After conducting a literature study and survey of project data, interviews with respondents and stakeholders were carried out to group desires which would later become inputs for determining attributes and also technical responses for modeling Android APK systems for monitoring and controlling multi-project construction.

From the results of the attribute grouping the desires of the respondents/stakeholders, the researcher then distributed questionnaires to the stakeholders who had been interviewed to get the weight of each attribute result which might be simultaneously or in parallel, a technical response would be made to these attributes. The results of the determination of the attributes and the technical response of the APK model will then be used as research variables which as input for Android APK modeling and in parallel will then be analyzed by adopting a House of Quality (HoQ) study.

3.1 Analysis of House of Quality

HoQ analysis is done with the following steps:

1. Perform calculations by providing an assessment of the relationship between the attributes (customer requirements) and the functional requirements attributes.
2. A strong relationship between attributes will be given a weight value of 9 (nine)
3. The relationship between weak attributes will be given a weight of 1 (one)
4. The next step is to assess the correlations between the technical response attributes (functional requirements) to determine which attributes support each other.Atribut respon teknis yang saling mendukung akan diberikan tanda tenda positif (+)
5. Attributes that can decrease other technical responses will be marked with a negative (-)

After conducting the House of Quality (HoQ) analysis, the order of the importance of the technical response attributes is used as a reference for compiling the Android APK model for the design of multi-project monitoring and control systems.

4. RESULTS

The analysis of the house of quality gets priority in designing a multi-project monitoring and control system that is modeled and applied in the form of an android application. For the results of the house of quality analysis, it can be seen in Figure 3.

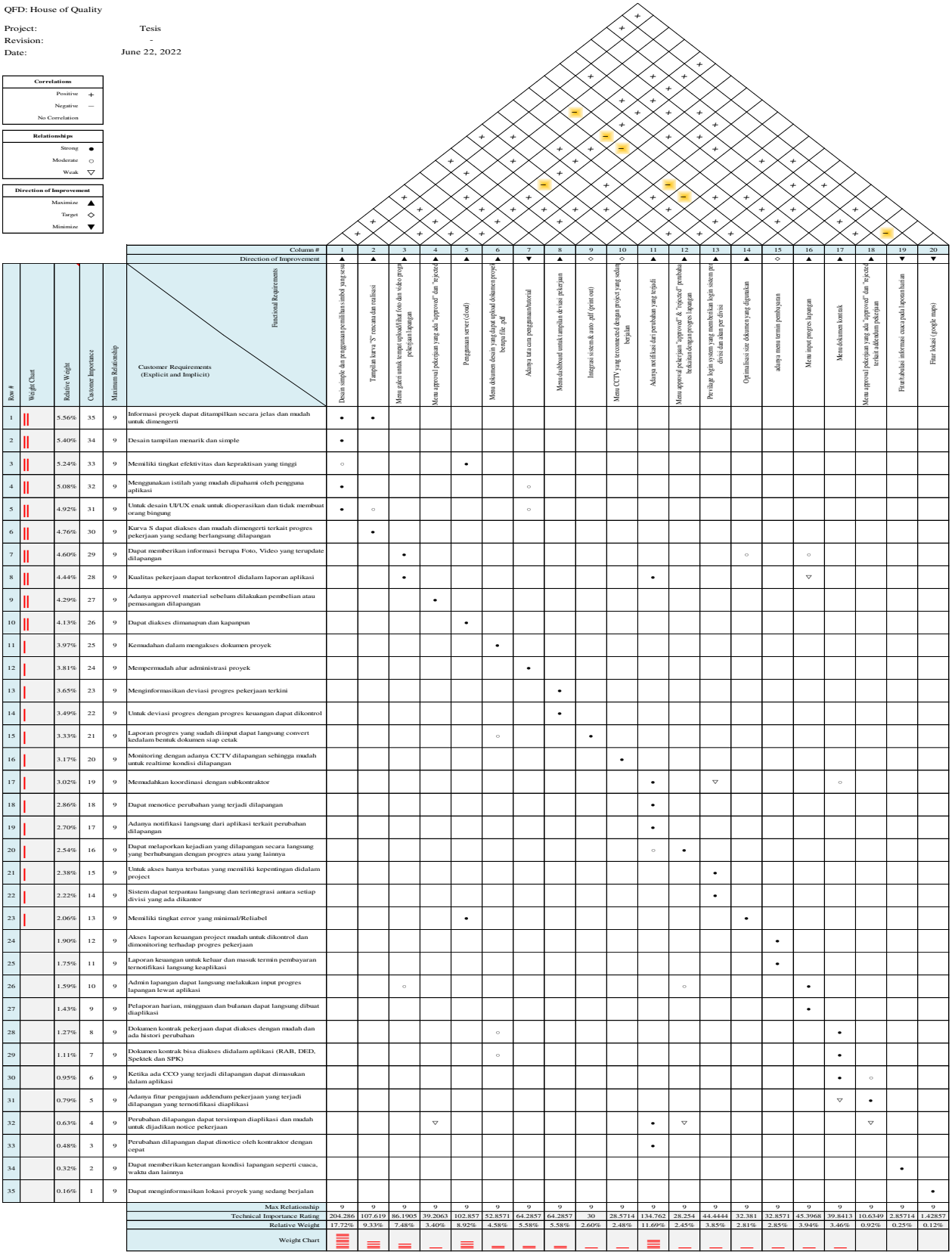


Figure 3. House of Quality Analysis

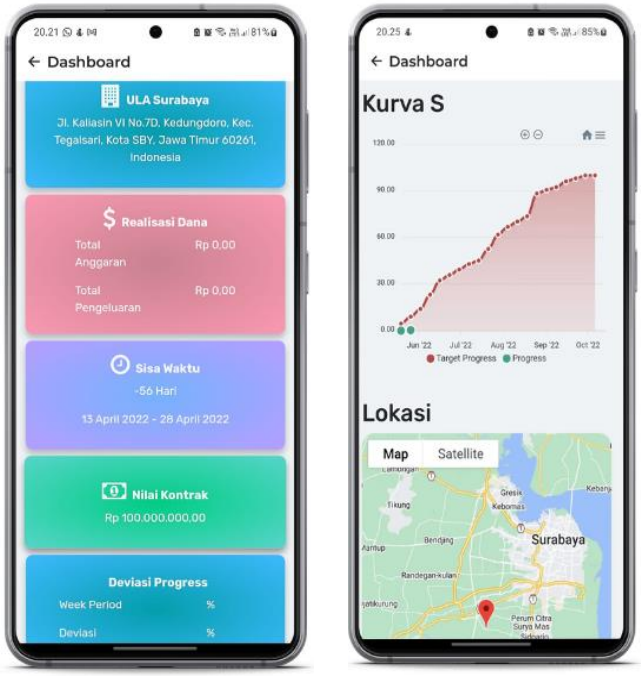


Figure 4. Menu Dashboard

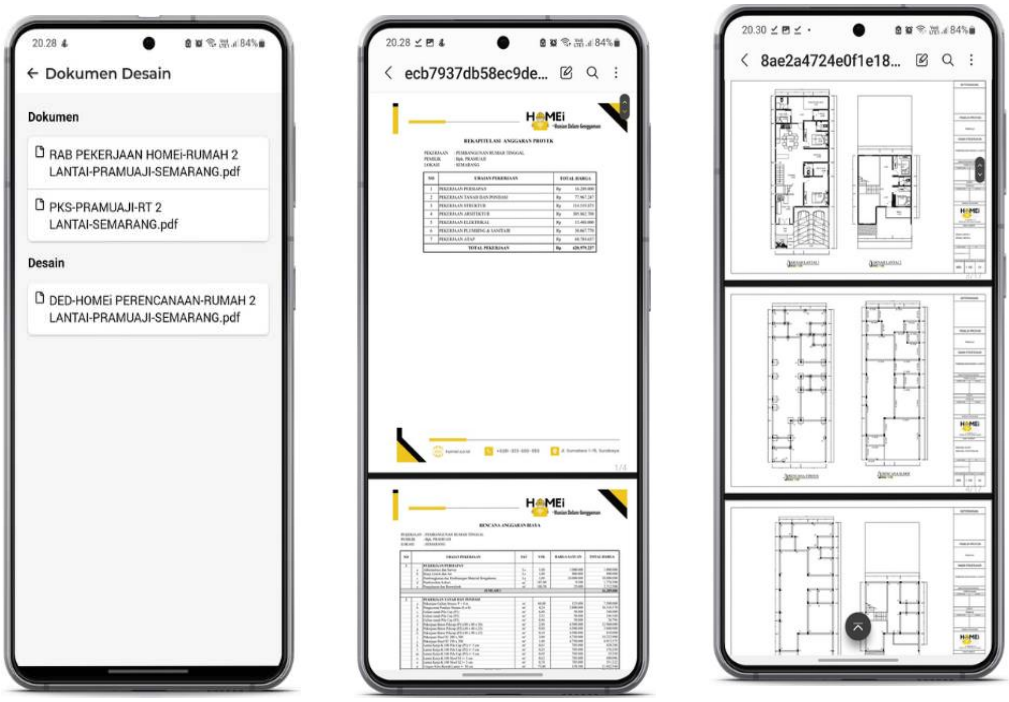


Figure 5. Menu Document Design

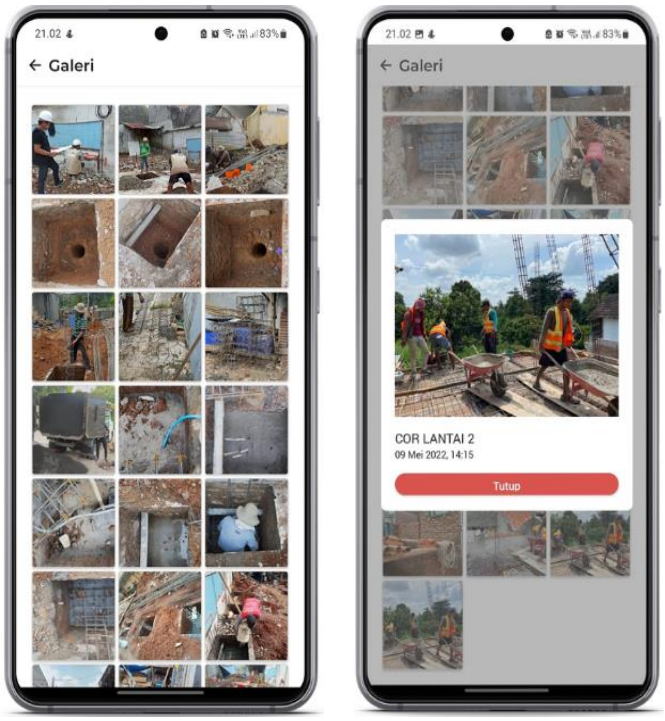


Figure 6. Menu Gallery Progress



Figure 7. Menu Financial

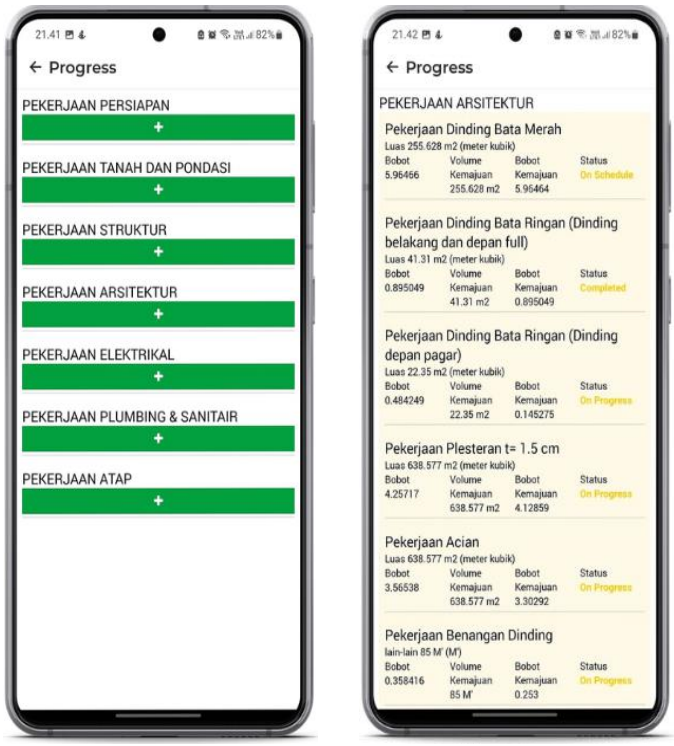


Figure 8. Menu Progress

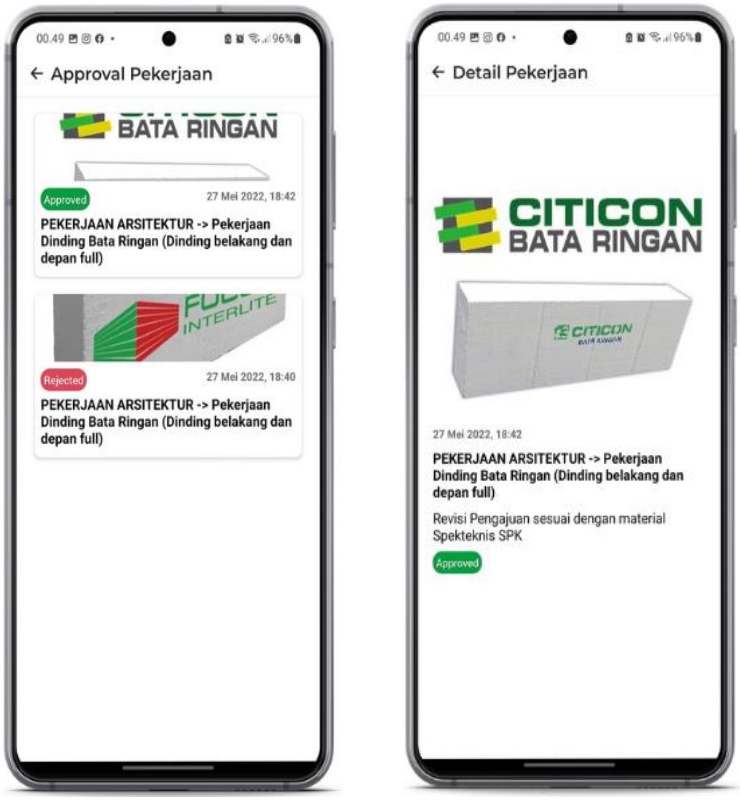


Figure 9. Work Approvel





Figure 10. Menu Termin



Figure 11. Menu CCTV

6. CONCLUSIONS

1. This research has implemented the House of Quality (HoQ) which has the following results:
   - Obtained 35 (thirty five) attributes of customer requirements, all of which were considered important with the highest score of 91 and the lowest of 60.
   - Of the 35 (thirty five) customer requirements attributes, 20 technical responses were obtained which were used as functional requirements which became the basis for compiling services on an Android-based multi-project monitoring and control system.
   - From the 20 functional requirements, it was obtained "simple design and use of appropriate symbol selection" the first rank with a value of 204.286 or 17.72% for relative weight, for the second rank is "there is notification of changes that occur" with a value of 134,762 or 11.69% and for the third rank is “Plan and realization S curve display” with a value of 107.619 or 9.33%.
2. The application of House of Quality (HoQ) can be structured and also systematically capable of being a method in selecting what services will be displayed in an Android-based multi-project monitoring and control system.

REFERENCES

Akao, Y. (1996). Quality Function Deployment on Total Quality Management and Future Subject. *QFD and TQM Series No.1 Quality Control*, *47(8)*, 55–64.

Zubair, A. M., Zaimi, M., Majid, A., & Mushairry, M. (2006). A systematic approach formonitoring and evaluating the construction project progress.

emardi, B. W., Wirahadikusumah, R. D., Abduh, M., & Pujoartanto, N. (2006). Konsep Earned Value untuk Pengelolaan Proyek Konstruksi. *Institut Teknologi Bandung*

Nugroho, Y. P., Sriyana, S., & Pranoto, S. (2012). *Pengembangan Sistem Informasi Manajemen Proyek Berbasis Website (Studi Kasus : Pelaksanaan Proyek Konstruksi di Kampus UNDIP Tembalang)* (masters)

Aprilliya, P., Effendi, U., & others. (2015). Analisis Perencanaan Strategi Peningkatan Kualitas Pelayanan Konsumen Dengan Metode Quality Function Deployment (QFD). *Industria: Jurnal Teknologi dan Manajemen Agroindustri*, *4*(1)

Marques, A., Varajão, J., Sousa, J., & Peres, E. (2013). Project Management Success I-C-E Model – A Work in Progress. *Procedia Technology*, *9*, 910–914

Siswanto Agus, 2017. Pengembangan Desain Sistem Monitoring dan Pengendalian Multi Proyek Konstruksi Menggunakan Metode House of Quality (Studi Kasus Dinas Pekerjaan Umum Kabupaten Gresik). *Tesis.* Departemen Manajemen Teknologi, Fakultas Bisnis dan Manajemen Teknologi, Institut Teknologi Sepuluh Nopember, Surabaya.

Husen, A. (2009). Manajemen Proyek; Perencanaan Penjadwalan dan Pengendalian Proyek. Penerbit Andi. Irawan, I. P. D., & Syairudin, B. (2015). Penjadwalan Multi Proyek Pembangunan Tower Pemancar Pt Smartfren TELEcom Di Surabaya Menggunakan Metode Critical Chain. Prosiding Seminar Nasional Manajemen Teknologi XIX.

STUDY OF RESEARCH IMPACT INFORMATION SYSTEM IN THE DIRECTORATE OF INNOVATION AND SCIENCE TECHNO PARK - ITS

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ABSTRACT

Based on Presidential Regulation of the Republic of Indonesia Number 106 of 2017 concerning Science and Technology Areas, the Science and Technology Area is a professionally managed vehicle to develop and encourage sustainable economic growth through the development of applications of science and technology and the growth of technology-based startup companies. The Innovation Research Assistance Program is owned by the Directorate of Innovation and Technology Science Area (DIKST) ITS as a management platform for the implementation of funding programs for research, procurement of goods and services, as well as monitoring and evaluation of research in the ITS academic community. To support the program with a long-term vision of innovation research success, it is also essential to examine the impact aspects of how DIKST ITS manages research in several categories, including academic and social. Build a business intelligence dashboard with visuals in the form of various KPI indicator diagrams, which will then be used as reports and can be used as insights for those involved in the implementation process.

Keywords: Science Techno Park, Impact Research, Business Intelligence

1. INTRODUCTION

Based on Presidential Regulation of the Republic of Indonesia No.106 chapter.8 (2017) concerning the Science and Technology area can be in the form of an integrated zone, which is an area that is unified in providing facilities and infrastructure for economic development and growth through the use of science and technology, and a connected zone, which is an area that is located in several separate but interconnected locations providing facilities and infrastructure for development and economic growth through the use of science and technology. The location in question must consider the effectiveness and accessibility of each location.

The university is synonymous with research and has great potential for creating activities that are updated or innovated by the entire academic community. Also, as a center of innovation, it will always have the potential to move innovatively, creatively,

and adaptively to changes that move dynamically along with technological developments. Through the Science Technopark (STP), ITS provides space for all academic communities to conduct research, development, and as a center for the application of technology in various existing clusters.

In order to achieve the objectives of increasing the value-adding production chain in innovation, an assistant is needed who functions to monitor research managed by the Directorate of Innovation and Science Technology (DIKST) ITS, especially research that has been successfully funded by various research funding institutions both from within and outside the organization. Innovation research assistance at ITS DIKST includes managing the implementation of funding programs for research, procurement of goods and services, as well as monitoring and evaluation of research. In addition, it is expected to have more of an impact on the institutions involved and the community than the research carried out. Through monitoring and evaluation activities carried out by both parties, DIKST ITS and the funding institutions involved currently only focus on the quality and productivity of research that is managed and funded, while based on Presidential Regulation Number 38 of 2018 in Article 7, there are three indicators of the achievement of targets in national research planning, namely input indicators, output indicators, and impact indicators. In order to measure the impact of research that is successfully managed and supported within the DIKST ITS environment, it is required for the institution to decide on the decisive indicators.

By leveraging the role of information and communication technology to support the requirement for managing information, bureaucracy, information integration between sectors and organizers involved in industrial cluster associations, as well as various other processes at DIKST ITS, as well as increasing the potential of human resources by the academic community and opportunities for competitiveness through innovations created digitally and consistently. The development of information systems in an organization has become a solution to maintaining the quality of data and information, which is increasing both in quantity and volume of data as well as in terms of the quality of services presented in research Wahyuniardi1, et al., (2016). The establishment of an information system is anticipated to be a solution for boosting the competitiveness of the Science and Technology Area (KST) at ITS, as it can provide general information about business processes, manage innovation research, the instruments involved, and provide an insight based on the outcomes of information management. In BI reports, data visualizations can be utilized to support policy.

Based on the background description, the formulation of the problem in this research is how to determine the indicators for measuring the impact of research funded and managed at the ITS DIKST and how to determine the concept of an information system to support the measurement of the impact of research on the ITS DIKST environment.

The aim of this study is to identify indicators for measuring the impact of research conducted in the ITS DIKST environment and formulate the design concept of research and innovation management information systems by building a business intelligence dashboard for visualizing KPI indicators from the impact of research in the ITS DIKST environment. In this study, the problem constraints are established, i.e., the innovative research data used in the study has a time span since the founding of DIKST, so that the debate is not too broad and can be focused on strategy analysis (2020). Only the research findings and KPI indicators used to monitor the effectiveness of the innovation research

are mentioned on the business intelligence dashboard.

2. LITERATURE REVIEW

2.1 Science Technopark

Based on Presidential Regulation of the Republic of Indonesia No.106 (2017), The Science and Technology Area is a specially prepared area and a vehicle that will facilitate the flow of inventions into innovation to increase productivity and competitiveness. professionally managed to develop and encourage sustainable economic growth through the development and application of science and technology and the growth of technology-based startups. Science Technopark facilitates the potential of local industries to conduct research, innovate, and then create organizations, objects, and spin-offs. Conducting coaching and mentoring in developing the industry is carried out by entrepreneurial incubators on participants with the aim of developing and utilizing science and technology to encourage economic growth. Through technological assistance, Science Technopark facilitates the development of industry through the through the assistance carried out by entrepreneurial incubators on participants with the aim of developing and utilizing science and technology to encourage economic growth.

In the explanation of Presidential Decree 106/2017 article 4, regarding the function of the science and technology area (KST), it is stated that KST has the following functions and services:

KST Functions

1. A platform for central government, regional governments, universities, R&D institutions, and industry to collaborate on sustainable development and research.
2. Promoting the growth of innovative businesses through incubation and/or spin-off.
3. Providing KST service recipients with value-added and high-quality services.

KST Services

1. Technical Include at least training, demonstration, and technical consultation information.
2. Technological Advancement Include at the very least: technology design, prototyping, intellectual property management, and legal consulting.
3. Incubation of Technology Businesses in the form of technology and management support for technology-based startups.
4. Assistance Service at least it includes limited-scale production facilities, office space, and conference/seminar/exhibition rooms.

2.2 Research Impact

According to the Australian Research Council (ARC) (2017), the impact of research is a tangible contribution resulting from research to the economy, society, environment, and culture beyond the contribution of academic research. Not much different from the Australian Research Council, in his research on the Research Impact Assessment written by Kementzky & Hinrichs-Krapels (2020), stating that the impact of research is a change or benefit that is proven to be real outside academia as a result of

research activities, driven by funding organizations, research or funders, namely the government or other public funders from a research funding institution. The Research Impact Assessment will be used as a means to analyze strong aspects such as effectiveness, efficiency, and equity of research. According to Nutley and Morton at Reed, et al. (2021), impact is defined as a change in "awareness, knowledge, and understanding; ideas, attitudes, and perceptions; and policies and practices as a result of research."

The main objectives of conducting a research impact assessment by Penfield et al. (2014) are to:

1. Overview of Higher Education Institutes (HEIs)
   Research organizations, including HEI, use this information to understand, monitor, and manage the performance of researchers in conducting research as well as to help disseminate the contributions of the research at local, national, and international scales.
2. Accountability
   To demonstrate the importance of research to the government, stakeholders, and the general public.
3. Funding Details
   To understand the socioeconomic value of research and further inform funding decisions. By evaluating the contribution made by what has been done to the community and economy, it will then have a good impact on funding institutions because funds are allocated where they are considered to have an impact.
4. Understand
   To understand which methods and research lead to real impact in order to maximize research results and make better developments.

Referring to Presidential Regulation Number 38 of 2018 concerning the 2017–2045 National Research Master Plan in Article 7, there are three indicators of target achievement in national research planning, namely input indicators, output indicators, and impact indicators. The output indicator is the achievement of the productivity of Science and Technology Human Resources in 2045 of as many as 22 (twenty-two) international scientific publications of renown for every 100 (one hundred) Science and Technology Human Resources. While the impact indicator is the achievement of 70 percent (seventy percent) multifactor productivity in 2045.

Payback Framework

Based on research by Donovan & Hanney (2011), the Payback Framework was originally developed by Martin Buxton and Stephen Hanney at the Health Economics Research Group (HERG) at Brunel University, UK, to examine the 'impact' or'return' of health care research in 1996 and was developed further. continued in a research study funded by the National Health Service (NHS) in 1998, and then extended collaboration with RAND Europe to also examine baseline and initial clinical biomedical research in 2004.

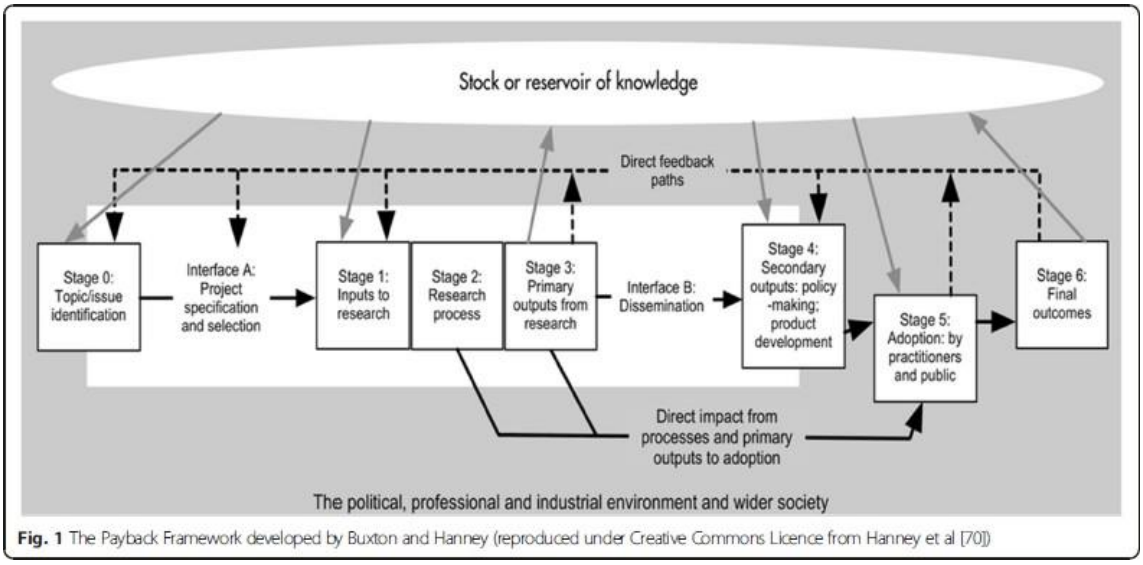


Fig. 1 The Payback Framework developed by Buxton and Hanney (reproduced under Creative Commons Licence from Hanney et al [70])

Figure 1 Payback Framework

The Payback Framework model facilitates research from the beginning (Stage 0), which is how to identify the topic, to the research process (Stage 2), the dissemination process (Interface B), and towards its impact on society, and also has the potential to achieve the expected final results and economic benefits (Stage 6). In the early stages (Stage 0), there may be two somewhat different forms of topic identification as the figure shown above.

Categories in the Payback Framework:

In the Journal of Clinical and Translational Science research by Latrice, et al. (2020) it is stated that the domain categories in the Payback Framework are as follows:

- Knowledge Production
- Research targeting, capacity building, and absorption
- Informing policy and product development
- Sector Benefits
- Broader economic benefits

Methods performed in the Payback Framework:

- Timeframe
- Case Selections
- Key Informant Interviews
- Bibliometrics Analysis
- Publication Data Collection
- Impact Measure

2.3 Business Intelligence

Business intelligence (BI) is defined as a decision-making process supported by the integration and analysis of critical organizational data resources and has been recognized for developing analytical-based decision-making capabilities in computer software and systems. If BI is developed as a tool and implemented for a company, it will provide several advantages, such as improved architecture and hierarchy of data information, information efficiency, and customer management. BI has become indispensable for strategic decision-making in companies around the world and has an important role for business survival because companies will face large datasets that cannot be used without BI. As a better decision-making tool, BI will build insights from

existing data. BI is the key to the development of industries in the era of smart factories, better known as "Industry 4.0." Romero et al. (2021). Business intelligence is a collection of mathematical models and analytical methodologies that are collected and integrated and available to generate information, insight, and knowledge to support decision-making processes and databases, providing easy access for business communications to complex business data in an organization. Steven, et al. (2021).

Power BI

In the implementation of BI implementation, several tools can provide standardization with a fast and persuasive decision-making process based on various data sources, which may affect the sustainability of the organization's market. Due to changes in the extrinsic business environment and the needs of the profession, new access to BI solutions, as well as BI self-services, have been introduced in recent years, and the number of market players using this approach is rapidly increasing, according to Upadhyay (2017). One of the BI tools used in the market is Microsoft Power BI.

Microsoft Power BI is a data analysis service created by Microsoft that is cloud-based and can provide a business analysis solution. Power BI is able to visualize data from various sources. Widowati and Yumni (2018) Power BI is a suite of business intelligence and business analytics tools for analyzing data and sharing insights, and can facilitate visualization and interactive data with fast performance. Using the dashboard available on every device, whether it's apps, desktop, mobile, or others, With the help of visuals and filters, so as to make users comfortable and easily understand the data, Bhargava et al. (2018).

3. METHODS

This research conducted in several stages. In the stage of data collection, data and various needs are obtained by observing the DIKST ITS and its environment, as well as several websites related to the science and technology area. And they understand directly what needs must be met based on the data collected. Conduct interviews with several administrators and members to get a real of situation, conditions, and business processes of its DIKST, and then Collect some documentation to support research such as system flow documents and business processes that are currently running at ITS DIKST.

The next step is data processing. Data and information gathered in the previous stage will be processed. Data processing is the process of converting data into usable or desired forms according to research needs. Data processing is done to determine models and get insights that have an impact on a business process, especially in the development of information systems as business intelligence report. In data processing systems, analysis of a business process is needed to know the real condition of innovation research at DIKST. Data processing is carried out to determine the model and gain insight that has an impact on a business process, especially in the development of information systems.

Identification of Research Impact Measurement Indicators. At this stage, the requirements and data that have been collected either through observation, interviews, or documentation that have been collected, then identify the indicators used in measuring the impact of the research. Based on the literature study on the research impact measurement framework, which is mostly used in health research, the following is a comparison of each framework:

Table 1Table Of Framework Comparison

Research Impact Measurement Framework	Pro	Cons
Payback Framework	• Starting with which project/research is being funded, this measurement framework is project-focused. • The indicators used are not limited to the health sector and can be applied in a variety of other fields.	Not suitable for inter-agency or inter-funder group projects.
Canadian Academy of Health Sciences (CAHS) Framework	Focus more on producing products and working with government to build a work environment that supports research and impact economic and social.	The indicators used are more focused on government policies and regulations.
Monetisation Models	The emphasis on economic indicators and inter-agency cooperation can be applied broadly, not just in the health sector.	Focus on the economy and output in the form of policies for institutions.
Societal Impact Assessment	Detailed assessment in the context of both qualitative and quantitative metrics on the interactions, outputs, and results of a study.	• This model does not allow comparisons between programs and across projects. • It focuses only on subjective research and requires a detailed qualitative and quantitative assessment of all subject

		interaction.
UK Research Excellence Framework	Focus groups, interviews, surveys, and documentary analysis were used to develop the European Rand. a scoring system based on discussions in the research sector.	Many research cases are given low points without providing more detailed and detailed information.

Based on the comparison table above, it can be concluded that the appropriate framework in this study uses the Payback Framework because it focuses on each project in the DIKST ITS environment.

By using the Payback Framework method, the collected data is then identified and classified based on the following points:

1. Timeframe Time Range of Research Research Data in the ITS DIKST Environment.
2. Case Selection Research Research to distribute cases across all Payback Framework criteria by considering the relevance of inputs and outputs from the research research.
3. Key Informant Interviews: Conduct interviews or data collection according to the categories of the Payback Framework, namely:
    - Knowledge Production
    - Research Targeting, Capacity Building, and Absorption
    - Informing policy and product development
    - Sector Benefits
    - Broader Economic Benefits
4. Publication Data Collection Outcome analysis of research research in the form of publications.

Based on indicators from the results of measuring the impact of research, the stages in developing a business intelligence dashboard are:

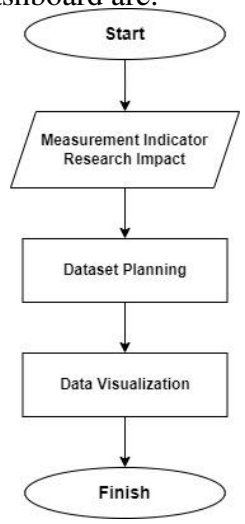
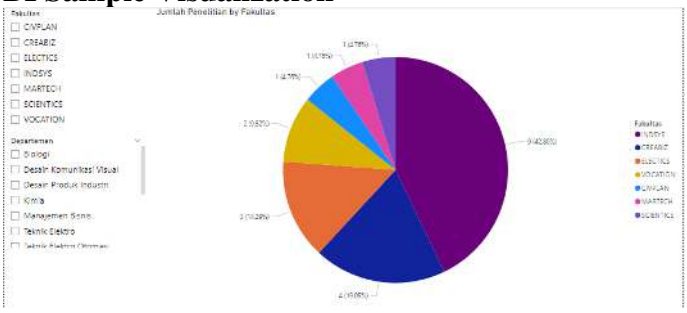


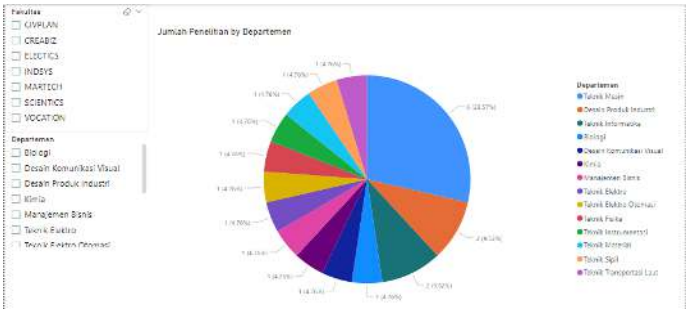
Figure 2 Stages of Business Intelligence Development

4. RESULTS

Payback Domains	Result
Knowldege Production	
Has the research produced a product?	Most of the research is still ongoing and is in its second and third year.
How far is the product of the research achieved?	At least for intellectual property rights, there must be some research results in the form of prototypes that have been produced on a small scale.
Research Targeting, Capacity Building, & Absorption	
What is the scope of the research targets?	All studies have defined their scope well and on target.
Is there additional funding for research?	Usually in the second and third year, if it is considered feasible by an external reviewer, research funds are immediately given, excluding additional funds from other funders. The absorption of research funds must be considered.
Has this research been discussed with the parties in the related research sector?	All studies have conducted discussions with related parties and also routinely scheduled monitoring and evaluation, both internal and external to DIKST.
Informing Policy & Product Development	
Are there outcomes or products from research that have been produced and/or adopted by practitioners in the relevant research sector?	Mostly at least for intellectual property rights there must be some research results in the form of prototypes that have been produced on a small scale.
Are there new policies that can be generated from this research?	So far, the scope of research is in the form of a prototype and not on a large-scale commercial manufacturing scale.
Sector Benefits	
What is the overall impact on the relevant research sector?	The impact on all sectors is highly considered in accordance with the research sector and the target scope under study.
Are there potential mechanisms that impact each research sector?	Of course, there will be a lot of potential for further research that can be carried out by the civitas within the ITS environment.
Broader Economic Benefits	
What is the economic benefit of the research (if any)?	
Is there an economic burden on the research? And if there is how to solve it?	So far, all research is in accordance with the range of funds provided.

BI Sample Visualization





5. CONCLUSIONS

We can draw conclusions from a series of studies that vary from problem identification to needs analysis to determining information system design based on problem formulation and research objectives, all based on research and analysis. By using the Payback Framework in measuring the impact of research, it is possible to map and involve all instruments of research aspects and benefits based on the research sector, research funds, research actors, and the outcomes of the research. Further details of the data and information can be visualized properly with the Power BI Platform so that it can assist in monitoring and evaluation as well as the impact of research managed by DIKST ITS. This conclusion can be used as improvement material in future research.

REFERENCES

Bhargava, M. G., Kiran, K. T. P. S. & Rao, D. R., 2018. Analysis and Design of Visualization of Educational Institution Database using Power BI Tool. Global Journal of Computer Science and Technology: C Software & Data Engineering, 18(4), pp. 1-9.

Council, A. R. (2017). *Engagement and Impact Assesment Pilot 2017.* Australia: Commonwealth of Australia 2017.

Donovan, C., & Hanney, S. (2011). The 'Payback Framework' explained. *Research Evaluation, 20*(3), 000-000.

Indonesia, R. (2018). Peraturan Presiden Republik Indonesia Nomor 38 Pasal 7-8. *Tentang Recana Induk Riset Nasional Tahun 2017 - 2045*.

Kementzky, & Hinrichs-Krapels. (2020). How do organisations implement research impact assessment(RIA) principles and good practice? A narrative review and exploratory study of four international research funding and administrative organisations. *Health Research Policiy and Systems*.

Latrice, R., Nicole, L., Manzi, N., Eric, N., Dorothy, R., & M.Sands, C. a. (2020). Using the payback framework to evaluate outcomes of pilot projects supported by the Georgia Clinical and Translational Sciene Alliance. *Journal of Clinical and Translational Science*, 1-9.

Penfield, T., Baker, M. J., Scoble, R., & Wykes, M. C. (2014). Assesment, evaluations, and definitions of research impact: A review. *Research Evaluation 23*, 21-32.

Reed, M., M.Ferre, J.Martin-Ortega, Blanche, R., Lawford-Rolfe, R., Dallimer, M., & Holden, J. (2021). Evaluating impact from research : A methodological framework. *Research Policy 50*.

Republik Indonesia, 2017. Peraturan Presiden Republik Indonesia Nomor 106 Pasal 8. *Tentang Kawasan Sains Dan Teknologi.*

Romero, C. A. T., Ortiz, J. H., Khalaf, O. I. & Prado, A. R., 2021. Business Intelligence: Business Evolution after Industry 4.0. Sustainability 2021, Volume 13, pp. 1-12.

Steven, K., Hariyanto, S., Arijanto, R. & Wijaya, A. H., 2021. Penerapan Business Intelligence Untuk Menganalisis Data Pada PT. Suryaplas Intitama Menggunakan Microsoft Power BI. Jurnal Algor, 2(1), pp. 41-50.

Upadhyay, A. B. A. K., 2017. Microsoft Power BI. International Journal of Soft Computing and Engineering (IJSCE), 7(3), pp. 14-20.

Wahyuniardi1, R., Afrianti2, L., Nurjaman1, S., & Gusdya3, W. (2016). Pembangunan Sistem Informasi Berbasis Web Untuk Monitoring Dan Evaluasi Sentra Industri Kecil Dan Menengah Di Jawa Barat. *4*.

APPLYING BLUE OCEAN STRATEGY FOR BUSINESS DEVELOMPENT: A CASE STUDY OF ENGINEERING CONSTRUCTION COMPANY

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ABSTRACT

The engineering construction industry nowadays is highly competitive and requires companies to continuously explore the various strategy to maintain their competitive position. Driven by infrastructure development and growth in other sectors, this industry remains attractive. The existing companies need to identify a new strategy to maintain and improve their competitiveness. Employing Blue Ocean Strategy Framework, this research attempts to identify opportunities business development strategy for a case study of engineering construction company. The current competitive position of the company was analyzed using PEST, Porter Five Forces and SWOT Analysis. Using interviews and focus-group discussion, the analysis of Eliminate-Reduce-Raise-Create (ERRC) was then performed to determine the best strategy to develop its current business.

Keywords: Business Development, Blue Ocean Strategy, ERRC

1. INTRODUCTION

The contribution of construction to the Indonesian economy is in fourth place, 10.12 percent of Indonesia's Gross Domestic Product (GDP) in the second quarter of 2021. The Central Statistics Agency (BPS) monitors construction progress through the Quarterly Construction Company Survey (SKTR) conducted on construction companies. medium and large scale in Indonesia. (BPS, 2021)

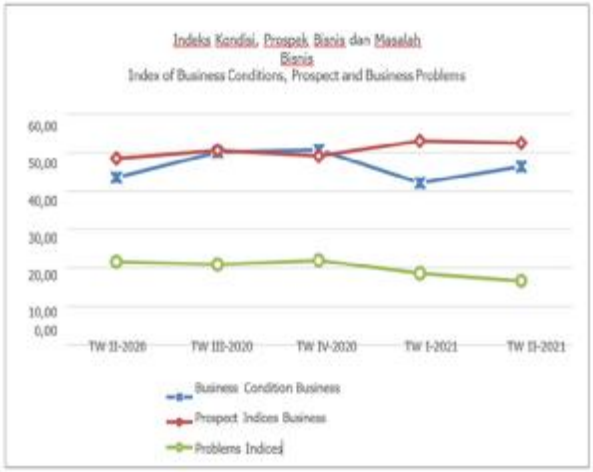


Figure 1. Graph of business conditions, business prospects & business problems in Indonesia

In the midst of the intense competition in this business, companies are required to be able to find innovative and creative business ideas and strategies. With a creative strategy, creative business opportunities will open. Companies need to implement innovations that business competitors don't think of. Although innovations are created outside of the comfort zone. One of the strategies implemented is the Blue Ocean Strategy.

The existence of this research is a case study at Engineering Construction Company and expected to provide benefits to find out its current strategic position which can then be used to provide appropriate business strategy proposals in the company's business development. Internal and external analysis using SWOT, PEST & 5 Force Porters. From the SWOT, PEST & 5 Force Porters analysis, optimization or development of the company's business strategy is carried out by combining Blue Ocean Strategy, Eliminate-Reduce-Raise-Create (ERRC).

2. LITERATURE REVIEW

2.2.1 PEST

Organizational external environmental factors which include analysis of political, economic, social and technological factors (PEST) can affect the activities and performance of an industry (Wheelen & Hunger, 2012). The PEST analysis model is carried out by collecting and describing information about external factors that have the potential to affect the business. PEST analysis is useful for assessing the market of a business unit or organizational unit. Directional PEST analysis is a framework for assessing a situation, and assessing a strategy or position, company direction, marketing plan or idea. This analysis can analyze a new opportunity or threat for the company (Ward & Peppard, 2002)

2.2.2 FIVE FORCE PORTERS

Competition in an industry depends on five competitive forces. This set of forces determines the profit potential in the industry as measured by the long-term return on invested capital (Ward & Peppard, 2002). Analysis of Porter's Five Competitive Factors (Porter's Five Forces) provides a powerful picture of how the level of competition in an industry is, both in terms of suppliers (suppliers) and customers (supply chain) as well as markets (new players and substitutes or substitute products). These four forces contribute to competitive rivalry or the level of competition in the industry.

2.2.3 SWOT

SWOT analysis is a strategic planning method that functions to evaluate the strengths, weaknesses, opportunities, and threats of a company (David & David, 2017). This process involves determining the specific objectives of the business speculation (opinion) and identifying the internal and external factors that support and which do not achieve these goals. SWOT analysis is the identification of various factors systematically to formulate company strategy (Rangkuti, 2016). This analysis is based on logic that can maximize strengths and opportunities, but simultaneously minimize weaknesses and threats. The strategic decision-making process is always related to the development of the company's mission, objectives, strategies, and policies. Thus strategic planning must analyze the company's strategic factors, namely strengths, weaknesses, opportunities and threats in the current conditions. SWOT following PESTEL analysis can easily compete following company’s current strategy since value; growth and innovation are the core elements forming the

foundation of this business. Together, company define the strategic directions and the structural plan as well as the driving force behind Company's vision (Onyusheva et al., 2020).

2.2.4 BLUE OCEAN STRATEGY

Blue Ocean is a strategy that focuses on customers with the main paradigm of "*how to make competition Irrelevant"*, which in its implementation must be meet customer demands. To get the exact customer needs, *customer intelligence skills* are needed, namely by conducting research & market studies carefully (Kim & Mauborgne, 2015). Blue Ocean plans to catch new requests, and to make rivalry unessential by presenting an item with unrivaled highlights. It enables the organization in make gigantic benefits as the item to can be valued somewhat soaked in view of its remarkable highlights (Rezeki et al., 2019).

In principle, Blue Ocean Analysis is divided into 5 stages of the process with 6 tools used (Kim, W. Chan; Maugborgne, 2018) :

1. Get Started
   - The tool used is Map Pioneer – Migrator – Setler (PMS Framework)
2. Understand where you are now
   - The tool used is Canvas Strategy
3. Imagine where you could be
   - The tools used are buyer utility map framework & Three tiers of non customer framework
4. Find how you get there
   - The tools used are Six paths frameworks & Four action frameworks / ERRC (Eliminate Reduce Raise Create)
5. Make your move
   - Alternative selection & market test

3. METHODS

In conducting the PEST & Five Force Porters analysis, the data are obtained from:

- Analyse & observe the PEST & Five force porters factors that currently have an effect on the business climate. These data, hereinafter referred to as secondary data, are obtained from online, offline media, journals.
- Focus Group Discussion (FGD) consisting of 6-8 top management with the positions of General Manager & Board of Directors from similar companies and classification of middle and or greater grade.

This FGD discussed issues that are developing in the current business world, sharing experiences and input for engineering construction company to develop their business.

As the basis for determining the company's business development strategy, customer satisfaction analysis is then carried out. This analysis is carried out by distributing customer satisfaction questionnaires to 3 main elements of work, namely: Cost, Quality, & Time, and other factors, and customers are expected to provide input to companies.

After all the data and information that affect the continuity of the company, the next step is to utilize these data in a quantitative model of strategy formulation. SWOT analysis provides four perspectives by identifying how the strengths and weaknesses that exist within the company and

how the opportunities and potential threats faced by the company. The identification of opportunities and threats comes from external data (EFAS) obtained from the PEST & Five Force Porters analysis & customer satisfaction analysis. While the identification of strengths and weaknesses comes from internal data (IFAS) obtained from questionnaires distributed to all internal stakeholders of the company. In conducting a SWOT analysis, several models are used at once in order to obtain a more complete and accurate analysis. The model used for SWOT analysis IE Matrix & QSPM

In this study, the blue ocean analysis used is stages 2 and 4 because the core of the blue ocean strategy theory is customer needs/demands and is followed up with market differentiation. by using ERRC tools or a four-Step framework, namely: Eliminate Threats / Eliminate Threats, Reduce Weakness / Reduce Weaknesses, Raise Strengths / Increase Strengths, Create Opportunities / Create Opportunities.

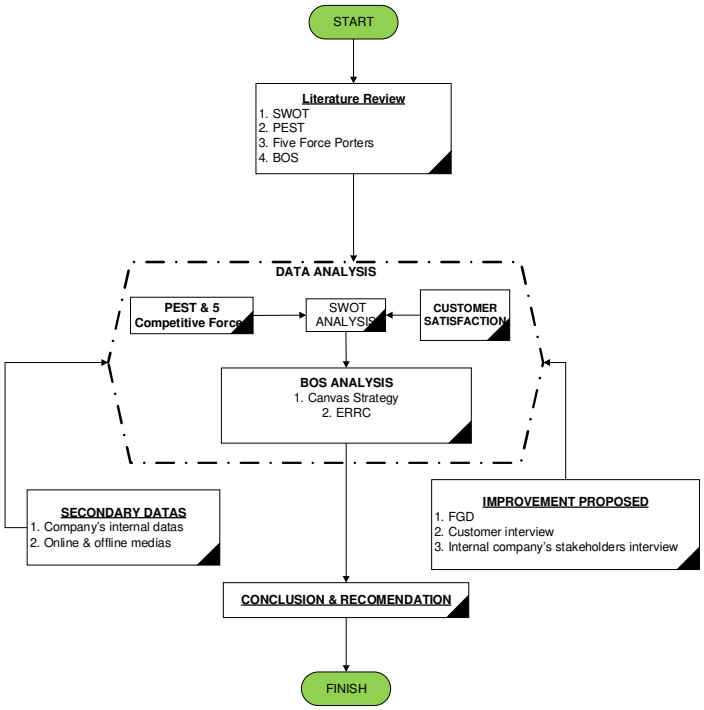


Figure 2. Flowchart Research Methods

4. RESULTS

The following are the results of the FGDs that have been carried out which greatly influence the determination of the company's strategy:

PEST indicators

- The cost of setting the minimum wage in Indonesia
- Maximum working hours a week 40 hours & a maximum of 18 hours overtime (PP no. 35/2021)
- The importance of management Information System applications
- Loyal workers

Porters' Five Force Indicators

- Suppliers with payment due
- Supplier of e-commerce with very low price

- The entry of Chinese products at low prices
- The number of competitors for construction services at the middle grade level

Suggestion

- Fellow construction service companies, for at least there is communication, especially mutually beneficial cooperation to deal with the unfavorable conditions in advance
- Improvisation & Ability to specialize construction in special fields
- Rules can be made where the distribution of orders for small and medium-sized companies in the area of the company is located. Rules for state-owned construction services are made more reasonable in price, because state-owned enterprises are at a low price, the private sector cannot compete. In other words, state-owned enterprises dare to lose, this will also harm the government.
- Stay optimistic, every business must have competition while maintaining quality, the business world will continue to change along with the development of technology and information, of course, must be followed for the progress and development of a business, especially in the field of construction services still have to move forward and develop.

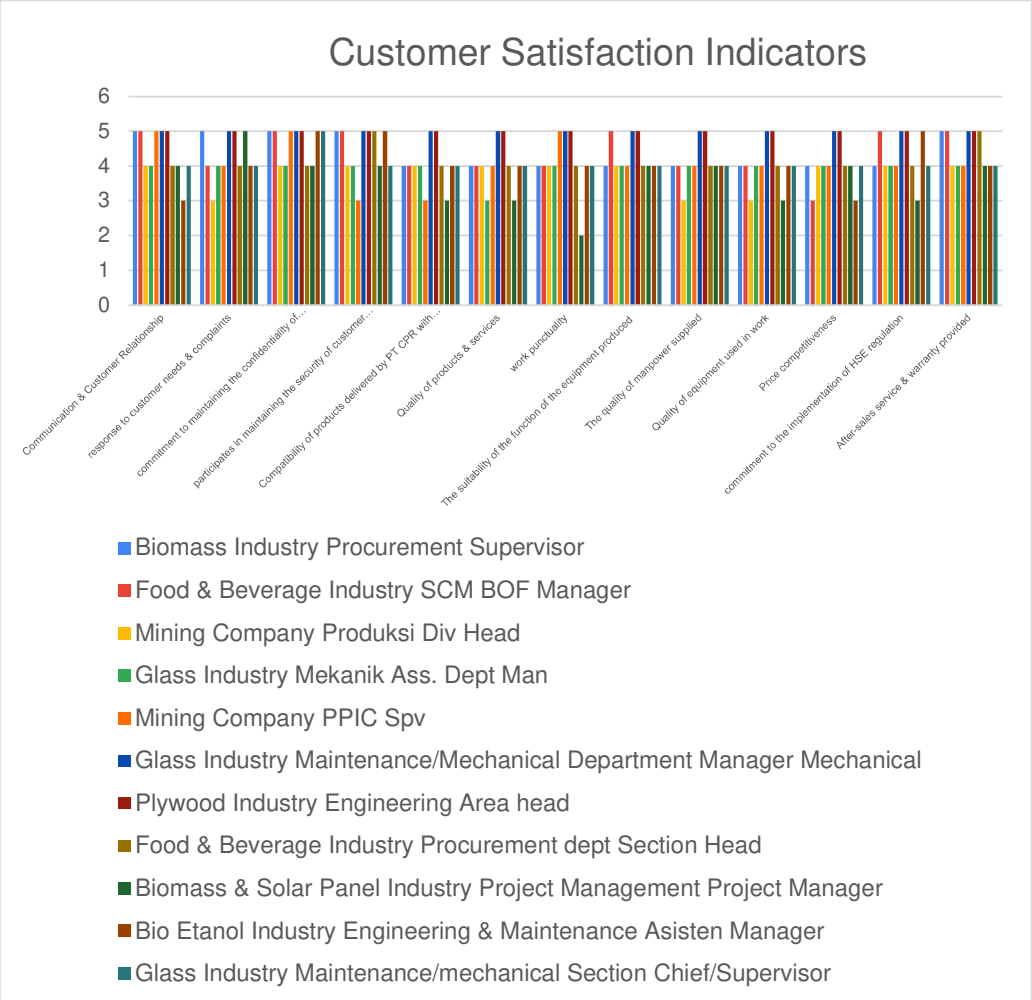


Figure 3. Customer Satisfaction Indicators

Based on the graph above, it is known that the customer response has a good & very good score, which means the company needs to maintain & improve as well as expand to other companies.

The parameters used in the Internal – External matrix include the parameters of the company's internal strength and external influences faced. The purpose of using this model is to obtain a more detailed business strategy at the corporate level.

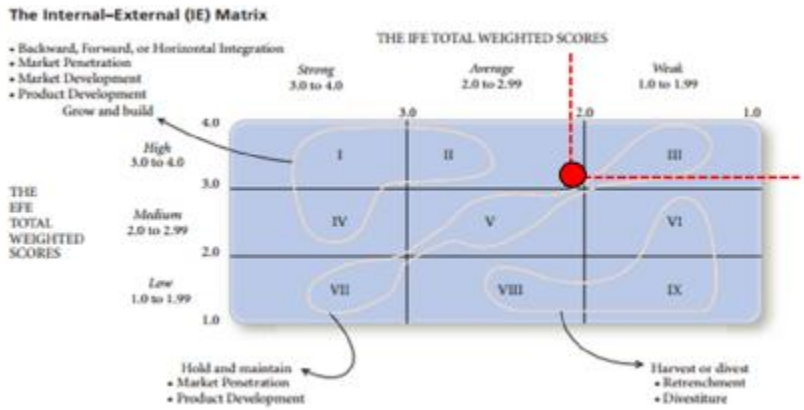


Figure 4. IE Matrix

Based on Figure 2 above, it is known that the position of company is in quadrant 2, namely the company is in the Grow & build strategy zone, then the business strategy that should be carried out are *Horizontal Integration, Market Penetration & Product Development*.

After the alternative strategies appear in the IE Matrix Analysis Analysis, the next analysis is the Quantitative Strategic Planning Matrix (QSPM) Analysis, in this analysis the best choice will be obtained among the alternative strategies generated from the IE Matrix quadrant. The results of alternative strategies that emerged from the SWOT Analysis were handed back to the informants, namely through FGDs consisting of 8 top management from similar companies for weighting or Attractive Score. From the QSPM table below, it is known that the largest TAS value with a value of 5.54 is for an alternative product development strategy by making improvements and specializing in construction services.

Table 1. QSPM Matrix

QSPM			ALTERNATIVE STRATEGI					
			HORISONTAL INTEGRATION		PRODUCT DEVELOPMENT		MARKET PENETRATION	
QUANTITATIVE STRATEGIC PLANNING MATRIX			JOINT VENTURE		PRODUCT IMPROVEMENT & SPESIALISASI		EXPANDING MARKET REACH	
No	(STRENGTH)	WEIGHT	AS	TAS	AS	TAS	AS	TAS
No	(OPPORTUNITY)	WEIGHT	AS	TAS	AS	TAS	AS	TAS
1	Huge market construction in Indonesia	0,07	2,00	0,14	3,00	0,21	4,00	0,28
2	Government policies to accelerate development	0,07	2,00	0,14	1,00	0,07	3,00	0,21
3	Abundance of project workforce	0,07	2,00	0,15	2,00	0,15	3,00	0,22
4	Many new suppliers who want to become vendors	0,07	2,00	0,14	2,00	0,14	2,00	0,14
5	Many banking institutions / lenders to channel their funds	0,07	2,00	0,14	3,00	0,21	4,00	0,28
6	Purchase materials & tools in very cheap e-commerce	0,08	1,00	0,08	2,00	0,15	2,00	0,15
7	This organization is a few of the many medium grade construction services that have EPC capabilities	0,07	2,00	0,14	3,00	0,21	3,00	0,21
	TOTAL OPPORTUNITY	0,50						
No	(THREAT)	WEIGHT	AS	TAS	AS	TAS	AS	TAS
1	Huge competition among middle-grade companies	0,07	2,00	0,15	4,00	0,29	4,00	0,29
2	Competitors are easy to imitate the innovations made by the organization	0,07	2,00	0,14	4,00	0,28	1,00	0,07
3	Government regulation regarding 11% VAT increase	0,07	1,00	0,07	1,00	0,07	1,00	0,07
4	Relatively high minimum wage	0,07	3,00	0,20	3,00	0,20	2,00	0,13
5	The complexity of investment licensing in Indonesia	0,07	2,00	0,13	2,00	0,13	1,00	0,07
6	Rise in material prices due to the impact of the Russia-Ukraine war	0,08	2,00	0,16	2,00	0,16	1,00	0,08
7	The entry of imported goods from China are very cheap	0,07	2,00	0,15	3,00	0,22	3,00	0,22
	TOTAL THREAT	0,50						
	TOTAL EFAS	1,00		4,84		5,54		5,02

Canvas Strategy is a tool to see where the company is now among competitors (Understand where we are now). This strategy is a strategy that is commonly used in Blue Ocean Analysis, the data is taken from customer interviews with competitors

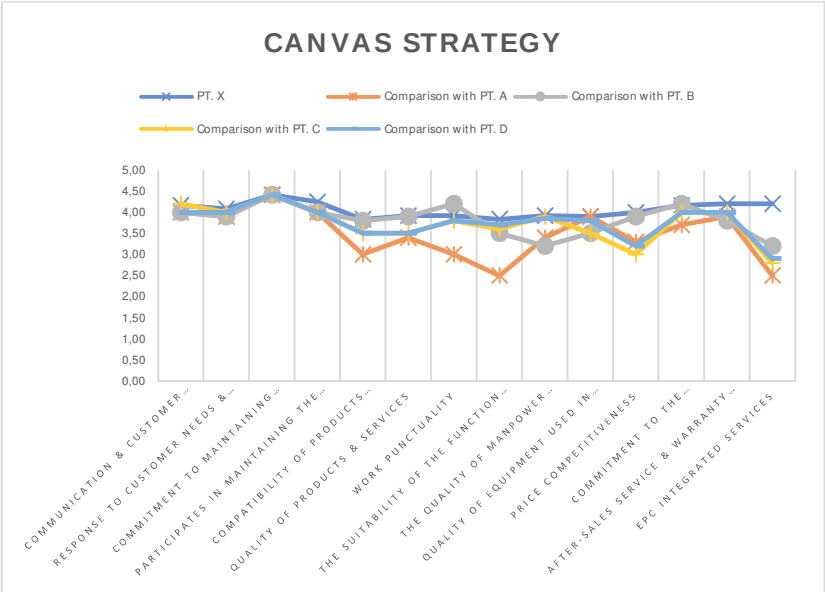


Figure 5. Canvas Strategy

Then an ERRC analysis is carried out on the factors that support alternative strategies from the QSPM results by taking the 3 largest TAS values for each internal and external factor of the company.

Table 2. ERRC Matrix

BLUE OCEAN STRATEGY			ALTERNATIVE STRATEGI	
			PRODUCT DEVELOPMENT	
ERRC TOOLS			PRODUCT IMPROVEMENT SPESIALISASI	
No	**ELIMINATE - ANCAMAN (THREAT)**	**WEIGHT**	**AS**	**TAS**
1	Huge competition among middle-grade companies	0,07	4,00	0,29
2	Competitors are easy to imitate the innovations made by the organization	0,07	4,00	0,28
7	The entry of imported goods from China are very cheap	0,07	3,00	0,22
No	**REDUCE - KELEMAHAN (WEAKNESS)**	**WEIGHT**	**AS**	**TAS**
1	Strong Engineering capabilities	0,06	4,00	0,26
3	Less quality culture	0,07	4,00	0,27
6	Lack of manufacturing facilities	0,08	4,00	0,31
No	**RAISE - KEKUATAN (STRENGTH)**	**WEIGHT**	**AS**	**TAS**
1	Liquidity of managed funds	0,06	4,00	0,22
5	Sufficient physical facilities & infrastructure	0,06	4,00	0,25
6	Having competent human resources & young at heart so it has the potential to be developed	0,06	4,00	0,23
No	**CREATE - PELUANG (OPPORTUNITY)**	**WEIGHT**	**AS**	**TAS**
1	Huge construction market in Indonesia	0,07	3,00	0,21
5	Many banking institutions / lenders to channel their funds	0,07	3,00	0,21
7	This organization is a few of the many medium grade construction services that have EPC capabilities	0,07	3,00	0,21

6. CONCLUSIONS

The formulation of engineering construction companies's business development strategy is as follows:

- § SWOT analysis with strength & weakness parameters comes from the company's internal questionnaire and Opportunities & Threats parameters obtained from FGD and customer satisfaction questionnaires generated by companies's business development strategies which are in the growth & build zone are Horizontal Integration, Market Penetration and Product Improvement. Then, the strategy that needs to be carried out through the QSPM method is an alternative strategy for Product Improvement
- § Strategy Canvas – Blue ocean tools, taken from customer interviews on the performance of several vendors stating that the company is superior in product improvement and engineering support.
- § ERRC – Blue Ocean tools. These tools are the most important in the Blue Ocean strategy, because with these tools the company is required to know "How to create", then it produces several threat factors that must be eliminated, namely great competition, products that are

easy to imitate & the inclusion of Chinese products. While the weakness factors that must be reduced are weak engineering, poor quality culture & manufacturing facilities. The strength factors that must be raised are the liquidity of funds owned, adequate infrastructure and quality of human resources. The last factor is creating opportunities, namely taking advantage of the vast market in Indonesia, offers of capital from banks and improvements in engineering so that company can have differentiation among other medium-grade construction service companies.

REFERENCES

BPS. (2021). INDIKATOR KONSTRUKSI. *Katalog 6302002*, *TRIWULAN I*.

David, F. R., & David, F. R. (2017). Strategic Management A Competitive Advantage Approach, Concepts & cases. In *Pearson Education Limited*.

Kim, W. Chan; Maugborgne, R. (2018). *BLUE OCEAN - SHIFT* (third edit). Gramedia Pustaka utama.

Kim, W. C., & Mauborgne, R. A. (2015). Blue Ocean Strategy, Expanded Edition: How to Create Uncontested Market Space and Make the Competition Irrelevant. In *Harvard business school publising corp* (Vol. 53, Issue 9).

Onyusheva, I., Machula, M., & Manuthammathorn, T. (2020). Strategic Analysis for Business Success: the Case of Vgi Company. *The EUrASEANs: Journal on Global Socio-Economic Dynamics*, *3*(3(22)), 7–22. https://doi.org/10.35678/2539-5645.3(22).2020.7-22

Rangkuti, F. (2016). *ANALISIS SWOT TEKNIK MEMBEDAH KASUS BISNIS* (22nd ed.). Gramedia Pustaka utama.

Rezeki, S., Gede Eko Putra Sri Sentanu, I., Sanawiri, B., Shankar, K., & Nguyen, P. T. (2019). Blue ocean strategy for creating value of the organization: Examination of differentiation with red ocean strategy. *International Journal of Recent Technology and Engineering*, *8*(2 Special Issue 11), 3827–3831. https://doi.org/10.35940/ijrte.B1504.0982S1119

Ward, J., & Peppard, J. (2002). Strategic planning for an information system. In *john willey & son, ltd: Vol. 3rd editio*. https://doi.org/10.1016/0024-6301(90)90122-k

Wheelen, T. L., & Hunger, J. D. (2012). *Strategic Management Model and Business Policy*.

DEVELOPMENT OF RISK MANAGEMENT ON THE DELAY OF POWERED ROLLING STOCK PROJECT AT XYZ

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ABSTRACT

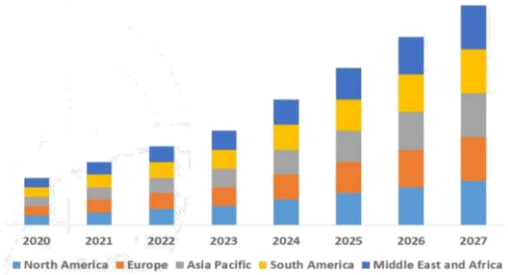
Rolling stock projects in Indonesia and abroad have become important in meeting the growing demand for transportation. The process of procuring rolling stock has potential associated risks and also be able to cause delays in the procurement process, resulting in penalties or even termination of a project's contract. From all rolling stock procurement projects handled by XYZ, there were delays as indicated by the difference in lead time of planning and realization of 35.58% - the average delay. This study aims to be able to develop a mitigation strategy for the potential risks that occur by adopting the process of procuring powered rolling stock in 2018 – 2022.This research went through 3 stages, which began with the process of identifying potential risks , analyzing the results using the Failure Mode and Effects Analysis (FMEA) method, identifying mitigation strategies through Focus Group Discussions (FGD), and also Analytical Hierarchy Process (AHP) method is used to determine mitigation priorities. The results of this study obtained 4 priority risks at each stage of the procurement of powered rolling stocks including the long time approval risk (to the customer) (RPN value of 38.98) with 4 mitigation strategies, Lack of coordination between units / subsidiaries (RPN value of 34.24) with 4 mitigation strategies, shortages and delays in the arrival of components (RPN value of 25.62) with 6 mitigation strategies, and the number of workers not in accordance with needs with a RPN value of 25.43 with 5 mitigation strategies. With the results of this study, the potential for risk is reduced and can be prevented so that the risk of the powered rolling stock project can be completed on time.

Keywords: Risk Management, FMEA, AHP, *Project Management*

1. INTRODUCTION

Considering the aggressive competition and the current fluctuating business environment, the need for accountability of a company is increasing. In this case, the need leads to the demand for operational effectiveness and efficiency. Activities in the project life cycle process have the potential to face risks, including delays in project completion, non-conformance of product specifications with contract documents, difficulty in obtaining raw materials, high dependence on imports or certain suppliers, to the risk of contract termination by service users.

Projects with broad strategic complexity and importance also occur in the rail industry project. It is undeniable, the need for rolling stocks as a mode of mass transportation in this era is very important. Based on Bridge Market Research data (Rolling Stock Market - Global Industry Trends and Forecast to 2027) as depicted in Graph 1.1, it shows that the global rolling stock market is expected to gain market growth in the forecast period 2020 to 2027 by region.



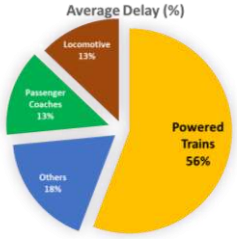
Graph 1. 1 Rolling Stock Market - Global Industry Trends and Forecast to 2027)

Based on Graph 1.2, it shows that all projects experienced a longer actual lead time than the planning lead time. In this case, it can mean that the entire project is delayed. If accumulated for each project delay, it is found that the average project delay is 35.58% of the planning lead time. The difference between the planning lead time (planning) and the actual/realized lead time has an impact on various things including project schedule delays, increased project costs, to project fines that lead to project failure.



Graph 1. 2 Comparison of Planning and Realization Lead Time

If accumulated by type, Graph 1.2 shows a comparison of the average percentage of delays based on the type of rolling stock. By looking at the complexity of the work on the 4 types of rolling stocks and the dominance of the procurement of rolling stocks in the last 5 years, this research focuses on powered rolling stocks. This is because in the process of procuring powered rolling stocks, all methods/processes from the design, procurement, fabrication, and testing stages are complex and have higher difficulties than other types of rolling stocks.



Grafik 1. 3 Average Percentage of Delay in Each Project by Rolling stock Type

To prevent repeatation of delays in the rolling stock project at XYZ in the future, this research is expected to produce a list of potential significant risks that can cause delays and effective risk control or mitigation measures against significant risks that may occur. So that the risk of delay can be minimized either in terms of probability or occurrence, impact or hazard effect or impact and potential risk detection.

2. LITERATURE REVIEW

2.1 Risk

Risk is associated with losses caused by events that may occur at a certain time. According to Frosdick (1997) systematically risk can be described as in the formula below:

Risk (risk)=Likehood (likely to happen)×Impact (impact)

where:
Risk = consequence / time
Likehood = event / time
Impact = consequence / event

2.2 Project

According to PMBOK (Guide to the Project Management Body of Knowledge (PMBOK® Guide) (5th Edition) - Knovel, 2017) Important characteristics contained in a project include: Temporary or temporary which means that every project has a clear schedule of when it will be started and when it will be completed. A project ends when its objectives have been achieved or the need for the project ceases to exist and the project is terminated.Unique which means that each project produces a particular product, solution, service or output that is different from one another.

Based on Morris's opinion in the PMBOK book, the life cycle of a construction project can be illustrated in Figure 2.2 below.

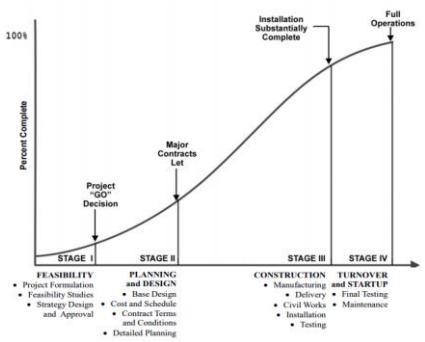


Figure 2. 2 Morris Project (Construction) Activity Cycle (PMBOK 2000)

2.3 Delay

The definition of delay according to Ervianto (2005) is as an implementation time that is not utilized in accordance with the activity plan, causing one or several activities to follow to be delayed or not completed exactly according to the planned schedule

2.4 Risk Management

Risk management is a scientific approach related to risk issues with the aim of eliminating or reducing risks faced by companies and organizations. To ensure that risk management planning goes well, it must be based on a team or individual with good knowledge and skills regarding the related project, such as senior managers, relevant stakeholders, project managers, experts, consultants and other professionals (PMBOK, 2013).

2.5 Risks of Procurement of New Rolling stocks

With the nature of Make to Order where this refers to the requirements contained in the contract as well as those that have been regulated in the rules & regulations drawn up by the clarification agency as well as the rules of the country where the rolling stock will be used, then

from all procurement processes there are several risks that may arise. be the cause of delays or failure of railway construction projects. In a survey analysis conducted on 252 experts from 11 companies in similar industries (major shipbuilding in Korea) it was concluded that there are 16 different risks (Lee, Park & Shin 2009). Of the 26 main risks in medium-sized shipyards, 6 main risks are obtained such as Labor Supply, Material Supply, HR / Design Personnel, Exchange Rate, Design Change, and Capital Funding.

2.6 FMEA

The FMEA method is used to eliminate and reduce the possibility of failure of certain problems in order to prevent the recurrence of failures in the future. FMEA is one of the preventive measures (before the event) according to Carlson (2012). In this case, FMEA consists of three steps, including:

1. Identify Failures
2. Identification of failures by identifying errors in a process, which in this case is equipped with the causes and effects resulting from errors in the process.
3. Prioritize Failures
4. Priority failure by using the Risk Priority Number (RPN), to get the error or risk with the highest value.
5. Reduce Risk
6. Reducing risk in various ways, such as risk mitigation, etc.

In this study, references are sought that are relevant to the rolling stock procurement process. Based on the existing literature, Liu & Lin's theory is quite relevant to the case study taken, which is used for industrial construction. The following is a detailed explanation of Severity, Occurrence and Detection.

1. The severity of the impact of a failure mode is Severity (S).
2. The frequency of occurrence or how often a failure mode occurs is indicated by Occurrence (O).
3. The level of ability to detect a failure is indicated by Detection (D).

2.7 Risk Priority Number (RPN)

The risk priority number is a measure used to assess risk to help identify critical failure modes regarding a particular process or design. By looking at and analyzing the values of severity, occurrence, and detection, RPN can be easily calculated by multiplying the three criteria or risk elements. Decisions on how to improve an operation are based on the Risk Priority Number (RPN) at the FMEA stage. This method is quite effective in determining the risk assessment of a case. In FMEA analysis, the RPN value can be used in implementing or guiding a risk assessment. There is no standard used to describe the number of RPNs that meet to be added to the risk management process and which ones are not, According to Mulcahy 2010. The RPN value does not play an important role in the choice of an action against the failure method, where the RPN value is obtained by the formula;

$$RPN=S \times O \times D$$

2.8 Analytical Hierarchy Process (AHP)

An AHP method shows a decision support model by breaking down a complex multifactor or multi-criteria problem into a hierarchy. According to Saaty (2008), a hierarchy is a representation of complex problems in a multilevel structure where in this case the first level is the goal, followed by the level of factors, criteria, and then down to the last level of alternatives.

3. METHODS

The research in this thesis in the future will be used as a preventive measure / prevention of repetition of the occurrence of delays in similar rolling stock procurement projects at XYZ, especially for powered rolling stock projects with risk management methods as a tool that can be used to assess potential delays that may occur. Assess it as a risk and how to handle or mitigate risk effectively and document it in accordance with the risk management rules in chapter 2 as a note for reviewing projects or similar activities to be carried out.

Therefore, this research is expected to produce a list of potential significant risks that may cause delays and effective risk control or mitigation measures (which have high potential) that may occur. So that delays can be minimized either by probability or occurrence. In this research, a research design is needed, namely in the form of a planned and systematic method in order to get an answer to the problem in an integrated manner.

Assumptions and ideas in this study are sourced from data, documents, and conclusions from interviews, FGDs, and questionnaires collected from respondents or sources that are directly correlated with problems as stakeholders in the process of completing the rolling stock project.

4. ANALYSIS OF CASE STUDY IN PT

4. 1 Identification of risks

Based on the results of the collection of questionnaire 1, a list of risks relevant to the project was obtained as many as 46 risks. The total risk consists of 33 risks that have been determined at the beginning which is an adaptation of the synthesis of the literature and 13 additional risks mentioned by several respondents. The following are details of failure mode that consists of 33 risks and 13 additional risks (marked in yellow) to components and functions as follows:

Table 4. 1 List of 46 risks (failure mode)

Component & Function	Risk ID	Failure mode
Design & Administration Planning	R1	Image Delay (Basic Design)
	R2	Image Revision
	R3	Difficulty Fulfilling Contract Terms
	R4	Difficulty Doing Billing
	R5	Late Payments to Suppliers and others
	R6	Weaknesses in the memorandum of agreement, can't claim insurance
	R7	Fluctuations in the exchange rate of the rupiah with the dollar
	R8	Inaccurate material price reference
	R9	Old Approval (to customers)
	R10	There is an administrative process between Subsidiaries, Affiliates, and Parent
	R11	There is a change in the specifications of the driven train
	R12	Changes in customer requests on material specifications that are not described in detail in the contract
	R13	Late issuance of Bill Of Materials
	R14	The specifications on the Bill of Materials are less detailed
Technical Planning	R15	Calculation of Material Requirements Inappropriate
	R16	Lack of coordination between units/subsidiaries
	R17	Production plan changes
	R18	Sudden demand for components (not according to schedule)
	R19	No long term plans
	R20	Old technical evaluation and need budget adjustment
	R21	Determination of equipment specifications that are not clear
	R22	Inaccuracy in the preparation of SOW/KAK PR services

Component & Function	Risk ID	Failure mode
Procurement of Materials & Tools	R23	Shortage and late arrival of components
	R24	Material needs in large quantities
	R25	A large variety of goods, the quality of goods from suppliers is not in accordance with quality standards
	R26	Incorrect Material Quantity
	R27	Product Specifications Do Not Match
	R28	Request for goods does not mention clear specifications
	R29	Lack of reference to comparison prices
	R30	Dependence on one source of supply (supplier)
	R31	Incorrect item request verification
	R32	Material scarcity
	R33	Old Custom Clearance Process
	R34	Swelling of production costs
	R35	Non-conformance of goods comes with requirements
Production Execution	R36	The qualifications and skills of the workforce do not match
	R37	The number of workers is not in accordance with the needs
	R38	Production procedure error
	R39	Production work delays
	R40	Natural disturbance factors / natural disasters (floods, storms / bad weather)
	R41	Power supply stopped / power outage from energy supplies
	R42	There is a change in the new Company's Organizational Structure
	R43	There are components that are damaged during installation
	R44	Product quality does not meet requirements
	R45	Insufficient production capacity
	R46	Low equipment productivity

4. 2 Analysis the Most Dominant Risks

Taking into account the different Severity, Occurrence, and Detection values for each respondent, to get the RPN value for each Risk ID, the average is used to get a single value from the seven respondents. From the results of the average calculation for each level of S,O,D values, then an analysis is carried out using the FMEA method as in some of the priority risks exemplified in table 4.1.

Table 4. 2 FMEA Analysis

Component & Function	Failure mode / Kejadian Risiko	Potential effect(s) of failure	Severity	Potential cause(s) of failure	Occurrence	Current Controls, detection	Detection	RPN
Design & Administration Planning	The long approval lead time (to the customer)	Work delays so that the basic design process is hampered	3,86	Due to a third party from the customer	3,71	Carry out intensive follow-up & coordination with related parties	2,71	38,89
Technical Planning	The lack of coordination between units/subsidiaries	Work late	3,86	Occurrence of missed information with children & company affiliates	4,14	Develop reliable guidance and SOW to subsidiaries / affiliates on related projects	2,14	34,24
Procurement of Materials & Tools	The shortage and late arrival of materials	Delayed procurement and fabrication processes	3,71	Late procurement process Change of quantity / specification on Bill Of Material	3,71	There is progress control that can be monitored comprehensively	1,86	25,62
Production Execution	The number of workers not in accordance	Late work process & uneven work load	3,40	The number of employees who have been reassigned ; work load that does not match the availability of employees	3,40	Work Load Analysis & periodic control	2,20	25,43

In table 4.1 above are some examples in the FMEA analysis that has been carried out. In this case, the FMEA analysis was carried out for all 46 failure modes, table 4.1 only shows the risk that has the highest RPN value in each component & function.

From graph 4.1 as shown below, it can be shown that the highest RPN of each process including the percentage of influence on the pareto diagram below.

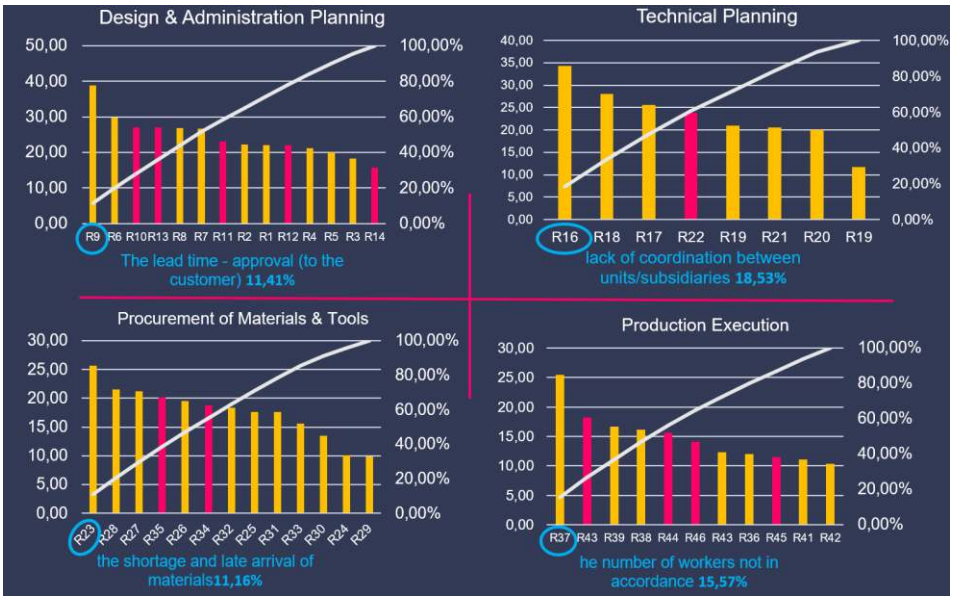


Figure 4. 1 Pareto Diagram (Priority Risk)

4.3 Priority Risk Determination

Calculation of risk weights can use the Analytical Hierarhy Process using Expert Choice software. Determination of risk weights using a hierarchy as shown in the image below:

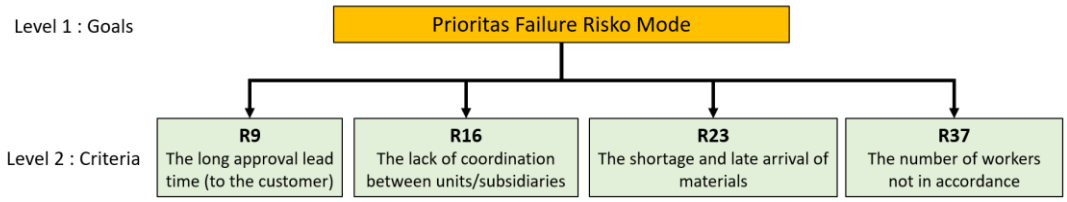


Figure 4. 2 Hierarchy of risk weights

In determining the weight of each risk obtained from the results of the AHP questionnaire from all respondents. Each respondent has a consistency ratio level on Expert Choice of < 0.10 or no more than 0.1 so that the inconsistency can be accepted. The calculation of the consistency ratio carried out by the Project Department is as follows, with the first step starting with pairwise comparisons obtained from the respondents' results, as shown in table 4.4 as obtained from the SCM (Supply Chain Management) Department.

Table 4. 3 Pairwise Comparison

Risk	R9	R16	R23	R37
R9	1	5	5	5
R16	0,20	1	1	3
R23	0,20	1,00	1	5
R37	0,20	0,33	0,20	1
TOTAL	1,60	7,33	7,20	14,00

After getting the value of pairwise comparison, the next step is normalization.

Table 4. 4 Normalization

Risk	R9	R16	R23	R37	Total	Rata - Rata	Consistency Measure
R9	0,625	0,682	0,694	0,357	2,358	0,590	4,480
R16	0,125	0,136	0,139	0,214	0,615	0,154	3,749
R23	0,125	0,136	0,139	0,357	0,757	0,189	3,792
R37	0,125	0,045	0,028	0,071	0,270	0,067	2,521

Based on the calculation, the CR value is 0.1 so that the inconsistency is not more than 0.1 so it can be said "Acceptable". By considering the risk weight of each respondent, a recapitulation of the risk weight of each respondent is obtained so that the resulting Pareto diagram is as safe as below:

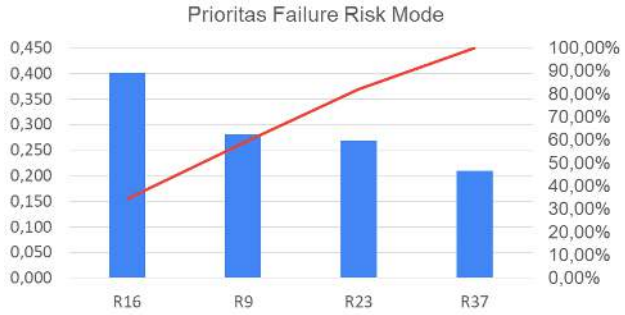


Figure 4. 3 Pareto Diagram Priority Failure Risk Mode

The Pareto graph in Figure 4.8 shows that of the four priorities for each component and function, R16, namely Lack of coordination between units/subsidiaries is the most prioritized risk because it accounts for more than 30% of the total priority risk for each component and function with a final weight of 0.401 .

4. 4 Analysis The Mitigation for Priority Risk

By considering the opinions of the 7 respondents to determine the weight of risk and mitigation obtained in the four components & functions, the seven respondents have equal weight in

determining mitigation priorities. 4 Mitigation weights on R9, R16, R23, and R37 shown in figure 4.9 below.



Figure 4. 4 Pareto Diagram (Mitigation)

From the Pareto image above, it can be shown that the risk mitigation weight analysis on R9, R16, R23, and R37 was carried out in a similar stage, so that the following results were obtained:

Table 4. 5 Risk Mitigation based on priority

		Priority Risk			
		1	2	3	4
		R16	**R10**	**R23**	**R37**
		The long approval lead time (to the customer)	The lack of coordination between units/subsidiaries	The shortage and late arrival of materials	The number of workers not in accordance
Priority Risk Mitigation	1	Understand the design concept & procurement scheme of related mobile train projects	Prepare informative and clear approval documents according to contract goals and customer needs	Fixation of design concepts (Pre-design) early, to avoid changes during the project	Ensure the HR needs of each department are in accordance with their respective workloads & skills
	2	Creating reliable SOW concepts with work requirements on certain projects	Develop a project timeline that is mutually agreed with the customer and related parties	Develop basic design concepts by taking into account the availability of components & materials available in the market and warehouse (stock)	Provide training that is in accordance with the skills needed in related jobs
	3	Coordinate regularly with subsidiaries & affiliates	Carry out follow-up and intensive coordination with customers & related parties	Ensure component approval / acceptance in accordance with guidance approval (related Quality Instructions)	Monitoring work load analysis on a regular basis for even distribution of job descriptions
	4	Compilation of Subcont Plan with subsidiaries & affiliates in a complex & detailed manner to avoid changes	Benchmarking (by making the train design similar to the existing train product as an initial guideline to make it easier for customers to make considerations)	Develop an informative and detailed Bill of Materials	Using sub contractors with capabilities as needed
	5			Seeking information and collaborating with several selected local vendors in sufficient numbers at the beginning of implementation.	Increase resources both manpower and tools to speed up the production process.
	6			Increase engineer and drafter resources when starting the civil works design process to speed up the design process	

4.5 Managerial Implications

Based on the priority risk analysis and priority mitigation in reducing the risk of delays in the powered rolling stock project, the following are some formulations of managerial implications that can be applied in XYZ operations, including the following:

1. In preventing the risk of lack of coordination between units and subsidiaries which may result in delays in some work so that it can cause project delays, it is necessary to have an

even understanding of the design concept and procurement scheme for the self-driving rolling stock project with related units, subsidiaries, and affiliates.

2. Taking into account the potential for project delays caused by the number of workers who are not in accordance with the needs, it is necessary to follow up in a work load analysis to be able to ensure the HR needs of each related department or unit that the available resources / HR are sufficient both in number and ability, in this case it can be said to be competent.

6. CONCLUSIONS

From the results of the identification and risk analysis on the procured rolling stock project at XYZ, conclusions can be drawn, including:

1. Based on the four stages studied in the process of procuring a powered rolling stock, 46 risks were obtained, it can be seen that the 4 risks with the highest RPN consisting of each component and function are priority risks and have a high impact on project delays, including The risk of lead time approval (towards the customer) with an RPN value of 38.98, The risk of lack of coordination between units/subsidiaries with an RPN value of 34.24, the risk of shortages and late arrival of components with an RPN value of 25.62, and the risk that the number of workers is not in accordance with the needs with a RPN value of 25.43.
2. Based on the results of the FGD, each risk mitigation was obtained in order to reduce the occurrence of potential failure at each stage of risks.

REFERENCES

An American National Standard ANSI/PMI 99-001-2004, A Guide to The Project Management Body of Knowledge (PMBOK Guide), Sixth Edition (2017) Pennsylvania Project Management Insttitute Inc.

Bakhtiyar, A. dkk. 2012. Analisis faktor-faktor yang mempengaruhi keterlambatan proyek konstruksi pembangunan gedung di Kota Lamongan. Jurnal Rekayasa Sipil, Volume 6, No. 1

Basuki, M & Widjaja, S, 2008, Studi Pengembangan Model Manajemen Risiko Usaha Bangunan Baru pada Industri Galangan Kapal, Prosiding Seminar Nasional Teknoin 2008 Bidang Teknik Industri.

Basuki, M & Choirunisa, B, 2012, Analisa Risiko Proses Pembangunan Kapal Baru 3.500 LTDW White Product Oil Tanker – Pertamina di PT. Dumas Tanjung Perak Surabaya , Jurnal Neptunus, Volume 18, Nomor 2, pp. 97 – 109, Edisi Juli 2012, Fakultas Teknik UHT.

Guide to the Project Management Body of Knowledge (PMBOK® Guide) (5th Edition) - Knovel.(2017).

Industry Trends and Forecast to 2027 (2020), Global Rolling Stock Market, Data Bridge Market Research, https://www.databridgemarketresearch.com/reports/

Kerzner, H.R. (2013) Project Management: A Systems Approach to Planning, Scheduling, and Controlling. John Wiley, New York

Kusuma, D. (2017). Manajemen Risiko Pipa Migas Bawah Laut Dampak Jalur Pelayaran Kapal Peti Kemas Patimban Menggunakan Metode Kent Muhlbauer Dan Analytic Hierarchy Process (Ahp) Di Lapangan Arjuna. 227.

Mardianto, S. M., 2021, Penilaian Risiko Pada Proses Pembangunan Kapal Bantu Rumah Sakit di PT. PAL INDONESIA (PERSERO), Thesis, Institut Teknologi Sepuluh Nopember, Surabaya.

Mulcahy, R, 2010. Risk Management Tricks of the Trade for Project Managers + PMI – RMP Exam Prep Guide. RMC Publications.

Nicholas, J. M. (2017). Project Management for Engineering, Business and Technology. Project Management for Engineering, Business and Technology. https://doi.org/10.4324/9781315676319

Nirmala, Utomo, 2012, Kajian Konsep Pengaruh Penerapan Budaya Organisasi Pada Keterlambatan Proyek Konstruksi , Prosiding Seminar Internasional Manajemen Teknologi XVI 2012 Bidang Keahlian Manajemen Proyek

Saaty, T.L, 2008, Decision Making With The Analytic Hierarchy Process, International Journal of Services Sciences Volume 1.

Shortreed, J.H., 2003. Institute for Risk Research, University of Waterloo, Waterloo, Ontario, Canada.

Sukoroto, Suparno, 2012, Manajemen Risiko Usaha pada Tender Lokomotif di PT INKA (Persero), Prosiding Seminar Internasional Manajemen Teknologi XV 2012 Bidang Keahlian Manajemen Industri

Suryadi, 2014, Kinerja dan Peramalan Pertumbuhan Angkutan Kereta Api Menggunakan Model Sarima, Badan Pusat sStatistik 2014.

Rianto, FS, et Al , 2017 , Implementasi Kapal Bantu Rumah Sakit KRI Dr, Soeharso 990 pada Operasi Militer Selain Perang (OMSP), Jurnal Prodi Strategi dan Kampanye Militer Volume 3 Nomor 1.

Ritchie Bob, Marshall David (1993), Business Risk Management, London, Chapman & Hall. Susilo L.J Kaho Victor Luwi (2009) , Manajemen Risiko Berbasis ISO 31000 Untuk Industri Nonperbankan, PPM Manajemen.

Acceptance Analysis of Human Resource Information System (HRIS) on Millennial Employee

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ABSTRACT

PT. ABC is a leading telecommunication company in Indonesia which always innovate its product and service in order to keep up with the advancement in technology. Product and service innovation is an essential means to keep the sustainability of the company in the age where technology life-cycle are rapidly moving. As well as product and service innovation, PT. ABC also transform its organization from telecommunication company into digital telecommunication company. In order to fully transform into digital company, ones must increase engagement among its employee. Then, a Human Resource Information System (HRIS) is built to increase engagement among employee in PT. ABC, specifically employee which fall into millennial categories. This research is conducted using the Technology Acceptance Model 3 (TAM 3). Partial Least Square Structural Equation Modelling (PLS-SEM) is used to test research hypothesis. As a result, it is found out that there are several significantly influencing factors which are Computer Playfulness, Perceived Ease of Use, Perceived Usefulness, and Result Demonstrability. Based on those influencing factor, several strategies are compiled. Those strategies later can be used by PT. ABC as references in developing HRIS in the future.

Keywords: Human Resource Information System (HRIS), Partial Least Square Structural Equation Modelling (PLS-SEM), Technology Acceptance Model 3 (TAM 3).

1. INTRODUCTION

Human resources is the most important asset for a company (Virdyananto, 2017). Human resource is one of the main agents to gain competitive advantage over competitor. How a company manage their human resources will affect their performance, if they able to well manage their human resources then their company will perform well thus gain competitive advantage over its competitor (Rubin, 2011). As the information technology advances, Human Resource Information System (HRIS) emerges as the facilitator in managing human resources (Noor, 2011). Many companies have adopted HRIS to aid their daily human resource related operations (Wang, 2008).

PT. ABC is a leading telecommunication company in Indonesia which transforming its organization into digital company. Among the steps required to become digital company, PT ABC must undergo three phases which are digitization, digital engagement, and digital transformation (Hunt, 2014). Among these three steps, digital engagement must be addressed. Internally, digital engagement among employee which fall into millennial-age categories are below the required standard, based on the internal survey conveyed by HR department. Since millennial employee are the most important part of the employee (Sahni, 2021), PT ABC launched a new HRIS to be used

inside its organization in order to address this issue. Millennial users have the characteristic such as they welcome changes, they are more open-minded to the use of a new technology, they like to use social media, they like to express themselves using many media, and generally they like to use gadget to search and process information (Manfreda, 2019). After the HRIS has launched, HR department wants to identify what are the most important factor in accepting HRIS.

There are many models and theories to explain attitude towards accepting a new technology (Taherdoost, 2018). Technology Acceptance Model (TAM) is the most widely recognized and the most used approach to study user behavior towards using information system (Boonsiritomachai, 2019). This research conducted using the latest iteration of TAM called Technology Acceptance Model 3 (TAM3) (Venkatesh, 2008). TAM3 is a model which is specifically designed for computer-based innovation (Jeffrey, 2015). Hypotheses testing are conducted using Partial Least Square Structural Equation Modelling (PLS-SEM). This research aims to identify the most influential factor in accepting HRIS among millennial employee and to give recommendation for further development of HRIS.

2. LITERATURE REVIEW

Technology Acceptance Model (TAM) is a model introduced by Fred Davis in 1989 as an instrument to explain the acceptance and usage level of a new technology (Davis, 1989). This model was derived from the Theory of Reasoned Action (TRA) suggested by Fishbein and Azjen in 1975 (Fishbein & Azjen, 1975). At first, Davis used TRA to study relationship between perception, factor of affection, and technology usage, the result then derived to create new model called TAM. TAM centered on Perceived Usefulness and Perceived Ease of Use as two main factors which influence user toward using technology. Venkatesh and Davis (2000) later introduced the extended model of TAM called Technology Acceptance Model 2 (TAM2) in 2000. TAM2 is an improved model from the original TAM which adds several new factors to provide better, more specific, and more accurate prediction (Taherdoost, 2018). Previous research related to acceptance of information technology has given valuable insight of how and why a person choose to adopt and use that technology. The bigger issue is how a manager make a decision in which led to the bigger technology adoption. To address this issue, Venkatesh and Bala combined determinants of technology acceptance from the previous research and produce new model of technology acceptance which further explain a person behavior towards accepting information technology (Almazroi, 2017). Venkatesh and Bala combined TAM2 with model determinant of perceived ease of use (Venkatesh, 2000) and as a result, TAM3 was invented. TAM3 presents a complete nomological network of the determinants of individual's information and technology adoption and use (2008). TAM3 shown in Figure 1.

Structural Equation Modelling (SEM) is a multivariate statistical technique which has been used since 1920 to analyze interaction among variables (Shah, 2022). SEM has the ability to reveal the direct or indirect relationships between exploratory variables and a dependent variable and then visualize the causal influencing pathways simultaneously (Kursunoglu, 2019). There are two approaches in SEM, namely Covariance Based SEM (CB-SEM) and Partial Least Square SEM (PLS-SEM) (Billyan, 2021). CB-SEM more focusing on constructing model to be used as an explanation to covariance among constructs, while PLS-SEM mainly used for exploratory research (Hair, 2014). According to Ghozali (2014), PLS is a powerful analytical method due to its ability to function with many scale of data without using many assumptions. PLS also able to give accurate prediction using To apply PLS, multi-stage process needs to be followed. This includes

the specification of inner and outer models, data collection and examination, models estimation, and evaluation of results (Hair, 2014).

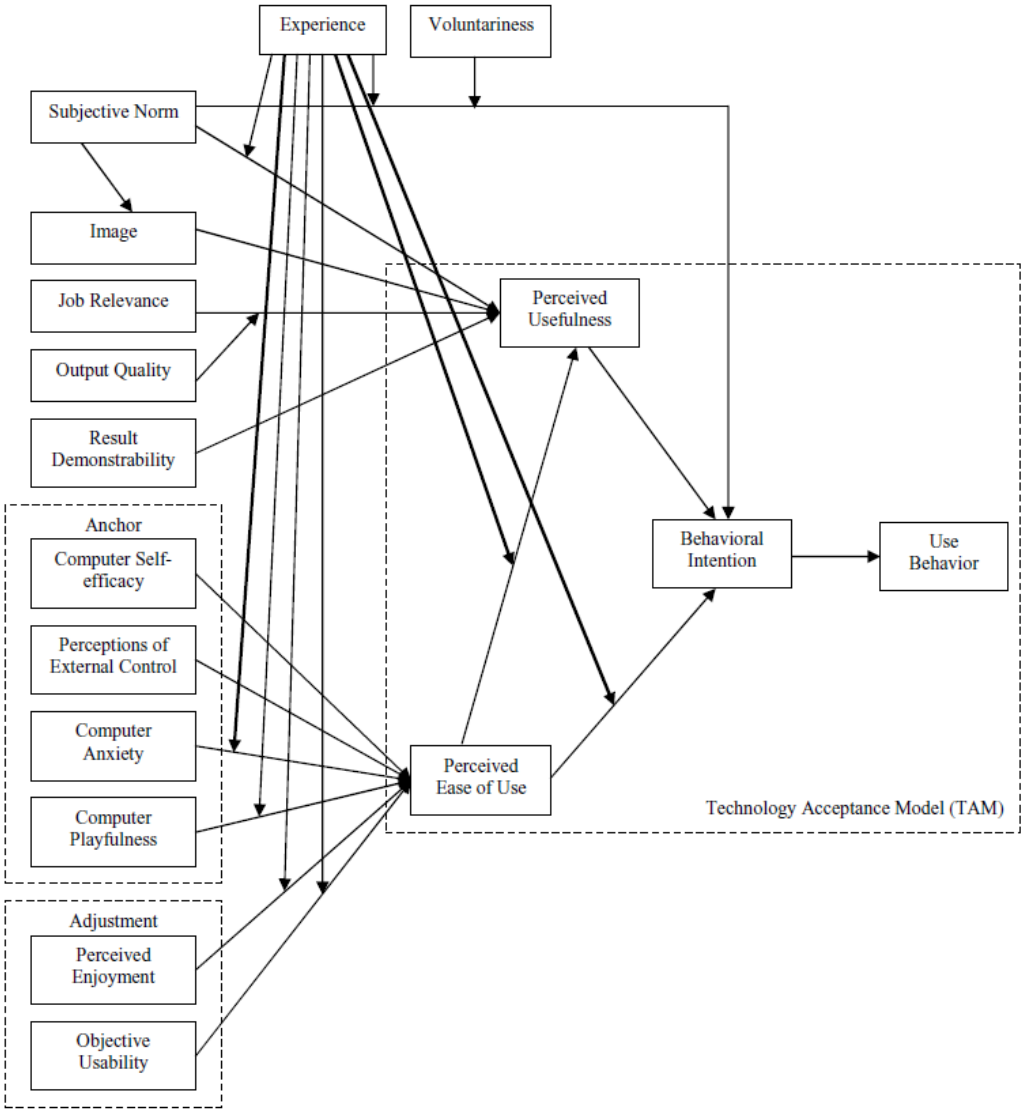


Figure 1. Technology Acceptance Model 3

3. METHODS

First step in this research is identifying problem through interview and observation. Interview conducted within the IT department as the infrastructure owner and HR department as the business process owner of the application. Observation administered by interacting with end-user and observing end-user behavior when using the application. After problem has been identified, research objective is determined. Subsequently, literature review is carried on to determine which model to be used as framework to study the technology acceptance.

Variables used in this research are taken from TAM3. Variables included in exogenous variable are Subjective Norm, Job Relevance, Result Demonstrability, Computer Self-Efficacy, Perception of External Control, Computer Anxiety, Computer Playfulness, Perceived Enjoyment, and Objective Usability. Variable which categorized in endogenous variable are Image, Use Behavior, Behavioral Intention, Perceived Usefulness, and Perceived Ease of Use.

This research conducted using quantitative approach. Questionnaire used a mean to collect data which later used to test the hypotheses. Subjects of this research were employees of PT ABC which still in millennial age group. Statement written on the questionnaire were made and modified from items for TAM3 construct. 5-scale Likert scale used in the questionnaire with this explanation (1) Strongly Disagree, (2) Disagree, (3) Neutral, (4) Agree, and (5) Strongly Agree.

Hypotheses proposed in this research constructed based on TAM3. Following are the hypotheses in this research:

H1: Subjective Norm affects Behavioral Intention, moderated by Experience and Voluntariness.
H2: Image affects Perceived Usefulness.
H3: Result Demonstrability affects Perceived Usefulness.
H4: Computer Self Efficacy affects Perceived Ease of Use.
H5: Computer Playfulness affects Perceived Ease of Use, moderated by Experience.
H6: Perceived Usefulness affects Behavioral Intention.
H7: Perceived Ease of Use affects Perceived Usefulness.
H8: Perceived Ease of Use affects Behavioral Intention.

After research hypotheses has been constructed, next step is to apply PLS-SEM to analyze the data. First stage in using PLS is to specify the research model. Model specification stage deals with the set-up of outer model and inner model. Outer model is depicted in Figure 2 below, while inner model is depicted in Figure 3 below. After model has been specified, data gathered from questionnaire are checked to confirm whether the data is fit for further analysis or not.

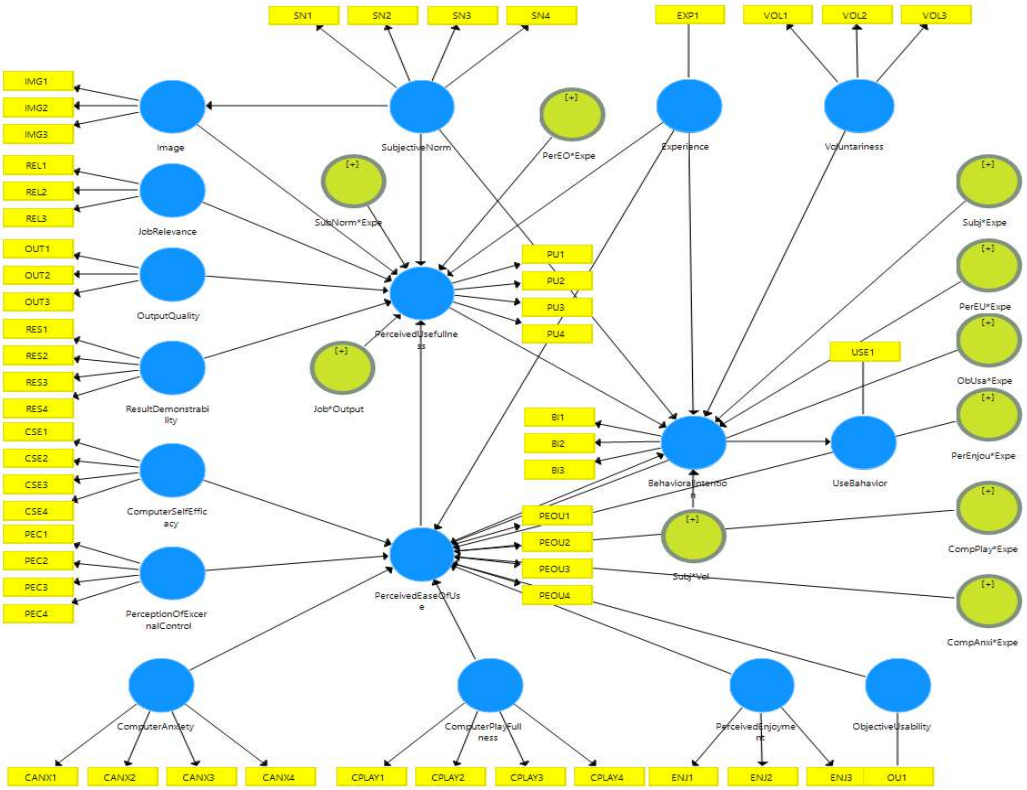


Figure 2. Outer Model

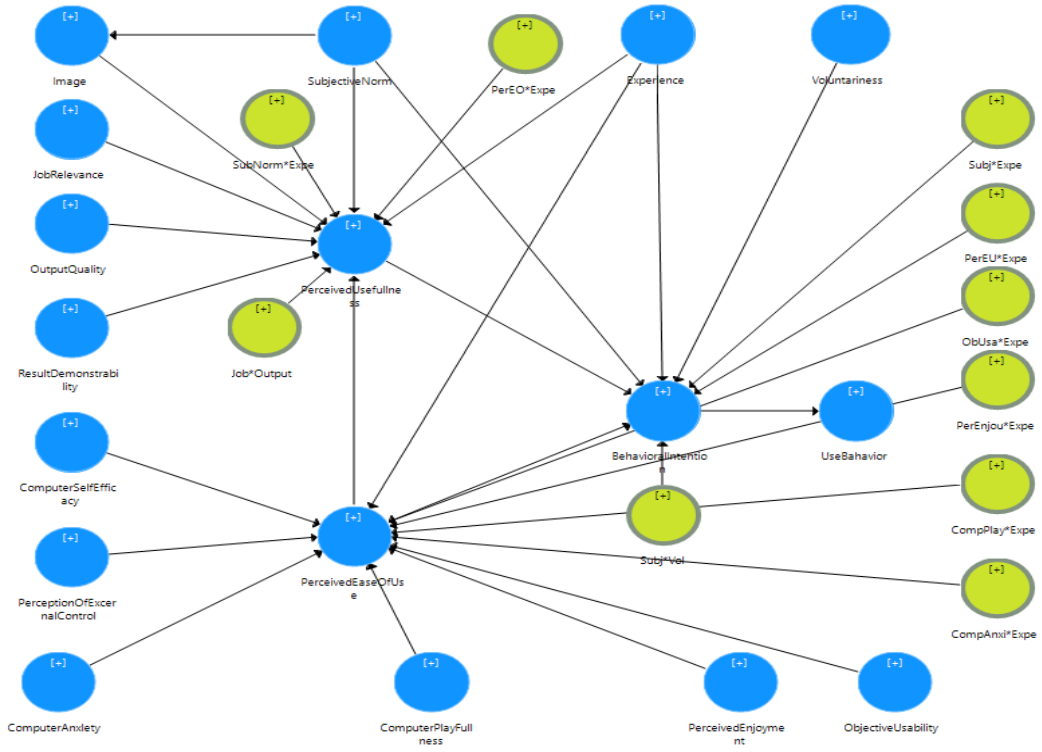


Figure 3. Inner Model

4. RESULTS

Outer Model Evaluation

First step of outer model evaluation is to evaluate indicator reliability. This task is performed by looking at the value of outer loading (loading factor). The outer loading value reflects how much the correlation between each indicator and its construct. Loading factor value must be greater than 0.7 to be considered as good indicator. Table 1 shows the loading factor from indicators. All indicators have met the required value of greater than 0.7, means all indicators have met indicator reliability.

Table 1. Outer Loading

Indicator	Loading Factor	Indicator	Loading Factor	Indicator	Loading Factor	Indicator	Loading Factor
BI1	0.848	CSE4	0.829	PEC3	0.822	RES2	0.838
BI2	0.887	ENJ1	0.859	PEC4	0.814	RES3	0.826
BI3	0.848	ENJ2	0.869	PEOU1	0.83	RES4	0.798
CANX1	0.841	ENJ3	0.842	PEOU2	0.855	SN1	0.848
CANX2	0.838	EXP1	1	PEOU3	0.796	SN2	0.845
CANX3	0.84	IMG1	0.86	PEOU4	0.786	SN3	0.846
CANX4	0.855	IMG2	0.871	PU1	0.85	SN4	0.812
CPLAY1	0.796	IMG3	0.877	PU2	0.838	USE1	1
CPLAY2	0.832	OU1	1	PU3	0.877	VOL1	0.86
CPLAY3	0.842	OUT1	0.854	PU4	0.825	VOL2	0.876
CPLAY4	0.843	OUT2	0.862	REL1	0.865	VOL3	0.804
CSE1	0.831	OUT3	0.821	REL2	0.839		
CSE2	0.827	PEC1	0.862	REL3	0.885		
CSE3	0.855	PEC2	0.877	RES1	0.831		

Internal consistency reliability is the next stage taken in this research. Internal consistency reliability is measured by observing Cronbach's Alpha and Composite Reliability. Each variable must meet the criteria value of greater than 0.7. Result from internal consistency reliability is shown in Table 2 below. As shown in Table 2 below, all variables have met the requirement value of greater than 0.7, this means all variable considered able to produce good reliability.

Table 2. Internal Consistency Reliability

Variable	Cronbach's Alpha	Composite Reliability	Description	Variable	Cronbach's Alpha	Composite Reliability	Description
BI	0.826	0.896	Reliable Data	PEOU	0.834	0.889	Reliable Data
CANX	0.865	0.908	Reliable Data	ENJ	0.819	0.892	Reliable Data
CPLAY	0.848	0.897	Reliable Data	PU	0.869	0.911	Reliable Data
CSE	0.856	0.902	Reliable Data	PEC	0.865	0.908	Reliable Data
EXP	1.000	1.000	Reliable Data	RES	0.841	0.894	Reliable Data
IMG	0.838	0.903	Reliable Data	SN	0.858	0.904	Reliable Data
REL	0.829	0.898	Reliable Data	USE	1.000	1.000	Reliable Data
OU	1.000	1.000	Reliable Data	VOL	0.802	0.884	Reliable Data
OUT	0.801	0.883	Reliable Data				

Convergent Validity is used to determine the suitability among indicator variables with the theoretical concepts which describe these indicators' existence. Convergent Validity is tested using Average Variance Extracted (AVE) test. Minimum value to be considered good value is 0.5. Result from this test is shown in Table 3 below. As show in Table 3 below, no variable with AVE less than 0.5 means that all variable data is valid.

Table 3. Convergent Validity

Variable	AVE	Description	Variable	AVE	Description
BI	0.742	Data valid	PEOU	0.668	Data valid
CANX	0.712	Data valid	ENJ	0.734	Data valid
CPLAY	0.686	Data valid	PU	0.719	Data valid
CSE	0.698	Data valid	PEC	0.712	Data valid
EXP	1	Data valid	RES	0.678	Data valid
IMG	0.755	Data valid	SN	0.702	Data valid
REL	0.745	Data valid	USE	1	Data valid
OU	1	Data valid	VOL	0.718	Data valid
OUT	0.715	Data valid			

Discriminant Validity represents the extent to which a construct can be said to be distinct from other constructs. Discriminant validity tested using the Heterotrait-Monotrait (HTMT) ratio.

HTMT ratio must be below 0.9 else it will considered as there is problem within the data because lack of discriminant validity. HTMT test shown that no variables with value less than 0.9 means that there is no problem related to validity value.

Inner Model Evaluation

Coefficient of Determinant (R^2) is a measurement of the model's predictive accuracy. In another point of view, R^2 represents the exogenous variable's combined effect on the endogenous variables. This effect ranges from 0 to 1 with 1 representing complete predictive accuracy. Table 4 below show the coefficient of determinant from endogenous variables. R^2 value must be greater than 0.6 to be considered good effect.

Table 4. Coefficient of Determinant

Variable	R^2
BI	0.84
IMG	0.705
PEOU	0.865
PU	0.832
UB	0.656

Path Coefficient measures the significant value and strength of the structural paths which have been hypothesized among constructs. This measurement is performed using PLS-SEM bootstrapping method in SmartPLS. Two-tailed test is used with the expected t-statistics value is 1.96 (α 5%) and p-value less than 0.05. Result is shown in Table 5 below.

Table 5. Path Coefficient

	***Original Sample* (O)**	**Sample Mean (M)**	**Standard Deviation (STDEV)**	**T-Statistics (|O/STDEV|)**	**P-Values**
BI -> UB	0.810	0.813	0.017	48.953	0.000
CANX -> PEOU	0.221	0.217	0.086	2.576	0.010
CPLAY -> PEOU	0.144	0.142	0.105	1.364	0.173
CSE -> PEOU	0.050	0.053	0.083	0.600	0.549
IMG -> PU	0.065	0.070	0.092	0.705	0.481
REL -> PU	0.133	0.138	0.092	1.452	0.147
OU -> PEOU	0.094	0.091	0.059	1.596	0.111
OUT-> PU	0.100	0.102	0.085	1.177	0.240
PEOU -> BI	0.236	0.225	0.099	2.398	0.017
PEOU -> PU	0.126	0.098	0.118	1.070	0.285
ENJ -> PEOU	0.153	0.152	0.081	1.887	0.060
PU -> BI	0.293	0.292	0.101	2.904	0.004
PEC -> PEOU	0.110	0.115	0.099	1.116	0.265
RES -> PU	0.216	0.215	0.100	2.169	0.031
SN -> BI	0.117	0.125	0.097	1.205	0.229
SN -> Image	0.840	0.842	0.022	37.579	0.000
SN -> PU	0.229	0.238	0.093	2.460	0.014

5. CONCLUSIONS

Based on the aforementioned analysis result, the following conclusion can be drawn. This research conducted using PLS-SEM to test hypotheses. From 17 research variables used, there are 4 variables with significant effect on user acceptance of HRIS while the other 13 variables do not have significant effect. Those 4 variables with significant effect are Computer Playfulness, Perceived Ease of Use, Perceived Usefulness, and Result Demonstrability. Based on the identified significant variables above, recommendation given to PT ABC is to continuously further enhance HRIS based on 4 variables with significant effect. Thus, HRIS in PT ABC will be used more by its employee. Recommendation given for future research is to include more variable previously not included in TAM3 such as training variable.

REFERENCES

Almazroi, A. A., Shen, H., Teoh, K. K., & Babar, M. A. (2017). Cloud for e-Learning: Determinants of Its Adoption by University Students in a Developing Country. *Proceedings - 13th IEEE International Conference on E-Business Engineering, ICEBE 2016 - Including 12th Workshop on Service-Oriented Applications, Integration and Collaboration, SOAIC 2016*, 71–78. https://doi.org/10.1109/ICEBE.2016.022

Billyan, B. F., & Irawan, M. I. (2021). Analysis of Technology Acceptance of Enterprise Resource Planning (ERP) System in The Regional Office of PT. XYZ Throughout Indonesia. *IPTEK The Journal for Technology and Science*. https://doi.org/10.12962/j20882033.v32i2.7876

Boonsiritomachai, W., & Pitchayadejanant, K. (2019). Determinants affecting mobile banking adoption by generation Y based on the unified theory of acceptance and use of technology model modified by the technology acceptance model concept. *Kasetsart Journal of Social Sciences*, *40*(2), 349–358. https://doi.org/10.1016/j.kjss.2017.10.005

Davis, F. D. (1989). Perceived usefulness, perceived ease of use, and user acceptance of information technology. *MIS Quarterly: Management Information Systems*, *13*(3), 319–339. https://doi.org/10.2307/249008

Fishbein, M., & Azjen, I. (1975). Belief, Attitude, Intention, and Behavior: An Introduction to Theory and Research. Reading, MA: Addison-Wesley. *Contemporary Sociology*.

Ghozali, & I. (2014). Structural Equation Modeling Metode Alternatif dengan PLS. *Edisi Ke-4. Semarang: Badan Penerbit Universitas Diponegoro Semarang*.

Hair, J. F., Sarstedt, M., Hopkins, L., & Kuppelwieser, V. G. (2014). Partial least squares structural equation modeling (PLS-SEM): An emerging tool in business research. *European Business Review*, *26*(2), 106–121. https://doi.org/10.1108/EBR-10-2013-0128

Jeffrey, D. A. (2015). Testing the Technology Acceptance Model 3 (TAM 3) with the Inclusion of Change Fatigue and Overload , in the Context of Faculty from Seventh- day Adventist Universities : A Revised Model. *Dissertations*, *3*(Paper 1581), 166.

Kursunoglu, N., & Onder, M. (2019). Application of structural equation modeling to evaluate coal and gas outbursts. *Tunnelling and Underground Space Technology*, *88*(February), 63–72. https://doi.org/10.1016/j.tust.2019.02.017

Manfreda, A., Ljubi, K., & Groznik, A. (2019). International Journal of Information Management Autonomous vehicles in the smart city era : An empirical study of adoption factors important for millennials. *International Journal of Information Management*, *March*, 102050. https://doi.org/10.1016/j.ijinfomgt.2019.102050

Noor, M. M., & Razali, R. (2011). Human Resources Information Systems (HRIS) for Military Domain – A Conceptual Framework. *Proceedings of the 2011 International Conference on Electrical Engineering and Informatics*, *July*, 1–5. https://doi.org/10.1109/ICEEI.2011.6021559

Rubin, R. S., & Dierdorff, E. C. (2011). On the road to Abilene: Time to manage agreement about MBA curricular relevance. *Academy of Management Learning and Education*, *10*(1), 148–161. https://doi.org/10.5465/AMLE.2011.59513280

Sahni, J. (2021). Employee Engagement Among Millennial Workforce: Empirical Study on Selected Antecedents and Consequences. *SAGE Open*. https://doi.org/10.1177/21582440211002208

Shah, B. A., Zala, L. B., & Desai, N. A. (2022). Structural equation modelling for segmentation analysis of latent variables responsible for environment-friendly feeder mode choice. *International Journal of Transportation Science and Technology*, *March*. https://doi.org/10.1016/j.ijtst.2022.01.003

Shelton Hunt, C. (2014). Managing Human Capital in the Digital Era. *People & Strategy*.

Taherdoost, H. (2018). A review of technology acceptance and adoption models and theories. *Procedia Manufacturing*, *22*, 960–967. https://doi.org/10.1016/j.promfg.2018.03.137

Venkatesh, V. (2000). Determinants of Perceived Ease of Use : Integrating Control , Intrinsic Motivation , Acceptance Model. *Institute for Operations Research and the Management Sciences*, *11*(May 2014), 342–365.

Venkatesh, V., & Bala, H. (2008). Technology acceptance model 3 and a research agenda on interventions. *Decision Sciences*, *39*(2), 273–315. https://doi.org/10.1111/j.1540-5915.2008.00192.x

Venkatesh, V., & Davis, F. D. (2000). Theoretical extension of the Technology Acceptance Model: Four longitudinal field studies. *Management Science*, *46*(2), 186–204. https://doi.org/10.1287/mnsc.46.2.186.11926

Virdyananto, A. L., Dewi, M. A. A., Hidayanto, A. N., & Hanief, S. (2017). User acceptance of human resource information system: An integration model of Unified Theory of Acceptance and Use of Technology (UTAUT), Task Technology Fit (TTF), and Symbolic Adoption. *2016 International Conference on Information Technology Systems and Innovation, ICITSI 2016 - Proceedings*, 1–6. https://doi.org/10.1109/ICITSI.2016.7858227

Wang, Y. S., & Liao, Y. W. (2008). Assessing eGovernment systems success: A validation of the DeLone and McLean model of information systems success. *Government Information Quarterly*. https://doi.org/10.1016/j.giq.2007.06.002

IMPLEMENTATION OF OTOBOS IN THE FRAMEWORK CONTRACT FOR THE MAINTENANCE OF OFFICES AND OFFICIAL RESIDENCES AT BUMN ENERGY SURABAYA

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ABSTRACT

Framework contracts for the maintenance of company offices and official residences through the OTOBOS (On Time, On Budget, On Scope) approach are important things to do in the State-Owned Enterprise of The Energy Units of Surabaya, to assist the implementation of the company's operations. In monitoring the implementation of a good framework contract, it is necessary to know what indicators in the OTOBOS approach, namely the timeliness, and financial and scope factors so that it can run well. In addition, it is necessary to know what priority indicators are in the OTOBOS approach so that they can be considered in the implementation of the framework contract. This study uses the Delphi method to determine what indicators need to be in the implementation of the framework contract and uses the analysis of AHP (Analytical Hierarchy Process) to find out which indicators are the priority. From the results of this study, 20 sub-criteria indicators that need to be present in the application of the company's office and home maintenance contracts are applied. Then the indicators that become the most priority in the OTOBOS criteria are time indicators, while the indicators that become the most priority in the sub-criteria are work monitoring and evaluation indicators with implementation in the field on time criteria; indicators ensure that there is an agreement on a work contract on-budget criteria, and quality control indicators or quality on scope criteria.

Keywords: Framework Contract, OTOBOS, Delphi, AHP.

1. INTRODUCTION

In the implementation in the field, there are various types of contracts such as lump sum contracts, unit rate contracts (unit prices), framework contracts, and so on. For work that is a single project, several alternative contracts can be used, such as a lump sum contract, and unit rate contract (unit price), while for multi-project work, a framework contract can be used. The type of contract for the procurement of goods or construction work or other services consists of a lump sum, unit price, combined lump sum and unit price, turnkey, and framework contact (Wiyatno, 2018).

Framework contracts are used for goods/services whose volume and/or delivery time cannot be determined at the time the contract is signed, such as motor vehicles, and computer equipment (LKPP, 2018).

In the Project Implementation Control Module (2017) the Project Management Triangle is a Project Management model used by Project Managers to analyze and understand the difficulties

that may occur during project implementation and implementation. In general, Three Main Constraints are interdependent in a project namely Time, Cost, and Scope. The triple constraint theme has various interpretations, the literature shows a general agreement that project scope, time, and cost comprise the three key triple constraint variables (Pollack, 2018).

In the implementation of the framework contract at the Surabaya Unit Company, it has been carried out routinely with data from 2018-2021 maintenance in the form of office repairs as many as 1 (one) unit and as many as 99 (ninety-nine) units of the Company's Office House in Surabaya consisting of 2 Job categories are Minor Jobs with a work value of under Rp 100 million and Major Jobs with a value of Rp 100 million to Rp 500 million. In the course of this framework contract, there are also obstacles encountered such as the implementation timetable, the planned scope of work to be carried out, as well as the availability of a budget with the scope of work in the framework contract.

The purpose of this study is to determine the OTOBOS (On Time, On Budget, On Scope) indicators that need to be in the framework contract for the maintenance of the Company's Office and Official Homes and to be able to find out the OTOBOS (On Time, On Budget, On Scope) indicators that become a priority in the framework contract for the maintenance of the Company's Office and Official Home so that in its implementation it can run well.

2. LITERATURE REVIEW

2.1. Framework Contract

The types of Government Goods/Services Procurement Contracts in Presidential Regulation 16/2018 and its derivative rules consist of framework contracts used in terms of work that will be carried out repeatedly with definite specifications but the volume and time of the order cannot be determined. Framework contracts are used for example the procurement of certain drugs at hospitals, catering services, travel services, or material procurement (Wiyatno, 2018).

2.2. OTOBOS

In a project, the term OTOBOS approach is known, which stands for On Time, On Budget, and On Scope. This polarization is used to measure KPIs on several projects at once called KPI OTOBOS which stands for On-Time, On-Budget, and On-Specification. KPI with this polarization has the aim of encouraging all managed projects to achieve the highest performance, namely on time, on budget, and specifications (Abdullah 2017).

Djukardi (2018) said that several performance indicators for Materials and Finance are as follows:

a. Material
   1) Procurement of materials on time
   2) Delivery of materials on time according to schedule (not piling up on the project)
   3) Zeroness in material defects
   4) Implementation of material testing in the laboratory regularly
   5) Compliance with terms and regulations that are actively applicable regarding material specifications
   6) Material suppliers are selected partners

b. Financial
   1) Ensure that there is an employment contract agreement
   2) Analyze risk control
   3) Provide a source of funding for project activities

4) Develop & monitor cash flow that is adjusted to the work schedule
5) Cost control according to the set budget (including daily operating cash)
6) Cost considerations in choosing a supplier

Sufa (2012) said that there are several critical success factors for Time Focus as follows:

a. Evaluate suppliers/subcontractors based on schedule
b. Creating additional resources
c. Take corrective action to control progress against the project schedule
d. Minimizing priority of project duration over other goals

2.3. Delphi Method

Hanavi (2020) said that the Delphi method by definition is a group process that involves interaction between researchers and a group of experts related to a particular topic, usually through the help of a questionnaire. This method is used to gain consensus on future projections/trends using a systematic process of gathering information. Some things need to be considered in implementing the Delphi method, namely:

a. Selection of expert panel (expert)
b. Number of expert panelists
c. Number of iterations
d. Anonymous feedback process
e. Time requirement
f. Consensus measurement

Dilip (2010) explains that the respondents were not asked to choose between the two statements in a given pair, but rather to rate each item on a scale ranging from 1 (definitely not) to 9 (definitely so).

2.4. Analytical Hierarchy Process (AHP)

AHP is a decision support model developed by Thomas L. Saaty. This decision support model will describe complex multi-factor or multi-criteria problems into a hierarchy which is defined as a representation of a complex problem in a multi-level structure where the first level is the goal, followed by the level of factors, and criteria, sub-criteria, and so on. down to the last level of the alternative (Supriadi, 2018).

Muataz (2021) explains The priority as indicated by values ranging from 1 to 9 :

Table 1. The Saaty Scale

Numerical	Scale	Numerical	Scale
1	Equally preferred	2	Equally to moderately preferred
3	Moderately preferred	4	Moderately to strongly preferred
5	Strongly preferred	6	strongly to very strongly preferred
7	Very strongly preferred	8	Very strongly to extremely preferred
9	Extremely preferred		

3. METHODS

After conducting a literature study, the next step is to determine the indicators that have been made based on the existing research variables, namely using the Delphi method by doing 2 iterations. The survey form contains a Likert scale of 1 to 9 accompanied by an explanation from the respondent. For the first step, the survey form with iteration 1 made using the Delphi method will be distributed to respondents who have met the criteria to be able to fill out. The results of the filling will be analyzed by the researcher as reference material for iteration 2. Then the survey form with Iteration 2 is distributed back to the same respondents to get better consensus results.

After selecting the variables based on the Delphi method, the next step is to manage the data using AHP (Analytical Hierarchy Process) analysis. From the results of data management using AHP through a pairwise comparison matrix with a scale value of 1 to 9, it will be known the weighting value through questionnaires to respondents who meet the criteria so that the most priority variable indicators can be known and can be applied in the OTOBOS (On Time, On Budget) approach. , On Scope) which is appropriate for use in monitoring the framework contract for the maintenance of offices and official residences.

4. RESULTS

4.1. Delphi Method Results

The data collection carried out in this study involved 8 (eight) respondents by filling out questionnaires and some deepening using interviews. After determining the 8 (eight) respondents in this study, it is necessary to determine the criteria and sub-criteria that will be studied more deeply. Meanwhile, at the beginning of this study, there were 3 criteria and 16 sub-criteria, the results of which the questionnaire can be submitted in the following explanation.

4.2. Delphi Iteration 1

From the data recap of the results of the Delphi questionnaire from round 1 (iteration 1) in Table 2, it can be conveyed that to meet the consensus or agreement among the respondents, the standard deviation value is below 1.5. From the table above, it can be seen that there are 6 sub-criteria that still have a standard deviation value above 1.5 so they still cannot meet consensus or agreement where respondents still have diversity in assessing the indicators of the 6 sub-criteria, which consist of:

a. Evaluate suppliers/subcontractors based on schedule
b. Creating additional resources
c. Minimizing priority of project duration over other goals
d. Provide a source of funding for project activities
e. Implementation of material testing in the laboratory regularly
f. Material suppliers are selected partners

In addition, one sub-criteria item was removed, namely the sub-criteria for Implementation of material testing in the laboratory regularly, because the input from respondents on these items was irrelevant in practice in the field so they were not used in the application of the framework contract for office and home maintenance.

In addition, there are inputs from respondents to add new sub-criteria proposals, namely as follows:

a. In the On Time Criteria, a Sub Criteria for Monitoring contractor work through the proposed S Curve diagram

b. In the On Time Criteria, a Sub Criteria for Estimated project work plan in case of addendum
c. In the On Time Criteria, a Sub Criteria for Monitoring and evaluation of work methods with implementation in the field
d. In the Material Criteria (On Scope) a Sub Criteria for Quality Control or Quality
e. In the Material Criteria (On Scope) a Sub Criteria for The incoming material is equipped with a mill sheet or mill certificate

Table 2. Round 1 Delphi Form Result Recap

Criteria	No	Sub Criteria	Respondent								Score	Score	Status
			A	B	C	D	E	F	G	H	Average	Standart Deviation	Consensus (K) atau No Consensus (T)
Time *(On Time)*	1	Evaluate suppliers/subcontractors based on schedule	5	8	9	9	4	6	9	9	7,375	2,07	T
	2	Creating additional resources	3	5	9	5	5	7	7	5	5,75	1,83	T
	3	Take corrective action to control progress against project schedule	8	7	9	9	9	6	8	9	8,125	1,13	K
	4	Minimizing priority of project duration over other goals	5	6	7	1	7	8	5	7	5,75	2,19	T
Financial *(On Budget)*	5	Ensure that there is an employment contract agreement	7	9	9	9	9	8	9	9	8,625	0,74	K
	6	Analyze risk control	6	9	9	9	9	8	9	7	8,25	1,16	K
	7	Provide a source of funding for project activities	5	9	9	9	9	7	1	7	7	2,83	T
	8	Develop & monitor cash flow that is adjusted to the work schedule	6	9	9	9	9	9	9	9	8,625	1,06	K
	9	Cost control according to the set budget (including daily operating cash)	6	9	9	9	9	8	8	9	8,375	1,06	K
	10	Cost considerations in choosing a supplier	4	7	7	7	6	8	9	6	6,75	1,49	K
Material *(On Scope)*	11	Procurement of materials on time	6	9	9	9	9	8	9	7	8,25	1,16	K
	12	Delivery of materials on time according to schedule (not piling up on	6	8	9	9	9	9	9	7	8,25	1,16	K
	13	Zeroness in material defects	7	8	9	9	9	9	9	9	8,625	0,74	K
	14	Implementation of material testing in the laboratory on a regular basis	5	8	6	9	8	4	9	9	7,25	1,98	T
	15	Compliance with terms and regulations that are actively applicable regarding material specifications	8	8	9	9	8	9	9	9	8,625	0,52	K
	16	Material suppliers are selected partners	4	8	9	9	7	9	9	7	7,75	1,75	T

4.3. Delphi Iteration 2

After completing the first round of Delphi analysis, it is necessary to do a second round of Delphi (iteration 2), namely by repeating the sub-criteria questionnaire in iteration 1 which has not received consensus, and submitting a new proposed sub-criteria questionnaire from the respondents.

Table 3. Round 2 Delphi Form Result Recap

Criteria	No	Sub Criteria	Respondent								Score	Score	Status
			A	B	C	D	E	F	G	H	Average	Standart Deviation	Consensus (K) atau No Consensus (T)
Time *(On Time)*	1	Evaluate suppliers/subcontractors based on schedule	6	8	9	9	9	8	9	9	8,375	1,06	K
	2	Creating additional resources	6	7	9	5	8	8	7	6	7	1,31	K
	3	Monitoring contractor work through the proposed S Curve diagram	7	9	7	9	9	8	9	8	8,25	0,89	K
	4	Minimizing priority of project duration over other goals	6	7	6	5	6	8	9	5	6,5	1,41	K
	5	Estimated project work plan in case of addendum	7	9	8	9	8	8	9	6	8	1,07	K
	6	Monitoring and evaluation of work methods with implementation in the field	7	9	9	9	9	8	9	9	8,625	0,74	K
Financial (On Budget)	7	Provide a source of funding for project activities	6	8	9	9	9	8	9	7	8,125	1,13	K
Material *(On Scope)*	8	Quality control or quality	7	9	9	9	9	8	9	9	8,625	0,74	K
	9	The incoming material is equipped with a mill sheet or mill certificate	7	8	7	9	6	8	9	8	7,75	1,04	K
	10	Material suppliers are selected partners	6	8	9	9	9	9	9	7	8,25	1,16	K

From the data in Table 3 that summarizes the results of the Delphi questionnaire from round 2 (iteration 2) above, it can be said that the 10 sub-criteria already have a standard deviation value, that is, all of them are below 1.5 both for the new proposed sub-criteria and for the sub-criteria that have not previously been proposed. get consensus, so that overall the sub-criteria have met the consensus or agreement among the respondents.

4.4. Delphi Iterations 1 and 2

The following is a recap of the results of combining the results of the Delphi round 1 (iteration 1) with the results of the Delphi round 2 (iteration 2) in Table 4 which has obtained consensus or agreement from the respondents and sorted from the sub-criteria that has the highest average value to the one with the highest average value. lowest, for further analysis of AHP, which is as follows:

Table 4. Recap of Combined Results of Delphi Forms for Rounds 1 and 2

Criteria	No	Sub Criteria	Respondent								Score	Score	Status
			A	B	C	D	E	F	G	H	Average	Standart Deviation	Consensus (K) atau No Consensus (T)
1	Time (On Time)	Monitoring and evaluation of work methods with implementation in the field	7	9	9	9	9	8	9	9	8,625	0,74	K
2	Financial (On Budget)	Ensure that there is an employment contract agreement	7	9	9	9	9	8	9	9	8,625	0,74	K
3	Financial (On Budget)	Develop & monitor cash flow that is adjusted to the work schedule	6	9	9	9	9	9	9	9	8,625	1,06	K
4	Material (On Scope)	Zeroness in material defects	7	8	9	9	9	9	9	9	8,625	0,74	K
5	Material (On Scope)	Compliance with terms and regulations that are actively applicable regarding material	8	8	9	9	8	9	9	9	8,625	0,52	K
6	Material (On Scope)	Quality control or quality	7	9	9	9	9	8	9	9	8,625	0,74	K
7	Time (On Time)	Evaluate suppliers/subcontractors based on schedule	6	8	9	9	9	8	9	9	8,375	1,06	K
8	Financial (On Budget)	Cost control according to the set budget (including daily operating cash)	6	9	9	9	9	8	8	9	8,375	1,06	K
9	Time (On Time)	Monitoring contractor work through the proposed S Curve diagram	7	9	7	9	9	8	9	8	8,25	0,89	K
10	Financial (On Budget)	Analyze risk control	6	9	9	9	9	8	9	7	8,25	1,16	K
11	Material (On Scope)	Procurement of materials on time	6	9	9	9	9	8	9	7	8,25	1,16	K
12	Material (On Scope)	Delivery of materials on time according to schedule (not piling up on the project)	6	8	9	9	9	9	9	7	8,25	1,16	K
13	Material (On Scope)	Material suppliers are selected partners	6	8	9	9	9	9	9	7	8,25	1,16	K
14	Time (On Time)	Take corrective action to control progress against project schedule	8	7	9	9	9	6	8	9	8,125	1,13	K
15	Financial (On Budget)	Provide a source of funding for project activities	6	8	9	9	9	8	9	7	8,125	1,13	K
16	Time (On Time)	Estimated project work plan in case of addendum	7	9	8	9	8	8	9	6	8	1,07	K
17	Material (On Scope)	The incoming material is equipped with a mill sheet or mill certificate	7	8	7	9	6	8	9	8	7,75	1,04	K
18	Time (On Time)	Creating additional resources	6	7	9	5	8	8	7	6	7	1,31	K
19	Financial (On Budget)	Cost considerations in choosing a supplier	4	7	7	7	6	8	9	6	6,75	1,49	K
20	Time (On Time)	Minimizing priority of project duration over other goals	6	7	6	5	6	8	9	5	6,5	1,41	K

4.5. AHP Analysis Based on Criteria and Sub Criteria

a. Criteria

From Figure 1 it can be illustrated that the inconsistency value is <0,1 so that the data meets the requirements and can be accepted. Then from the table, it can also be conveyed that the time criterion indicator has the highest priority weight, which is 0.414.

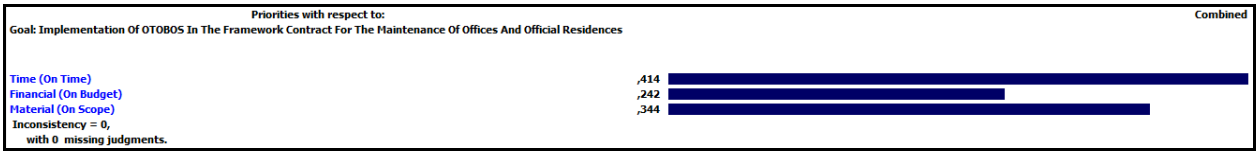


Figure 1. Weighting Between Criteria

b. Sub Criteria On Time Criteria (On Time)

From Figure 2 it can be illustrated that the inconsistency value is <0,1 so that the data meets the requirements and can be accepted. Then from the table, it can also be conveyed that the indicators for the sub-criteria for monitoring and evaluating work methods with implementation in the field have the highest priority weight, namely 0.268.

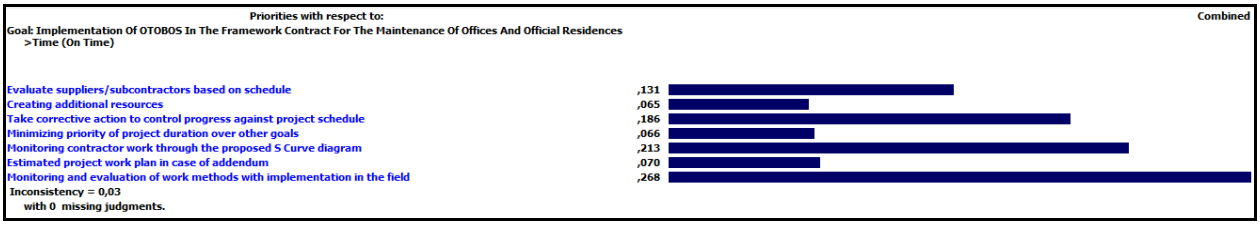


Figure 2. Weighting Between Sub Criteria on Time Criteria (On Time)

c. Sub Criteria On Financial Criteria (On Budget)

From Figure 3, it can be illustrated that the inconsistency value is <0,1 so that the data meets the requirements and can be accepted. Then from the table, it can also be conveyed that the sub-criteria indicator ensuring the existence of an employment contract agreement has the highest priority weight, which is 0.227.

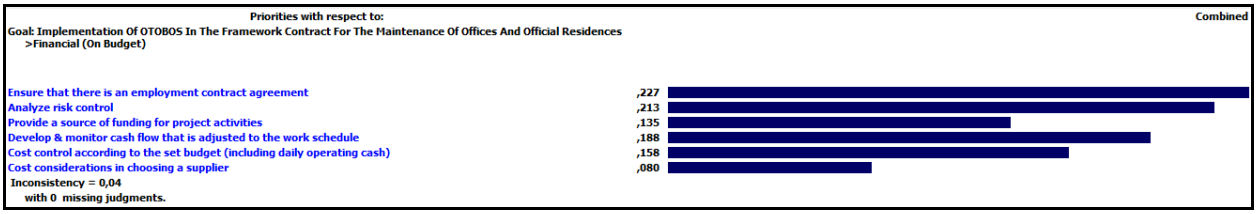


Figure 3. Weighting Between Sub Criteria in Financial Criteria (On Budget)

d. Sub Criteria On Material Criteria (On Scope)

From Figure 4 it can be illustrated that the inconsistency value is <0,1 so that the data meets the requirements and can be accepted. Then from the table, it can also be conveyed that the indicator for quality control or quality sub-criteria has the highest priority weight, namely 0.297.

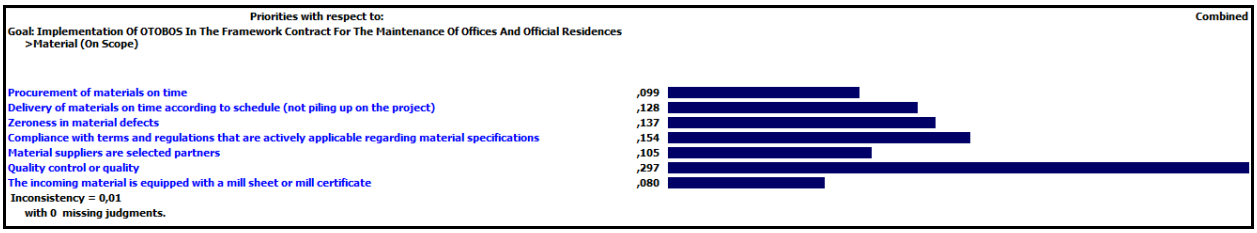


Figure 4. Weighting Between Sub Criteria on Material Criteria (On Scope)

e. Overall AHP Analysis Results

From the AHP analysis on the OTOBOS Criteria, Time Sub Criteria (On Time), Financial Sub Criteria (On Budget), and Sub Criteria (On Scope) in Figure 5, the overall results obtained using expert choice for the priority weight values are as follows :

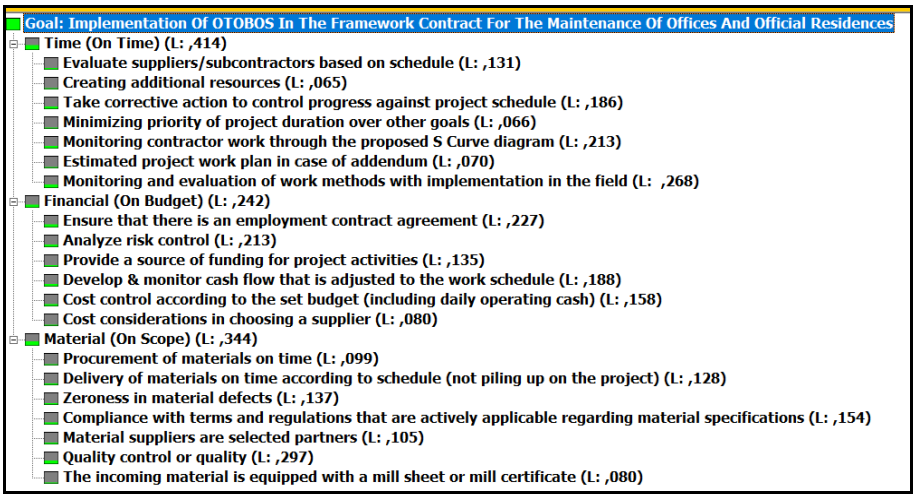


Figure 5. Priority Weight Based on AHP Analysis

Based on the foregoing, it can be stated that:

1). Criteria on OTOBOS (On Time, On Budget, On Scope)
   a) Time (On Time) has the highest priority weight of 0.414.
   b) Financial (On Budget) has the lowest priority weight of 0.242.
   c) Material (On Scope) has a priority weight in the middle position of 0.344.

2). Sub Criteria Time (On Time)
   a) Monitoring and evaluation of work methods with implementation in the field have the highest priority weight of 0.268.
   b) Creating additional resources has the lowest priority weight of 0.065.

3). Sub Criteria Financial (On Budget)
   a) Ensure that there is an employment contract agreement that has the highest priority weight of 0.227.
   b) Cost considerations in choosing a supplier have the lowest priority weight, namely 0.080.

4). Sub Criteria Material (On Scope)
   a) Quality control or quality has the highest priority weight of 0.297.
   b) The incoming material is equipped with a mill sheet or mill certificate have the lowest priority weight of 0.080.

6. CONCLUSIONS

From the results of this study obtained 20 sub-criteria indicators that need to be in the application of the framework contract for the maintenance of the company's office and official residence. Then the indicators that become the most priority in the OTOBOS criteria are time indicators, while the indicators that become the most priority in the sub-criteria are indicators for Monitoring and evaluation of work methods with implementation in the field on time criteria; indicators Ensure that there is an employment contract agreement on financial criteria, and quality control or quality on material criteria.

The managerial implication of the results of this study is that the company can evaluate the implementation of the framework contract for the maintenance of offices and official residences that are currently running regarding matters that are still not suitable to be adjusted by carrying out the OTOBOS approach by including 20 sub-criteria as indicators that need to be monitored and provide special attention to the priority criteria indicators and sub-criteria in their implementation in the field. This will assist the company in preparing the procurement package and also overseeing the framework contract by setting KPI to achieve the target, as well as the criteria and sub-criteria that become priorities can be used as the highest assessment weight from the company to provide reward and punishment so that its implementation can be achieved properly.

REFERENCES

Abdullah Yohanes dan Hegwisi Irra (2017). Key Performance Indicator: KPI A to Z Panduan Implementasi KPI yang Workable. Jakarta: PT Grasindo.

Dilip V. Jeste, Monika Ardelt, Dan Blazer, Helena C. Kraemer, George Vaillant, Thomas W. Meeks. (2010) Expert Consensus on Characteristics of Wisdom: A Delphi Method Study. Oxford University Press on behalf of The Gerontological Society of America.

Hanavi. (2020). Artikel Simulasi Analisis Penilaian Risiko Menggunakan Metode Delphi.https://www.researchgate.net/publication/344463631_Penilaian_Risiko_Menggunakan_Metode_Delphi. diakses pada 27 November 2021.

LKPP. Buku Informasi Persiapan Pengadaan Barang/Jasa Pemerintah (2018). Jakarta : Lembaga Kebijakan Pengadaan Barang/Jasa Pemerintah.

Modul Pengendalian Pelaksanaan Proyek. (2017). Pengendalian Pelaksanaan Proyek. Semarang : BPSDM.

Muataz Hazza Al Hazza1, Alaa Abdelwahed, Mohammad Yeakub Ali, Atiah Bt. Abdullah Sidek. (2021). An Integrated Approach for Supplier Evaluation and Selection using the Delphi Method and Analytic Hierarchy Process (AHP): A New Framework. International Journal of Technology, 13(1) 16-25 (2022)

Pollack, J., Helm, J. & Adler, D. (2018) What is the Iron Triangle, and how has it changed?. International Journal of Managing Projects in Business, 11(2), 527-547.

Djukardi, Andreas Kurniawan dan Semiawan, Adhiarta Emil. (2018). Model Indikator Kinerja Proyek Pada Sektor Bangunan Perumahan Bertingkat Tinggi Regional D.K.I. Jakarta. Jurnal Forum Mekanika: Vol. 7, No. 2, November 2018.

Sufa, Mila Faila (2012). Identifikasi Kriteria Keberhasilan Proyek. Performa: Vol.11, No.1:19-12.

Supriadi,Apip, Rustandi,Andi, Komarlina,Dwi Hastuti Lestari, Ardiani,Gusti Tia. (2018). Analytical Hierarchy Process (AHP) Teknik Penentuan Strategi Daya Saing Kerajinan Bordir. Yogyakarta:Deepublish (Group Penerbitan CV Budi Utama).

Wiyatno, Bima Ade. (2018). Surat Perintah Kerja (SPK) Sebagai Objek Jaminan Kredit. Dalam Jurist-Diction:Vol. 1 No. 2, November 2018.

RISK ANALYSIS OF PROCUREMENT AND ENFORCEMENT PROJECT ELECTRIC RUBBER TYRED GANTRY CRANE USING HOUSE OF RISK METHOD

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ABSTRACT

The proper action are needed to increase existing capacity of container terminal by providing proper facilities. Electric Rubber Tyred Gantry (ERTG) Crane is important fascilities in container terminal. The fail of target completion of a project is a loss for the company because of lossing thepotential income. This study aims to assess the influential risk causes and the effective preventive action to be taken in dealing with the main risks. This reasearch adding insight regarding the risk management that can be applied to the industrial projects. Risk assessment of the project of procurement ERTG has been carried out using the House of Risk (HOR) method, and collecting data by Fucus Group Discussion (FGD). The following main causes that affect the project of Procurement ERTG, are as follows: 1. Lack of strict supervision of work; 2. Economic changes conditions; 3. No basic communication procedure; 4. Natural conditions and 5. Government strategic policies changes. The Preventive efforts able to handle the causes of ERTG project risk as follows: 1. Making strategic policy decisions; 2. Proactively coordinate with contractors; 3. Coaching, mentoring and consulting; 4. Creating a system of supervision and punishments; 5. Evaluate the performance of the supervisory consultant on a regular basis; 6. Early budget adjustment.

Keywords: Electric Rubber Tyred Gantry Crane, Risk Assessment, House of Risk, Focus Group Discussion.

1. INTRODUCTION

The growth of the economy from time to time therefore makes the growth of container logistics also increase. Need an effort to anticipate the increasing troughput of containers in container terminal. Increasing production capacity are carried out by building a stacking yard, which is supported by loading and unloading equipment. One of the main types of loading and unloading equipment operating in the stacking yard is the ERTG

In similar projects, sometimes several problems occure related to terms of time and quality of work caused by various factors in some important stages. The Important stages that have a high risk as follows:

1. Planning
2. Bidding / procurement
3. Funding and payment
4. Supervision of work

There are various kinds of risks that can potentially hinder the project, which is time and losses incurred cannot be predicted. The risks that occur at the implementation of E-RTG Project can potentially losses for the company due to the potential loss of revenue. So it is necessary to do further research related to risk issues that be affect the implementation of the project.

Risk Management is a comprehensive ways in dealing with case that could potentially a risk for the project, which is consists of several stages. Risk assessment is one of the step of risk management. To handle the risks involved in the ERTG project, in this study was carried out a risk assessment using the House of Risk (HOR) method. The variables and data obtained from previous research references and Focus Group Discussion (FGD).

2. LITERATURE REVIEW

Based on ISO 31000:2018, risk management within an organization is a relation between principles, frameworks, and risk management. Process Process Risk management must be an integrated part of management, decision making and integrated into the structure, operations and organizational processes. Processes of Risk Management presented in Figure 1 below:

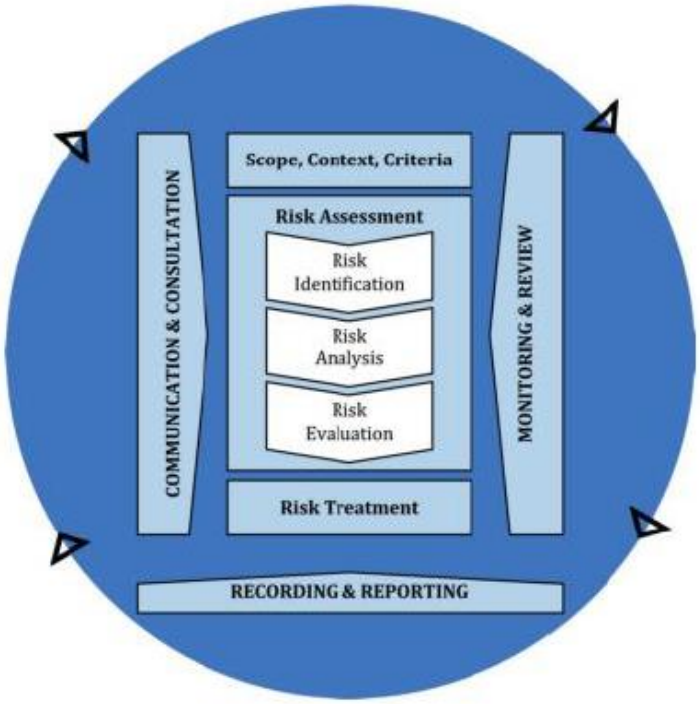


Figure 1. Risk Management Process

The risk management process is the application of the principles and framework that has been built. An explanation of the risk management process is presented as shown in Figure 1 above, consist of 6 interrelated components as follows:

1. Communication and Consultation
2. Scope, Context and Criteria
3. Risk assessment
4. Risk treatment to deal with the causes of the risks that may occur.
5. Monitoring and Review
6. Recording & Reporting

The risk management process can be applied at the strategic, operational and program or project levels. The application of the Risk Management process in an organization is adjusted to achieve the objectives and in accordance with the external and internal context of the company, although the human behavior and culture are dynamic and constantly changing. The Risk Management process is often presented sequentially, even though in practice this process is carried out iteratively. This study examined the risk assessment, wich is one of the important components in risk management.

The House of Risk (HOR) method used in this study, is a risk assessment method using the Supply Chain Operation Reference (SCOR) approach to business processes related to equipment procurement projects. HOR can be used to determine the relationship between risk and the causes of risk and also the risk mitigation actions that will be carried out (Trenggonowati & Pertiwi, 2017). The application of the HOR method is often carried out in the supply chain sector. HOR was developed by Pujawan & Geraldin (2009). In addition to conducting research in the supply chain field, HOR is also used to carry out risk management on a projects such as those carried out by Krisdianto & Santosa (2010), Saraswati & Negoro (2014), Nurlela & Suprapto (2014) and Cahyani, et al. (2016).

HOR is a method for conducting a risk assessment carried out using a spreadsheet application to obtain a risk matrix that can identify sources of risk and efforts to address them, to prevent the emergence of the most influential risk sources. HOR is the development of a combination of two methods, scilicet the Failure Mode Effect and Analysis (FMEA) method and the House of Quality method. FMEA is used to quantify risk, and adapt the House of Quality to prioritize which risk agent will be handled first and choose the most effective action to reduce potential risks caused by risk agents..

3. METHODS

3.1 *HOR* Stage 1

HOR consists of 2 stages, that is HOR stage 1 and HOR stage 2. HOR Stage 1 is used to determine the risk sources are prioritized for preventive action and HOR Stage 2 is to provide priority for risk mitigation actions that can be carried out by considering the effective cost and resources.

HOR 1 focuses on ranking the Aggregate Risk Potential (ARP) which is influenced by 3 factors, that is occurrence, severity and interrelationship (the process of identifying the relationship between risk agents and risk events). ARP calculation is carried out with the aim of determining the level of occurrence of risk agent which cause of risk events. Calculation of ARP value with the following formula as follows:

$$ARP_j = Oj \sum Si \ . Rij$$

Table 1. Phase 1 HOR matrix model

Business Proscess	***Risk event*** **(Ei)**	***Risk agent*** **(Aj)**					***Severity*** **of Risk Event i(Si)**
		A1	**A2**	**A3**	**A4**	**A5**	
Plan	E1	R11	R12	R13			S1
Source	E2	R21	R22				S2
Make	E3	R31					S3
Deliver	E4	R41					S4
Return	E5						S5
Occurance of agent j		O1	O2	O3	O4	O5	
Aggregate risk potential j		*ARP*1	*ARP*2	*ARP*3	*ARP*4	*ARP*5	
Priority rank of agent j							

Tabel 1 is the Phase 1 HOR matrix model, the matrix conveys the components of the variable components used in HOR stage 1, that is as follows : risk agents, risk events, the correlation between risk events and risk agents, ARP calculations and rank of ARP. Rank of ARP value to determine the most influential cause of risk.

3.2 HOR Stage 2

HOR stage 2 helps to consider the preventive action decisions by measure the effectiveness of the resources used and the level of performance of the object or project related. The following stages in HOR stage 2 as follows:

1. Determine the most influential cause of risk (Influential risk event) based on the output of HOR stage 1.
2. Identify relevant actions to prevent the risk event.
3. Determine the relationship between each preventive action and the risk agent with the criteria of 0.1, 3 or 9. Where these numbers indicate a relationship that is respectively, no, low, moderate and a strong relationship preventive action and the risk agent.
4. Calculate the level of effectiveness of each preventive action with the following formula:

$$TE_k = \sum ARPj \ . Ejk_j$$

5. Determining the level of difficulty by representing each preventive action, then calculating the total effectiveness of the predetermined difficulty ratio with the following formula:

$$ETD_k = TEk \,/\, Dk$$

6. Prioritize the ETD value from the highest ETD value to the lowest. The main priority value is given to the mitigation action that has the highest ETD value

Table 2. Model *House of Risk* Stage 2

Preventive Action (PAk)						
To be treated risk management	PA1	PA2	PA3	PA4	PA5	**Agregate Risk Potential (*ARP*j)**
A1	E11	E12	E13			*ARP*1
A2	E21	E22				*ARP*2
A3	E31					*ARP*3
A4						*ARP*4
A5					Ejk	*ARP*5
Total Effectiveness of action k	TE1	TE2	TE3	TE4	TE5	
Degree of difficulty performing action k	D 1	D2	D3	D4	D5	
Effectiveness to dificullty ratio	ETD1	ETD 2	ETD3	ETD 4	ETD5	
Rank of priority	R1	R2	R3	R4	R5	

Table 2 is the HOR matrix model stage 2, the matrix conveyed stage 2 HOR risk variables, namely Risk Agents that influence the ERTG procurement project, Preventive Action, the correlation value between risk agents and preventive action (from FGD), Total Effectiveness of Action (TE) Degree Value of difficulty (D), the value of Effectiveness to disability ratio (ETD), and the rank of the ETD value of each preventive action. The ETD ranking value determines the most effective preventive action.

4. RESULTS

4.1 HOR Stage 1

HOR stage 1 obtained the Aggregate Risk Potential (ARP) value from each Risk agent. Then ranks of the ARP calculation to identifying the risk causes that have the most influence on the ARTG procurement project. The results of ARP in HOR stage 1 are presented in table 1 as follows:

Table 3. The results of ARP HOR stage 1

No	Risk agent		ARP
1	Lack of strict supervision of work	A31	1204
2	Changes in economic conditions	A21	784
3	There is no basic communication procedure	A35	656
4	Natural conditions	A25	564
5	Changes in the government's strategic policy	A22	504
6	Lack of project experience	A38	423
7	Uncertain exchange rates	A2	370
8	Incompetent design vendors	A28	342
9	Changed government regulations	A20	339
10	Goods or services sent do not match the specifications or quantity	A6	324
11	The number of tender participants who submitted bid documents did not meet the minimum limit	A10	324
12	Vendor unpreparedness	A8	316
13	Incompatibility of the budget plan with real time conditions	A3	276
14	Incompetent contractor	A30	267
15	Design changes	A27	261
16	Mistakes in the selection of vendors participating in the tender	A5	258
17	The results of the negotiations did not reach the best price	A11	252
18	The scope of work changes	A18	252
19	Damage to port facilities	A24	240
20	Procedures are not reviewed and updated	A39	201
21	Imported materials required are subject to Prohibition and Restrictions	A41	196
22	Exposed to the Red Line	A42	196
23	The processing time/import permit is long due to Lartas or changes in import regulations	A43	196
24	Inaccurate survey data	A19	192
25	Lack of updated List of Selected Partners	A9	171
26	Congestion due to project	A23	171
27	Soil consolidation does not match the calculation	A26	156
28	The system used in the negotiation process is undergoing maintenance	A12	144

No	Risk Agent		ARP
29	The arrival of materials is not according to the predetermined schedule regarding time, situation and conditions	A16	140
30	Late payment of PIB from the Finance department	A44	116
31	The means of transportation available or provided are inadequate	A17	100
32	IT support/tools are lacking	A33	92
33	The requirements of the tender are not complete	A40	92
34	There is a regional regulation that regulates the obligation to use local vendors for the procurement of certain goods to a certain amount	A7	72
35	Vendors stalling negotiations	A13	72
36	Price information in the market is not available	A1	68
37	Documents for the completeness of the procurement process are incomplete and sudden	A4	66
38	No IT infrastructure/tools	A34	66
39	The company does not yet have a system to be able to monitor contracts	A14	60
40	Changes to the new organizational structure	A37	54
41	User requests for work are sudden and require immediate completion or breakdown conditions	A15	51
42	No active cctv system	A32	30
43	No assessment of organizational needs	A36	2
44	Contracts are not up to standard	A29	0

From table 1, it can be seen the results of the ARP calculations from 44 risk agents and the ranking from the highest ARP values to the lowest ARP values. Furthermore, will be carried out Pareto method to determine the most influance Risk Agent of the ERTG project.

4.2 HOR tahap 2

The Further action to handle risk causes / Risk Agent from the results of HOR 1 will be carried out at HOR stage 2. HOR stage 2 is to find out effective preventive action will bw taken to handle the tackle risk agents. The PA rating in the FGD stage 2 presented in table 2 as follows:

Table 3. The results of ARP HOR stage 1

No	Result of HOR stage 2				
	Preventive Action	Preventive Action Code	ETDk	%	% Acumulation
1	Making strategic decision makers (management plan)	PA14	9.985	22%	22%
2	Proactively coordinate with contractors	PA1	6.579	15%	37%
3	Coaching, Mentoring, Consulting (CMC) to contractors	PA10	4.934	11%	48%
4	Establishing a system of supervision and sanctions	PA5	4.492	10%	58%
5	Evaluating the performance of the supervisory consultant on a regular basis	PA11	4.171	9%	67%
6	Early budget adjustments	PA8	2.940	7%	74%
7	Create a patent monitoring reference	PA4	2.438	5%	79%
8	Make a comprehensive checklist	PA7	2.121	5%	84%
9	Fulfillment of the appropriate organizational structure	PA13	2.084	5%	89%
10	Fulfillment of funding requirements	PA9	1.764	4%	93%
11	Create a realistic schedule	PA6	1.262	3%	96%
12	Creating a management system for monitoring contracts	PA3	1.204	3%	98%
13	Conducting socialization regarding what documents are needed	PA12	401	1%	99%
14	Project management training and certification	PA2	348	1%	100%
		Total ETDk	**44.724**		

Table 2 above is the result of HOR phase 2 from the project of ERTG. There are 14 Preventive Actions (PA) recommended in the mitigation of the project of ERTG. The effective preventive action is determined from the ETD value of each PA. The ETD values are sorted from the highest to the lowest. The highest ETD value is the most possible/recommended mitigation value in dealing with risks in the E-RTG procurement project. The evaluation to determine the most effective ETD value in the ERTG procurement project using the Pareto method.

6. CONCLUSIONS

This research expect to provide benefits related to risk management for related parties in the project of ERTG and for the other similar projects. The results of the study obtained identification causes of risk that most influence the project of procurement and Enforcement ERTG. From the results of HOR stage 1 and analysis using Pareto diagrams, there are 5 influential risk agents, as follows: 1. Lack of strict supervision of work 2. Changes in economic conditions 3. No basic communication procedures 4. Nature conditions and 5. Changes in government strategic policies. The research also provides effective strategies for risk management in the project of ERTG in dealing with risk causes by HOR stage 2. From the results of HOR stage 2 and analysis using the Pareto method, there are 6 Preventive Actions, as follows: 1. Making strategic decision makers (management plan) 2. Proactively coordinate with contractors 3. Coaching, Mentoring, Consulting (CMC) with contractors 4. Create a system of supervision and sanctions 5. Periodic evaluation of supervisory consultant performance and 6. Early budget adjustment.

REFERENCES

Alyami, H., Lee, P. T. W., Yang, Z., Riahi, R., Bonsall, S., & Wang, J. (2014). An advanced risk analysis approach for container port safety evaluation. *Maritime PoliCY and Management*, *41*(7), 634–650. https://doi.org/10.1080/03088839.2014.960498

Chee, T. S., & Yeo, K. T. (1995). Risk analysis of a build-operate-transfer (B.O.T) power plant project. *IEEE International Engineering Management Conference*, 275–280. https://doi.org/10.1109/iemc.1995.524593

Geraldin, L. H., Pujawan, I. N., & Dewi, D. S. (2007). Manajemen Risiko dan Aksi Mitigasi untuk Menciptakan Rantai Pasok yang Robust. *Jurnal Teknologi Dan Rekayasa Teknik Sipil "Torsi,"* 53–64.

Gill, P., Stewart, K., Treasure, E., & Chadwick, B. (2008). Methods of data collection in qualitative research: Interviews and focus groups. *British Dental Journal*, *204*(6), 291–295. https://doi.org/10.1038/bdj.2008.192

ISO 31000:2018 Risk Management.

Lee, E., Park, Y., & Shin, J. G. (2009). Large engineering project risk management using a Bayesian belief network. *Expert Systems with Applications*, *36*(3 PART 2), 5880–5887. https://doi.org/10.1016/j.eswa.2008.07.057

Liu, H. T., & Tsai, Y. lin. (2012). A fuzzy risk assessment approach for occupational hazards in the construction industry. *Safety Science*, *50*(4), 1067–1078. https://doi.org/10.1016/j.ssci.2011.11.021

Paramita, A., & Kristiana, L. (2013). Teknik Focus Group Discussion dalam Penelitian Kualitatif. *Teknik Focus Group Discussion Dalam Penelitian Kualitatif*, *16*(2), 117–127. https://doi.org/10.22435/bpsk.v16i2

Phan, M. T., & Kim, K. H. (2015). *ICLS2012 183 special issue 121126*. *121126*.

Prihandono, M., & Syairudin, B. (2017). *(CASE STUDY OF NEW BUILD PERTAMINA TANKER 3 . 500 DWT ON PT . DUMAS TANJUNG PERAK SHIPYARDS). September 2020*.

Project Management Institute. (2008). A Guide to Project Management Body of Knowledge. Fourth Edition. In *Project Management Institute Inc.* http://publications.lib.chalmers.se/records/fulltext/245180/245180.pdf%0Ahttps://hdl.handle.net/20.500.12380/245180%0Ahttp://dx.doi.org/10.1016/j.jsames.2

011.03.003%0Ahttps://doi.org/10.1016/j.gr.2017.08.001%0Ahttp://dx.doi.org/10.1016/j.precamres.2014.12

Purwandono, D. K. (2014). Aplikasi Model House of Risk (*HOR*) Untuk Mitigasi Risiko Proyek Pembangunan Jalan. *Jurnal Ilmiah Teknik Industri*, *13*(2), 1–10.

Ridwan, A., Ferdinant, P. F., & Laelasari, N. (2019). Simulasi Sistem Dinamis Dalam Perancangan Mitigasi Risiko Pengadaan Material Alat Excavator Dengan Metode Fmea Dan Fuzzy Ahp. *FLYWHEEL : Jurnal Teknik Mesin Untirta*, *V*(1), 51. https://doi.org/10.36055/fwl.v0i0.5247

Trenggonowati, D. L., & Pertiwi, N. A. (2017). Analisis Penyebab Risiko dan Mitigasi Risiko dengan Menggunakan Metode House Of Risk Pada Divisi Pengadaan. *Journal Industrial Servicess*, *3*(1), 1–7.

Van de Voorde, E. and Winkelmans, W. (2002), "A general introduction to port competition and management", in: Hu5ybrechts, M. et al. (Ed.) "Port Competitiveness: An economic and legal analysis of the factors determining the competitiveness of seaports", Antwerp: De Boeck.

Bambang Triatmodjo, DEA.Dr.Ir.Prof.2009. Perancangan Pelabuhan,Beta offset. Yogyakarta.

INFORMATION SYSTEM CONCEPT DESIGN OF ICT AND ROBOTICS CLUSTER AT DIKST ITS

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ABSTRACT

ITS is one of the higher education institutions in Indonesia that is growing rapidly with specific strategies in dealing with the industrial era 4.0. One of ITS' steps is to form the Directorate of Innovation and Science Technology Area (DIKST) ITS, as a unit that aims to support increased innovation and commercialization of technology. Even so, the category is still Primary with a value of 414.91 with a weight on management resources of 17.55. This means that the maturity value of ITS DIKST is still considered low. In order to improve the performance of DIKST ITS including increasing Human Resources (HR), one of the improvements proclaimed by DIKST ITS is developing an information system related to HR. In connection with that, this research was conducted in order to develop the concept of designing a HR management information system for DIKST ITS using the Agile Scrum Development method to the design stage. The results obtained are the acquisition of 4 important factors for HR management of DIKST ITS, namely employee procurement, job performance appraisal, career path changes, and payroll and system design user interfaces that have been validated by representatives of management and employees of DIKST ITS, as well as the ICT and ITS Robotics cluster community.

Keywords: Agile Development Methods, ICT and Robotics Cluster, Information Systems, Model Scrum.

1. INTRODUCTION

DIKST ITS, with a maturity score of 414.91, belongs to the lowest group, namely the main category. It is well recognized that improving one of ITS DIKST's components, namely human resources (HR), is one approach to boost its maturity value (Ministry of Research, 2019). Furthermore, information system-based HR processing is known to improve organizational performance, with one study demonstrating that HR information systems influence employee performance by 82.5 percent (Lasmaya , 2016). Industry 4.0 is known to be one of the causes of the increasing need for information systems in almost all sectors, including the education sector and the manufacturing industry. This is because the information system can function as data integration, which can combine a lot of data so that it can include detailed information about all elements of each discrete step in the downstream process (Torres, 2020).

Sepuluh Nopember Institute of Technology (ITS) is one of the educational institutions in Indonesia that has made growth rapidly with specific strategies in facing the industrial era 4.0. This is evidenced by the Directorate of Innovation and Science Technology Area (DIKST) ITS, an institution that supports technological innovation and commercialization, development of business creation and employment and economic development from the results of downstream research by lecturers and students. DIKST ITS is a vehicle for sustainable research and development collaboration between the central government, local governments, universities, research and development institutions, and industry (Sepuluh Nopember, 2022)

Sector of this research is ICT and Robotics Cluster. It is known that this sector focuses on the future of industrial 4.0 and society 5.0, which includes networking, big data analytics, artificial intelligence, internet of things (IoT), machine learning, and robotics. The institution headed by Dr. Ir. Endroyono, DEA has seven facilities that are ready to be commercialized for the general public. The facilities consist of the Center for Excellence in Science and Technology (PUI) for the field of mechatronic automation (PUI MIA), PUI for the field of artificial intelligence for healthcare and society (PUI AI HeS), VR and MooC laboratory to create Virtual Reality (VR) and Massive Open Online Courses. (MooC) in the fields of future of industrial 4.0 and society 5.0, Smart-city and Intelligence Center, and others. It is known that the product has been successfully commercialized for the general public, some of which are as follows: Robot Raisa, Robot Violeta, iCar, iBoat, and others (Endroyono, 2021).

This study will discuss the factors that influence the design of the information system concept for the ICT and robotics industrial cluster at the DIKST ITS. Data collection was carried out by direct observation of related agencies, especially the ICT industry cluster and DIKST ITS robotics and their stakeholders, conducting interviews with the heads of relevant agencies, and conducting literature studies on the Agile Software Development Life Cycle (SDLC). The data processing process is carried out to obtain the most appropriate information system concept for the ICT and robotics industrial clusters at DIKST ITS.

2. LITERATURE REVIEW

2.1. Industry 4.0

The industrial revolution 4.0 or often shortened to industry 4.0 has another name for cyber physical systems. This phenomenon is a revolution that focuses on automation and collaboration between industry and cyber technology. The existence of industry 4.0 brings many changes in almost all sectors of life, one of the most visible examples is the large number of human resources in companies that are replaced by automated machines. The term industry 4.0 was first heard on April 4, 2011 at the Hannover Fair, where it was used by the German government to describe significant progress in the industrial sector with the help of technology, so it can be concluded that the main feature of industry 4.0 is the incorporation of information system technology into the industrial sector (Hamsan, 2019). Angela Merkel as Chancellor of Germany once said in a speech in 2014 that the meaning of the industrial revolution 4.0 is a comprehensive transformation of all aspects of production that occurs in the industrial world through the merger of digital technology, especially internet technology with conventional industry (Sarmadi, 2014).

2.2. Science and Technopark

Science and Technopark (STP) is a specially established area that is used as a place to develop and encourage economic growth so that it can develop rapidly with the process of developing and applying science and technology, as well as the growth of technology-based startup companies (Presidential Regulation of the Republic of Indonesia Number 106 concerning Science and

Technology Areas, 2017). STP has several functions and services for the process of developing and applying science and technology in accordance with (Presidential Regulation of the Republic of Indonesia Number 106 concerning Science and Technology Areas, 2017), namely:

KST function:

1. A platform for collaborative Research and sustainable development between the Central Government, Regional Governments, Universities, research and development institutions, and industry;
2. Facilitating the growth of Innovation-based companies through Incubation and/or Spin Off;
3. Providing value-added and quality services to KST services.

KST Services

1. Technical Services, include training, demonstration, and technical consultation information.
2. Technology Development Services, include at least design technology, prototypes, intellectual property management, and legal consultation.
3. Incubation of Technology Businesses in the form of technology and management support for technology-based startups.
4. Assistance Service at least it includes limited-scale production facilities, office space, and conference/seminar/exhibition rooms.

2.3. ICT and Robotics Cluster

The ICT and Robotics cluster is one of the clusters owned by DIKST ITS which is engaged in technology and information. The ICT and Robotics cluster is a prestigious field in a university. ITS develops this field seriously and has produced various types of robots with international reputations, including humanoid robots named Ichiro, fire fighting robots, flying robots, and robots that have the kinetic ability to dance like humans. The field of ICT and Robotics develops technology in several fields, for strategic research in the industry, namely using Radio Frequency Identification (RFID) technology which is applied in a Driver's License (SIM) to control fuel consumption. In the medical field, the TB Analyzer is made, which is a tool that helps doctors to calculate the number of tuberculosis bacteria in the image of sputum preparations. There are 7 sectors of expertise in research and innovation in the field of ICT and Robotics, namely:

- Creating Micro Electronics (IME) for robot development
- Manufacture of Micro Controller as a robotic processor
- Providing various robots at affordable prices so that they can be used by users from various circles, especially from the education sector
- Development of various applications and data sources
- Construction of satellite stations
- Create various tools to facilitate information
- Creating tools to facilitate information for medical purposes

2.4. System Development Life Cycle

The System Development Life Cycle (SDLC) is a structured process that allows the production of high quality software but at low costs and production time tends to be short. The goal of SDLC is to produce superior software that can meet user needs and expectations. SDLC works by defining and describing a detailed plan in several stages or phases, where each stage or phase has a process that can be easily understood. The development of an information system based on the SDLC can speed up the development process and minimize the risks and costs

associated with alternative production methods. The following are the details of the stages or phases of information system development based on the SDLC (Sysnopsys, 2019).

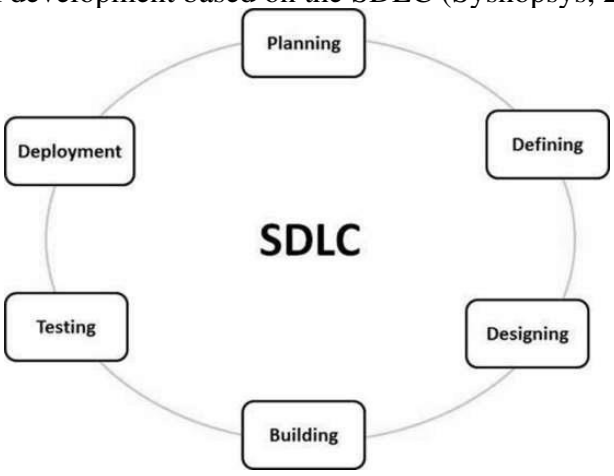


Figure 1. System Development Life Cycle

This is an explanation of each cycle in the System Development Life Cycle:

1. Planning and requirements analysis
   Requirements analysis is the most important and fundamental stage in the SDLC. This stage is carried out by senior team members with input from customers, sales departments, market surveys, and domain experts in the industry. This information is then used to plan a basic project approach and to conduct product feasibility studies in economic, operational and technical areas.
2. Defining requirements
   The next step after completing the requirements analysis stage is to clearly define and document product requirements and make them approved by customers or market analysts. This is done through a Software Requirement Specification (SRS) document which comprises all the product requirements to be designed and developed during the project life cycle.
3. Designing the product architecture
   SRS is a reference for product architects to produce the best architecture for the product to be developed. Based on the requirements specified in the SRS, typically, more than one design approach to the product architecture is proposed and documented in the Design Document Specification (DDS).
4. Building or developing the product
   This SDLC stage, the actual development begins, and the product is built. Programming code is generated as per DDS during this stage. If the design is detailed and organized, code generation can be done without much hassle. Developers should follow the coding guidelines defined by their organization and programming tools like compilers, interpreters, debuggers, etc. used to generate code.
5. Testing the product
   This stage is usually part of all stages as in modern SDLC models, testing activities are mostly involved in all stages of SDLC. However, this stage refers to only the product testing stage where product defects are reported, tracked, corrected, and retested, until the product reaches the quality standards specified in the SRS.
6. Deployment in the market and maintenance

The next stage is for the product to be officially released in the appropriate market. Sometimes product deployment occurs in stages according to the organization's business strategy. The product may be first released in a limited segment and tested in a real business environment. User Acceptance Testing (UAT).

2.4. Agile Scrum Methodology

Agile Scrum Methodology is a combination of agile philosophy and scrum framework. Agile means incremental, which means it allows a team to develop a project bit by bit. Scrum is one of many types of agile methodologies, known for breaking projects into fairly large chunks called sprints. Agile Scrum Methodology is good for businesses that need to complete certain projects quickly.

Agile scrum methodology is a project management system that relies on gradual development. Each iteration consists of sprints that are worked on over a period of two to four weeks, where the goal of each sprint is to build the most important features first and produce a potentially deliverable product. More features are built into the product in subsequent sprints and adjusted based on feedback from stakeholders and users between sprints. In contrast to other project management methods that emphasize building the entire product in one operation from start to finish. Agile Scrum Methodology focuses on delivering multiple product iterations to provide stakeholders with the highest business value in the least amount of time.

Agile Scrum Methodology has several benefits. First, it encourages products to be made faster, because each set of goals must be completed within the time frame of each sprint. It also requires frequent planning and goal setting, which helps the scrum team focus on current sprint goals and increase productivity (Peek, 2021).

3. METHODS

This study will be conducted utilizing a qualitative research method. The qualitative approaches are utilized to obtain data for this study by processing descriptive data such as interviews with the ICT and Robotics cluster. In addition to conducting interviews, data was gathered via looking for literature studies on the research topic, namely the aspects that could influence the design of information systems. After all of the data has been collected, we can processed the data and information system design concept can begin to develop.

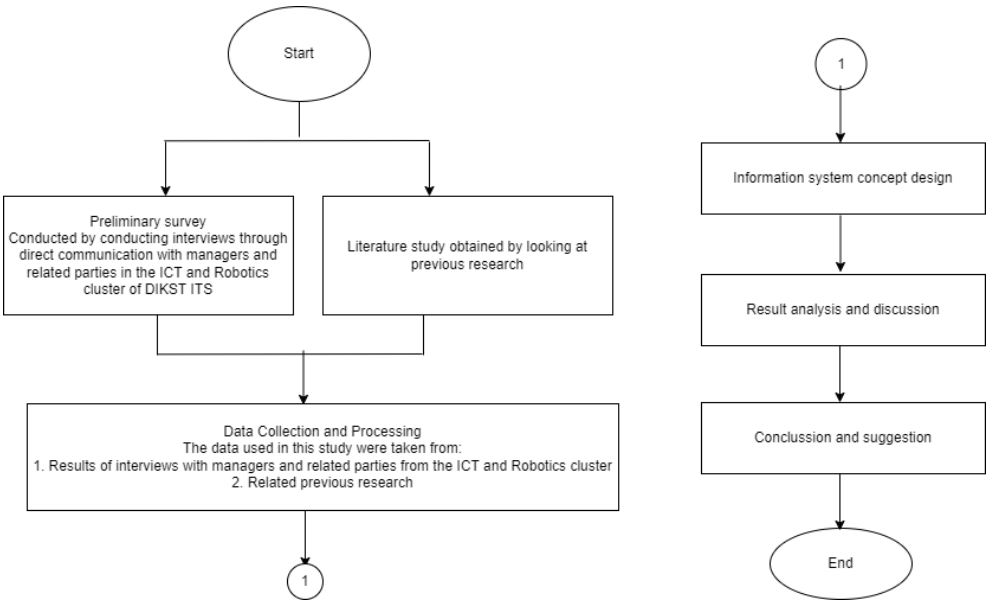


Figure 2. Flowchart of the Research

4. RESULTS

There are several activities currently in the Human Resources department, including: employee procurement, payroll, career path changes, and performance appraisal. In this research, the focus is related to employee procurement. To meet the needs of employees in supporting the company's performance, it is necessary to procure skilled employees in each of the existing job description. Employees in the ICT and Robotics Industry Cluster are divided into 4 types, namely Civil Servant of ITS Employees, Non-Civil Servant of ITS Employees, Contract Employees, and Freelance Daily Workers. for the recruitment of employees with civil servant status, carried out directly by the state. Meanwhile, the recruitment of Freelance Daily Workers is carried out at the discretion of the internal party. The following is the general flow of Non-Civil Servant of ITS Employees and Contract Employees:

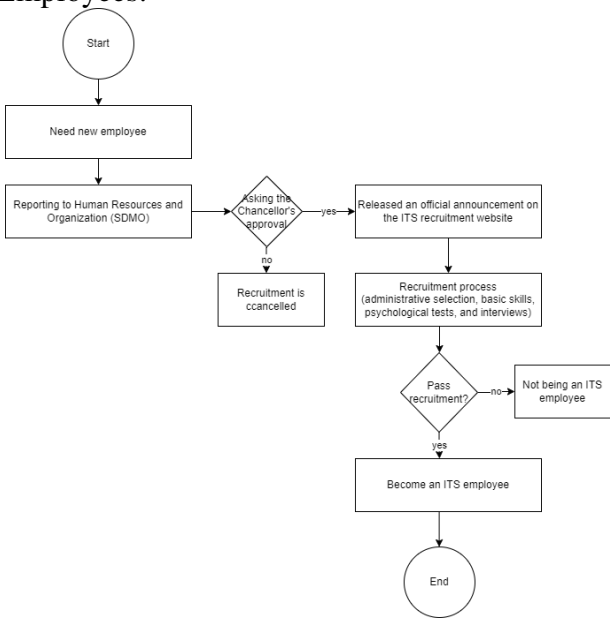


Figure 3. Flowchart of Recruitment

Based on the results of the analysis, it can be modeled the concept of an information system that is described using Use Case Diagrams and Activity Diagram. Use case diagrams are used to describe an interaction between one or more actors and the system to be created. In addition, it is used to find out what functions are in a system and who has the right to use these functions.

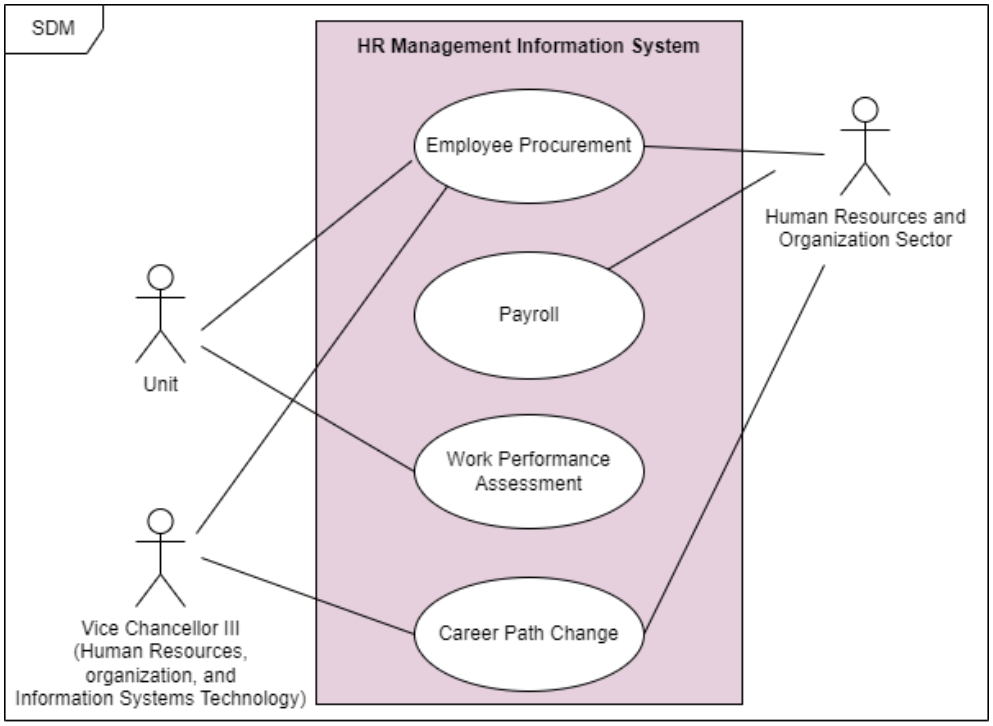


Figure 4. Use Case Diagram

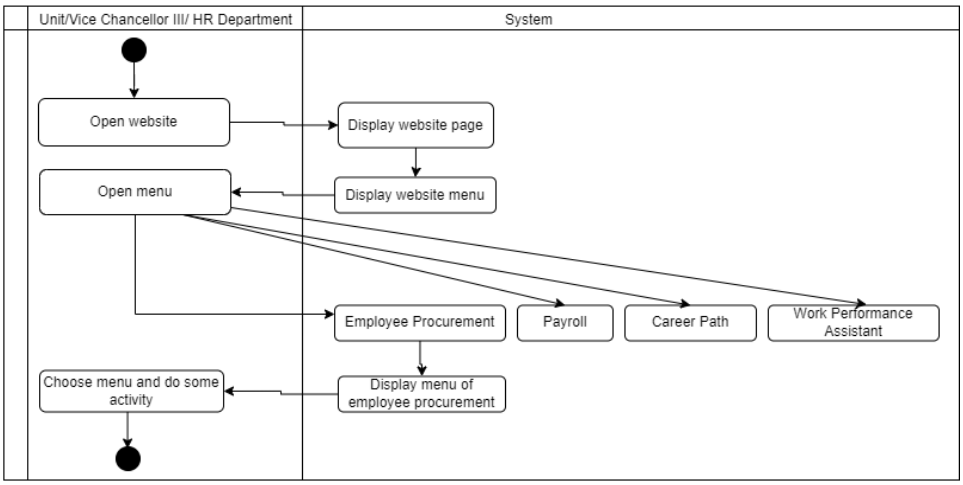


Figure 5. Activity Diagram

5. CONCLUSIONS

Based on the results of the analysis and system design that have been carried out, the scope of this research is initial design of the information system concept for managing the ICT and Robotics industry cluster HR at ITS. There are 4 important factors in the design of the information system concept for the management of human resources in the ICT and robotics industrial cluster at DIKST ITS, namely employee procurement, work performance assessment, career path

changes, and salary. The use of the Agile Scrum Methodology in this study was only limited to the design stage because it had not been completed until the information system for the management of human resources for the ICT and robotics industrial clusters at DIKST ITS could be used. The concept design of the human resource management information system for the ICT and robotics industrial cluster at ITS DIKST has been made with several desired functions and menus.

REFERENCES

DIKST. (n.d.). *Ilmu Pengetahuan di ITS Untuk Pengembangan Industri*. Retrieved from https://www.its.ac.id/stp/id/kawasan-sains-teknologi/#:~:text=STP%20ITS%20adalah%20lembaga%20yang,riset%20oleh%20dosen%20dan%20mahasiswa.&text=STP%20di%20ITS%20berfungsi%20menjembatani%20riset%20perguruan%20tinggi%20dengan%20dunia%20industri.

DIKST ITS. (2020). *Profil of Directorate of Innovation and Science Technology Area.* Surabaya.

Endroyono, D. (2021). *Peran Kawasan TIK-Robotika dalam Hilirisasi Inovasi dan Program MBKM*. Surabaya.

Hamsan. (2019). *Pengertian Revolusi Industri 4.0. Accessed 25 April 2022*. Retrieved from https://www.gramedia.com/best-seller/revolusi-industri-4-0/

Lasmaya , S. (2016). Pengaruh Sistem Informasi SDM, Kompetensi Dan Disiplin Kerja Terhadap Kinerja Karyawan. *Jurnal Ekonomi, Bisnis & Entrepreneurship Vol.10 No.1*.

Ministry of Research, T. a. (2019). *Hasil Penilaian Maturitas KST.* Jakarta.

Peek, S. (2021). *What Is Agile Scrum Methodology?* Retrieved from https://www.businessnewsdaily.com/4987-what-is-agile-scrum-methodology.html

(2017). *Presidential Regulation of the Republic of Indonesia Number 106 concerning Science and Technology Areas.*

Sarmadi, D. (2014). *Merkel calls for 'industri 4.0' at German IT Summit*. Retrieved from https://www.euractiv.com/section/digital/news/merkel-calls-for-industri-4-0-at-german-it-summit/

Sepuluh Nopember, I. (2022). *Directorate of Innovation and Science Techno Park*. Retrieved from Research at ITS for Industrial Development: https://www.its.ac.id/stp/science-techno-park

Sysnopsys. (2019). *What Is the Software Development Life Cycle (SDLC) and How Does It Work?* Retrieved from https://www.synopsys.com/glossary/what-is-sdlc.html

Torres, F. (2020, July). *Data Integration is a Key Driver for Industri 4.0 in Polymer Manufacturing*. Retrieved from Manufacturing Tomorrow: https://www.manufacturingtomorrow.com/article/2019/12/data-integration-is-a-key-driver-for-industri-40-in-polymer-manufacturing/14576

IMPLEMENTATION OF VALUE BASED DECISION ON ELEVATOR DESIGN SYSTEM SELECTION

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ABSTRACT

Along with the development of property, especially apartments, vertical transportation is an important aspect in supporting apartment operations. Therefore, it is necessary to design an appropriate elevator system that is able to accommodate the wishes of stakeholders and also users/residents of the apartment in terms of building vertical transportation. The methodology planned in selecting the best design for the elevator system is a value based decision. Hence, the functions and costs of each alternative will be compared. The function will be analyzed using FAST and the cost will be calculated based of the LCC of each alternative. This research is expected to help stakeholders and project leaders in carrying out decision making, especially in choosing an appropriate elevator system design for high-rise buildings that prioritizes the architectural and aesthetic values of the elevator, while still prioritizing the comfort and safety of users.

Keywords: elevator, value based decision, FAST, LCC.

1. INTRODUCTION

In designing a vertical transportation system in buildings, there are guidelines that become a reference, especially in Indonesia, namely SNI 03-6573-2001 and for K3 Elevators, namely Permenaker number 6 of 2017. In order to further improve comfort and safety in buildings, the Department of Settlement and Regional Infrastructure represents the government, professional associations, consultants, contractors, suppliers, building managers and universities, prepare standards for "Procedures for Designing Vertical Transportation Systems in Buildings (lifts)" which are then standardized by the National Standardization Body to become: SNI 03-6573-2001.

The design of the elevator/lift system requires a planned design management and goes through quite detailed process stages, starting from designing and planning the use of a roomless system or without a machine room, as well as the use of a system with a machine room (LMR = Lift Machine Room), planning and maintenance projections, comfort, safety and lifetime. In choosing the type of elevator, it is necessary to process and analyze functions, creative processes, life cycle cost analysis and decision making (Utomo, 2021), so that all stages of design management can be carried out and get the best and right design decisions.

Value-Based Decision Making Method (Value Based Decision) is taken as a decision-making method with several accompanying techniques or methods, including: AHP (Analytical Hierarchy Process), LCC (Life Cycle Cost), and FAST (Function Analysis System Technique). In

the concept of value, the most important considerations are function and cost, (Utomo, 2021) which will then be analyzed to compare how the function affects costs and vice versa. The results of decisions made based on alternatives are expected to be able to make a contribution that can help stakeholders in the best decisions.

2. LITERATURE REVIEW

A. Value

Utomo (2010), the meaning of value can be interpreted openly, but generally, the value of a product will be judged based on several factors such as high level of performance, ability, emotional appeal, style and others, relative to cost, or can be expressed in the following equation :

$$value = \frac{Performance + Capability}{cost} = \frac{funtion}{cost} \quad (1)$$

B. Life Cycle Cost

Pavol (2021), Life Cycle Cost Analysis (LCCA) provides more insight into the implementation of a project's life cycle (construction, product, system) and is one part of assessing the economic sustainability of a project.

Utomo(2014), Cost in the form of life cycle cost (LCC) is the second criterion in value. The term 'LCC' means a process for evaluating the total economic value of a project segment which can be used by analyzing initial costs and discounted future costs.

The term 'life cycle cost' (LCC) means the process for evaluating the total economic value of a project can be used by analyzing initial costs and discounted future costs, such as maintenance, and user costs over the life of the project. Life cycle costing (LCC) is an important design process for controlling the initial and future costs of building ownership. LCC can be implemented at any level of the design process and can be an effective tool for evaluation of existing building systems. The LCC equation can be broken down into three variables: the associated costs of ownership, the time period in which those costs are incurred, and the discount rate applied to future costs to equate them with current costs. For the calculation of LCC , the following equation is used . Can be calculated using the theory of time value of money with the following equation:

$$P = A\ x\ \frac{(1+i)^n - 1}{i\ x\ (1+i)^n} \quad (2)$$

Where : P = present value; F = future value; A = annual value; I= rate (%) per period; N = number of periods (years)

C. Funtion Analysis System Technique

Utomo (2014) Functional Analysis is a systematic process of identifying functions and their associated costs, and assessing the need for those functions based on established criteria for a product or service. Function analysis should include identification of functions, classification of functions, functional models, establishing function worth, cost functions, establishing value index and selection of function for study.

Function analysis consists of four sequential steps (Utomo, 2010) which are: (1) determination of project function, (2) examination and sorting of these functions into categories, (3) selection of critical functions and arrangement into a logical order, and (4) analyzing the importance of the function. There are several methods of function analysis, one of the most important and useful is FAST (Function Analysis System Technique)(Bytheway, 2007).

3. METHODS

In the process of determining the criteria, a group discussion forum is conducted, where the results of the criteria are used as a basis for carrying out the decision-making process. The result of the criteria for the function is architectural, operational and maintenance, electricity efficiency, comfortable, instalastion, and last are sparepart. And criteria for cost is intial cost and maintenance cost.

As for determining alternatives, interviews were conducted with the project manager, architect planning consultant and MEP, as well as vendors providing elevator procurement and installation services, which resulted in alternatives , as follows : roomless elevator with architectural on car, machine room elevator with architectural on car, and machine room elevator with architectural on car and panoramic.

The methodology of value based decision, with the three stage of the process. First stage process are value based that calculating of function and value, second stage are multi criteria decision that use AHP (Analytical Hierarchy Process) and satisficing option of value criteria, and last stage are use group decision that analysis of optimal payoff, agreement option and coalition for determining best option and alternative (Utomo, 2010). Figure 1. shown the process.

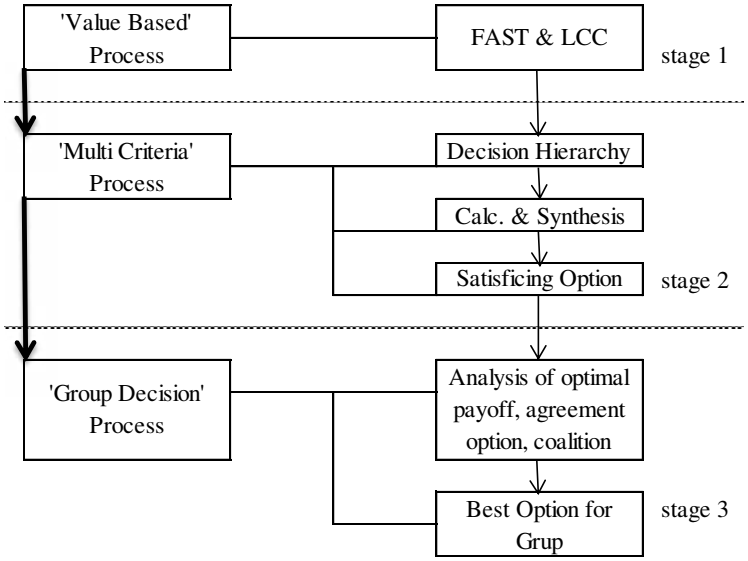


Fig. 1 The Methodology of Value Based Decision

4. RESULTS

Utomo (2010) suggested, the selection criteria of value-based decision are taken from the basic theory of VA(Value Analysis) namely function and cost. Function will be determined by Function Analysis System Technique(FAST) and Cost will be calculated by the concept of Life Cycle Cost (LCC).

1. Value Based

Fig.2 shown the FAST diagram. Based on FAST, functions can be identified. Figure 3.2 shows the FAST diagram. Next, the identified function will be become the attribute (f1-f7). FAST is an evolution of the Value Analysis (VA) process (Bytheway, 2007) that permits people with different technical backgrounds to effectively communicate and resolve issues that require multidisciplinary considerations by building complex systems that link simple verb-noun predications. FAST Diagram Reflects the perceptions of owner representatives, project managers and planning consultants.

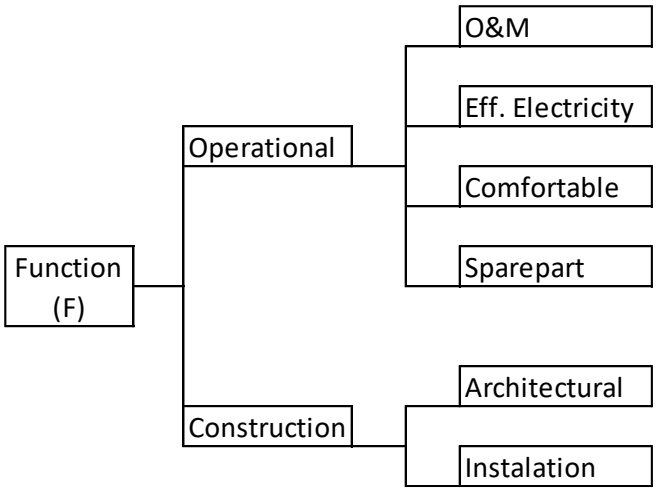


Figure 2. FAST Diagram of Elevator System Selection

Next step of stage one are LCC analysis, the cost of design system will calculated. For the investment cost, it was obtained from the submission that had previously been submitted, while the life cycle cost was obtained from the maintenance cost that was previously proposed project which also uses the same vendor of procurement and installation services for elevators. Table 1. present the table of initial cost and LCC. Furthermore, all costs, both Initial Cost and LCC are entered into table 1 below for further analysis using equation 2.

Table 1. Cost Of Design System Elevator

Cost Category	Alternative 1	Alternative 2	Alternative 3
Initial Cost (IDR)	956,700,000	1,440,000,000	1,989,500,000
LCC (IDR)	630,000,000	937,500,000	937,500,000

2. Multi Criteria

The next stage consists of three stages, which are analyze: the decision hierarchy, assessment and synthesis, and satisficing option on the value criteria.

a. Decision Hierarchy

Fig. 3 shows the four levels of the decision hierarchy. The purpose of this problem is "Choosing the best option for the elevator system ". The goal is indicated by several alternatives (A = a1; a2; a3). The problem is divided into two value criteria, namely Function (f) and Cost (c), which are further divided into sub-criteria f1, f2, f3, f4, f5, f6 and c1, c2.

b. Calculation and Synthesis

Tab. 2 presents the process for assigning weight to elevator system design choices. Support for any decision maker or stakeholder.

In table, it can be explained that for naming a1, a2 and a3, is the code used to name the alternatives that will be chosen by the respondents and calculated using the AHP method. Meanwhile, the naming of C1 and C2 is the cost of the initial cost and LCC. For F1 to F6, it is the use of codes for function values based on the results of the previous FGD.

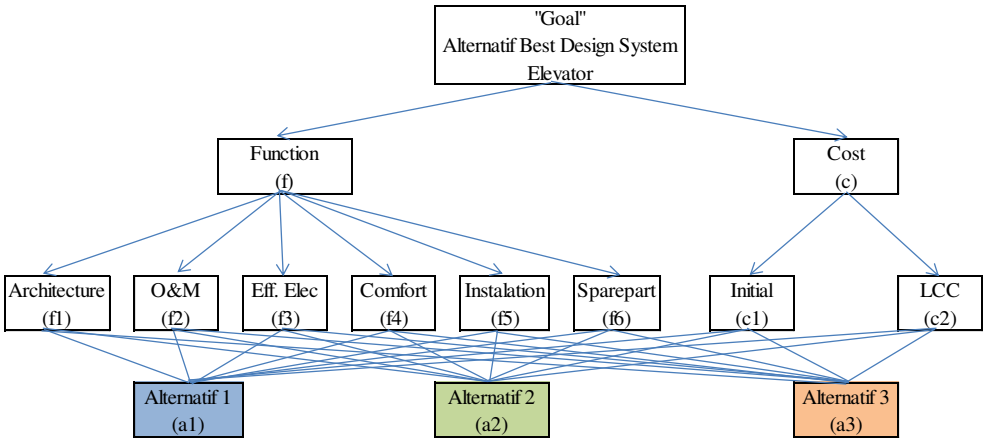


Figure 3. Decision Hierarchy to select Design System Elevator

Table 2. Process For Assigning Weight

ITEM		F1	F2	F3	F4	F5	F6	C1	C2	Weight
Stakeholder 1 (Owner)	A1									
	A2									
	A3									
Stakeholder 2 PM-MK	A1									
	A2									
	A3									
Stakeholder 3 Konsultan	A1									
	A2									
	A3									

Source : Utomo (2011)

c. Satisficing Option

According to Utomo, (2011) the option will be a rejection option if the cost value is higher than the function. In other words it can be said that there are unnecessary costs in technical solution options. Figure 3 provides a plot of the functions of the technical solution options. The highest value alternative is the one that can provide the highest level of satisfaction because of its high functionality and low cost (Utomo, 2010). Table 3, present the value of function and cost on every alternative.

Table 3. Value Of Function and Cost on Every Alternative

	Cost				Function						Normalization	
	C1	C2	ε	Loss	F1	F2	F3	F4	F5	F6	Cost	Function
A1												
A2												
A3												

In the process of calculating and comparing the best alternatives, the values of C1 and C2 are obtained by dividing the initial cost values and the LCC values. For function values from F1 to F6, obtained from conducting AHP analysis first for all functions, after obtaining the decimal value, it can be entered into a table which can then be further calculated for the value of weight, loss, and weight normalization.

3. Group Decision

First step from group decision are optimal payoff, agreement options, and coalition. In this section , select the best system elevator are important for building and operational. It is critical that the selected system satisfy all the criteria, and the criteria used to select a system depend on the perspective of the individual decision makers (Utomo 2014). For example, project manager might be more interested for cost and installation, consultant architecture more interested for architecture and comfortable , and for supervisory consultant more interested for operational maintenance and electricity efficiency.

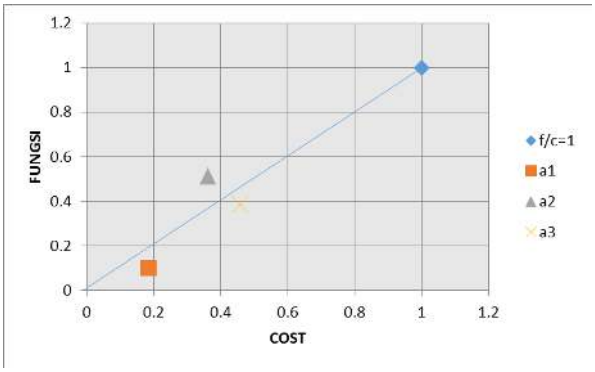


Figure 4. Value of System Design Elevator for Group Decision

Last step for group decision to determine the fitness of the best alternative solution. The best option of all stakeholder by looking at the function / cost ratio, the best selectability option with the least negative value (Utomo (2010). Figure 4 present the example of best alternative. Figure 4 shown the grup decision of all stakeholder, where the a2 as the best option for the design system elevator choose.

6. CONCLUSIONS

The 'value' in function/cost is the basis of the metodhology of this paper. For the Value Based Decision process has three stage : value based, multi criteria, group decision. The best alternative option chose by group decision, for example : the result of alternative 2 is the best option than alternative 1 and alternative 3.

The results of this study are expected to be useful in further research in this field, especially in determining the research methods and data used in the study. In addition, further studies can also use the approach generated in this paper. This paper can help further research for the use of value-based decisions with appropriate methods and analysis.

REFERENCES

Al-Sharif, L.(2017).*The Design of Elevator Systems in High Rise Buildings, Part 2.* Professor, Mechatronics Engineering Department, The University of Jordan, Amman 11942, Jordan.

Amin, N. (2018). *Implementasi value based decision pada pemilihan desain sistem kelistrikan di Ciputra World Surabaya phase 3* (Doctoral dissertation, Institut Teknologi Sepuluh Nopember).

Belany, Hrabovsky P., Kolkova, Z.(2021*). Combination of lighting retrofit and life cycle cost analysis for energy efficiency improvement in buildings.*

Bradshaw, C.M., (2019). *In search of a definition of reinforcer value: Some successes and failures of the multiplicative hyperbolic model*.

Bytheway, C. W. (2007). *FAST creativity and innovation: Rapidly improving processes, product development and solving complex problems*. J. Ross Publishing.

Chumaidi, M. (2017). *Implementasi Value Based DSIAPAecision pada Pemilihan Metode Kerja Ereksi Girder pada Pekerjaan Jembatan Kali Marmoyo Berdasarkan Kriteria Finansial dan Non-finansial* (Doctoral dissertation, Institut Teknologi Sepuluh Nopember).

Crespo, R. S., Kaczmarczyk, S., Picton, P., & Su, H. (2018). *Modelling and simulation of a stationary high-rise elevator system to predict the dynamic interactions between its components*. International Journal of Mechanical Sciences, 137, 24-45.

Idrus, A., C. Utomo. 2010. *Functionality of Negotiation Agent on Value-based Design Decision*. World Academy of Science, Engineering and Technology. 4(3): 351–355.

Kaufman, J. J. 2001. *Value Management: Creating Competitive Advantage*. Financial World Publishing, Canterbury, Kent, UK.

Kawakami, H. Katai,T. Sawaragi, T. Konishi & Iwai.(1996). *Knowledge design based acquisition method for conceptual on value engineering and axiomatic design theory*. Artificial Inteligence of Engineering.

Kelly, J., S. Male, D. Graham. 2004. *Value Management of Construction Project*. Blackwell Publishing, Oxford UK.

Permen No.6 tahun 2017. *Peraturan Menteri Ketenagakerjaan Republik Indonesia Nomor 6 Tahun 2017 Tentang Keselamatan Dan Kesehatan Kerja Elevator Dan Eskalator*.

Saaty, T. L. (2008). Decision making with the analytic hierarchy process. *International journal of services sciences*, *1*(1), 83-98..

Sachari, A ., Sunarya , Yan Yan.(2000). *Pengantar Tinjauan Desain*. Institut Teknologi Bandung.

Schinlder Elevator. (2013). *Schindler 7000 High-rise Elevators The journey to the top.*

Siikonen, dkk. (2018). *Elevator Traffic Simulation Procedure*.

SNI 03-6573-2001. (2001). *Tata Cara Perancangan Sistem Transportasi Vertikal dalam Gedung (lif)*

Strakosch, G., Caporale. S ., Robert. (2010). *The Vertical Transportation Handbook*, Fourth Edition.

Utomo, C., Idrus, A., Napiah, M., & Khamidi, M. F. (2009, March). Aggregation and coalition formation on value-based decision. In *2009 IEEE Symposium on Computational Intelligence in Multi-Criteria Decision-Making (MCDM)* (pp. 118-125). IEEE.

Utomo, C., & Idrus, A. (2010). *Value–based Group Decision on Support Bridge Selection*. *International Journal of Human and Social Sciences*, 791-796.

Utomo, C. & Idrus, A. (2011). *Negotiation Support for Value – based Decision in Construction. World Academy of science, Engineering and Technology*, International Journal of Social, Behavioral, Educational, Economics and Industrial Engineering Vol 5, no 12.

Utomo, C., Rahmawati, Y., Sulfiah Dwi Astarini, M. T., & Gita Widi Bhawika, M. M. T. (2021). *Monograf Manajemen Desain: Keputusan Desain Berbasis Nilai Edisi Revisi*. Deepublish.

Utomo, C., Zin, R. M., Zakaria, R., & Rahmawati, Y. (2014). A conceptual model of agreement options for value-based group decision on value management. *Jurnal Teknologi*, *70*(7).

Yaman, O., Baygin, M., & Karakose, M. (2016). *A new approach based on image processing for detection of wear of guide-rail surface in elevator systems*. International Journal of Applied Mathematics Electronics and Computers, (Special Issue-1), 296-300.

Zhou ,Y. Wang, K. Liu , H.(2018). *An Elevator Monitoring System Based On The Internet Of Things.*

Zubair, M . Zhang, X. (2020). *Explicit data - driven prediction model of annual energy consumed by elevators in residential buildings*. Journal Of Building Engineering.

CUSTOMER BEHAVIORAL ANALISYS TO IDENTIFY CUSTOMER INTERNET SERVICE PRODUCT CHOICE USING UTAUT2 MODEL IMPLEMENTATION

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ABSTRACT

The technological development in the current time can be said to be growing rapidly. Moreover, since the world have been hit by a pandemic. Some countries begin to use the online networking as a way to communicate. In order to be able to access the internet world, Indonesia has various options of Internet Service Provider (ISP). The type varies and is depending on the customer's need. This research aims to know the motifs of the customers behavior and motive on choosing their internet provider using research variables that exist in the UTAUT2 model. The usage of UTAUT2 has a purpose to know the customers behavior on choosing a product based on the determined variable. This research is expected to produce an output from the analysis product is reason the product is being chosen among the customer. The UTAUT2 model is selected because of the existing variables can be helpful in achieving the desired outcome of this research.

Keywords: Technology, Internet, Internet Service Provider, UTAUT2, Customer Behavioral.

1. INTRODUCTION

With the blast of rapid grows of technology, each country now has an Internet Service Provider (ISP) that can support internet network needs. The number of ISPs in Indonesia itself every year is also increasing, considering the need for an internet networks that is currently getting higher.

The motives for choosing customers also vary, with a range of the environment to hedonism. The research method that will be used later is the Unified Theory of Acceptance, and Use of Technology 2 (UTAUT2). UTAUT2 model showed the behavior intention and the behavior to use one technology (behavior) can be influenced by several factors such as performance expectancy, facilitating conditions, hedonic motivation, and others. UTAUT2 has been widely used in several studies and the extension of this theoretical model is based on each researcher who has a different technology, population, and culture. Thus, it is possible to build new constructs in this theoretical model due to differences between studies. With the implementation of the UTAUT2 model based on human behavior problems, it is expected that this research will obtain the factors for choosing an internet service product.

Customer Behavioral Analisys To Identify Customer Internet Service Product Choice Using UTAUT2 Model Implementation is expected to provide an output that can be used by companies as a reference in increasing annual income, especially for the marketing division which of course plays an important role in promoting their superior products.

2. LITERATURE REVIEW

2.1 *Unified Theory of Acceptance and Use of Technology 2* (UTAUT2)

Unified Theory of Acceptance and Use of Technology 2 (UTAUT2) is a model that has been developed from the previous model, the Unified Theory of Acceptance and Use of Technology (UTAUT). UTAUT2 can also be used to measure customer satisfaction based on the variables and parameters that have been settled. In UTAUT2, the models are related to each other and will later help in constructing patterns from customer characteristics.

2.2 Structural Equation Modelling (SEM)

Structural Equation Modeling is a method used to analyze multivariate data that is often used in marketing research (Chin, 1996; Haenlein & Kaplan, 2004; Statsoft, 2013). SEM has two variables, which is exogenous and endogenous. Exogenous is a variable that does not have an arrow that points to another latent variable so that the latent variable will not be affected by the exogenous variable.

SEM has several types of approaches, including Partial Least Squares (PLS) which focuses on analyzing several variants which then aims to predict the effect of latent and manifest variables. There are two forms of indicators in the PLS approach, namely reflective and formative approaches.

2.3 Partial Least Square Structural Equation Model (PLS-SEM)

Partial Least Square (PLS) is the second generation of SEM which is based on regression and is quite suitable to be used for market research, which the approach can minimize the residual variance of the construction of endogenous variables. The Algorithm of PLS-SEM will optimize the model parameters first, then estimate the coefficients in the structural model. The researcher will first examine the characteristic measurements and resolve the unaccpeted parameters. In PLS-SEM, there are some steps that needs to be followed, which is:

3. METHODS

3.1 Data Collection

In this research, researcher used a questionnaire to collect data. The questions contained in the questionnaire are structured questions for which alternative answers have been provided. on the questionnaire have the following values:

- Score 1 for Strongly Disagree category (STS)
- Score 2 for Disagree category (TS)
- Score 3 for Neutral category (N)
- Score 4 for Agree category (S)
- Score 5 for Strongly Agree category (SS)

For User Behavior Variables, questions are presented in the form of a scale for the intensity of subscribing to internet service products and explained as follows:

- Score 1 for the intensity of the desire to subscribe not interested
- Score 2 for the intensity of ordinary subscription desires
- Score 3 for the intensity of the desire to subscribe interested
- Score 4 for the intensity of the desire to subscribe is very interested

The description of variables, indicators, and question items from the questionnaire will be presented in Table 1.

Table 1 Description of variables, indicators, and question items

Variable	Indicator	Items
Performance Expectancy (PE)	Utility	Internet Service Products are useful to help with daily activities
	Productivity Boost	Internet Service Products can help increase daily productivity
Effort Expectancy (EE)	Easy Subscription Way	Purchasing Internet Service Products is quite easy to do
Social Influence (SI)	Environmental Influence	Internet Service Products used by colleagues or people around
	Perception of people around	A lot recommendation for using Internet Service Products
	Advertising Effect	The existence of promotions through advertisements can affect interest in subscribing to Internet Services
Facilitating Conditions (FC)	Facility Availability	The area is already included in the scope for subscribing to Internet Service products.
	Knowledge Possession	Having the knowledge of Internet Service products before subscribing
	Product acceptable	Customers receive internet service products
Hedonic Motivation (HM)	Pleasant to use	Customers are happy with internet services from ISP companies.
	Needs	Customers feels that Internet Service products are their needs
	Willingness to Use	Customers are willing to spend money to pay specifically for this product
Price Value (PV)	Cost	Internet service has an affordable price
	Benefits than costs	Internet service provides more benefits than the cost
	Value than cost	Internet Service Products provide more value than the cost
Habit (HB)	Habit	Customers are used to using other internet service products
	Requirement	Customers feel they have to subscribe to Internet Services
Behavioural Intention (BI)	Intention	Intention to subscribe to Internet Service products
	Usage Interest	Interest in subscribing to Internet Service products
User Behaviour (UB)	Intensity	How much do you want to subscribe to Internet Services?

3.2 Conceptual Model

The conceptual model used in this research can be described as shown in the Figure 2.

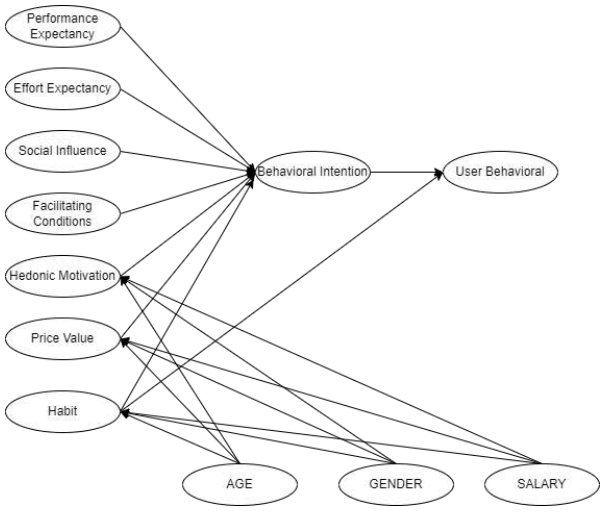


Figure 2. Research Conceptual Model

3.3 Hypothesis

In the hypothesis determination stage, the following hypotheses will be related to the influence of control variables, namely gender, experience, and income to dig deeper whether the control variables can influence the independent variables on Behavioral Intention to Subscribe Internet Service or User Behavior to Subscribe Internet Service, by using several hypotheses in Viswanath Venkatesh's (2012) research on UTAUT2.

Table 2 Hypothesis.

Hypothesis	Description
H_1	Performance Expectancy → Behavioral Intention
H_2	Effort Expectancy → Behavioral Intention
H_3	Social Influence → Behavioral Intention
H_4	Facilitating Conditions → Behavioral Intention
H_5	Hedonic Motivation → Behavioral Intention
H_6	Price Value → Behavioral Intention
H_7	Habit→Behavioral Intention
H_8	Behavioral Intention → User Behavioral

4. RESULTS

4.1 Data Collection

The number of questionnaire respondents obtained in the study were 185 respondents. The survey method was using google forms, where users could easily and directly filling out the questionnaire form instantly and was recorded directly by system. The descriptive statistical analysis of the questionnaire that was obtained when the data had been collected is described in **Table 3.**

Table 3 Descriptive Statistic

Gender		
Female	92	49.73%
Male	93	50.27%
Age		
≤ 30 years	149	80.54%
> 30 years	36	19.46%
Salary		
Rp.0-Rp.5.000.000	118	63.78%
>Rp.5.000.000	67	36.22%

4.2 Analysis Measurement Model

Measurement model analysis used in this study was used to see whether the indicators or question items in the study were able to properly measure the research variables (valid and reliable). The evaluation of the outer model in PLS-SEM was divided into three parts which are indicator reliability, internal consistency reliability, and convergent validity.

Table 4 Indicator Reliability

Variable	Indicator	Outer Loading results	Variable	Indikator	Outer Loading results

Performance Expectancy (x_1)	$x_{1,1}$	0.919	*Price Value* (x_6)	$x_{6,1}$	0.941
	$x_{1,2}$	0.751		$x_{6,2}$	0.924
Effort Expectancy (x_2)	$x_{2,1}$	1.000	*Habit* (x_7)	$x_{7,1}$	1.000
Social Influence (x_3)	$x_{3,1}$	0.950	*Behavioral Intention* (y_1)	$y_{1,1}$	0.978
	$x_{3,2}$	0.758		$y_{1,2}$	0.976
Facilitating Conditions (x_4)	$x_{4,1}$	0.782	*User Behaviour* (y_2)	$y_{2,1}$	1.000
	$x_{4,2}$	0.896			
Hedonic Motivation (x_5)	$x_{5,1}$	0.815			
	$x_{5,2}$	0.851			

Indicator reliability can be seen at the outer loading value (loading factor) which draws how big is the correlation to each manifest variable to latent variable where if the value is more than 0,7, then the indicator can be said as good as described in **Table 5**.

Table 5 Internal Cinsistency Reliability

Variabel	Composite Reliability
Performance Expectancy	0.800
Effort Expectancy	1.000
Social Influence	0.755
Facilitating Conditions	0.804
Hedonic Motivation	0.768
Price Value	0.814
Habit	1.000
Behavioral Intention	0.895
User Behavior	1.000

The process can be done with looking at the value of composite reliability. If the latent variable used is higher than 0,7, it can be said that the construct has a good reliability. While the convergent validity can be seen with looking at the Average Variance Extracted (AVE) values, where AVE drawn the variance of indicators which in the construct. This study can be categorized as good if the value of AVE is higher than 0,5. According to **Table 6**, the value of AVE being produced is higher 0,5. Thus, the constructs or latent variable that's used in this study is valid.

Table 6 Average Variance Extracted (AVE) Values.

Variabel	*Average Variance Extracted* (AVE)
Performance Expectancy	0.667
Effort Expectancy	1.000
Social Influence	0.610
Facilitating Conditions	0.672
Hedonic Motivation	0.625
Price Value	0.687
Habit	1.000

Behavioral Intention	0.810
User Behavior	1.000

4.3 Analysis Structural Model

In this evaluation, the Coefficient Determinant (R^2) can be used to seek for how huge is the influence between independent variable and dependent variable, where if the value of R^2 is higher, the more accurate is the accuracy.

Table 7 Coefficient Determinant

Variabel	R Square	R Square Adjusted
Behavioral Intention	0.489	0.469
Use Behavior	0.296	0.288

In **Table 7**, the value of R^2 on endogen or dependent variable for behavioral intention is 0.489 which can be said as moderate where the value in use behavior is 0.296 which can be mean that the exogen variable in this study moderately explain 48,9% variance from the behavioral intention variable, while variable behavioral intention and habit moderately explain 29,6% variance of use behavior variable.

The next stage, which can be seen in **Table 8**, aims to test the correlation between latent variables and the overall structural model. In this analysis, the structural model is divided into nine categories according to the hypothesis test to know if the independent variable have a significant impact on the dependent variable with the significant value (α) is 0,05. If the p-value ≤ α, theres a significant impact.

Table 8 Hypothesis testing result

Hipotesis	Hubungan Antar Variabel	T Statistics	P Values
H_1	*Behavioral Intention -> User Behavior*	6.103	0.000
H_2	*Effort Expectancy -> Behavioral Intention*	1.195	0.116
H_3	*Facilitating Conditions -> Behavioral Intention*	2.758	0.003
H_4	*Habit -> Behiavioral Intention*	2.741	0.003
H_5	*Habit -> User Behavioral*	0.467	0.320
H_6	*Hedonic Motivation -> Behavioral Intention*	1.609	0.054
H_7	*Performanc Expectancy -> Behavioral Intention*	1.129	0.130
H_8	*Price Value -> Behavioral Intention*	1.695	0.045
H_9	*Social Influence -> Behavioral Intention*	2.231	0.013

According to the **Table 8**, with significant value 5%, there is five relation of variables that's significant because p-value ≤ α, which is H_1, H_3, H_4, H_8, H_9 while the rest of it is not significant.

6. CONCLUSIONS

The result show that UTAUT2 method was successfully used in the study of customer behavioral analysis. The following are some results obtained by using behavioral intention and use behavior. Based on the value of path coefficient and p-value, it can be concluded that social influence, facilitating conditions, price value, and habit significantly influence behavioral intention and use behavior. This study contributes to the development of Internet services product by knowing the public's responses to it's products. So the marketing team is able to implement strategies based on the study that might increase the purchase to subscribe to the internet service products.

REFERENCES

Cohen-Almagor, R. (2011). Internet History. International Journal of Technoethics, Vol. 2, 45–64.

Datareportal.com (26 Januari 2022). Digital 2022: Global Overview Report. Diakses pada tanggal 28 April 2022 dari https://datareportal.com/reports/digital-2022-global-overview-report#:~:text=Global%20internet%20users%3A%20Global%20internet,of%20the%20world's%20total%20population.

Hair, J., Sarstedt, M., Hopkins, L., & Kuppelwieser, V. (2014). Partial Least Squares Structural Equation Modeling (PLS-SEM): An Emerging Tool for Business Research. European Business Review, 26, 106–121. https://doi.org/10.1108/EBR-10-2013-0128

Internet untuk segala kebutuhan / Yuniar Supardi | OPAC Perpustakaan Nasional RI. (n.d.). Retrieved June 29, 2022, from https://opac.perpusnas.go.id/DetailOpac.aspx?id=89059

Kbbi.com (2012-2021). Arti Kata Teknologi. Diakses pada 28 April 2022 dari https://kbbi.web.id/teknologi

(PDF) Partial Least Square Structural Equation Modelling ' use in Information Systems: An updated guideline of practices in exploratory settings. (n.d.). Retrieved June 29, 2022, from https://www.researchgate.net/publication/323783882_Partial_Least_Square_Structural_Equation_Modelling_'_use_in_Information_Systems_an_updated_guideline_of_practices_in_exploratory_settings

(PDF) PLS-sem: Indeed a silver bullet. (n.d.). Retrieved June 29, 2022, from https://www.researchgate.net/publication/236033273_PLS-sem_Indeed_a_silver_bullet

Putri, N., & Suardikha, I. (2020). Penerapan Model UTAUT 2 Untuk Menjelaskan Niat Dan Perilaku Penggunaan E-Money di Kota Denpasar. E-Jurnal Akuntansi, 30, 540.

Riahi Sfar, A., Chtourou, Z., & Challal, Y. (2017). A systemic and cognitive vision for IoT security: A case study of military live simulation and security challenges. 101–105.

Robitzsch, A. (2022). Estimation Methods of the Multiple-Group One-Dimensional Factor Model: Implied Identification Constraints in the Violation of Measurement Invariance. Axioms, 11(3), 119.

Venkatesh, V., Morris, M., Davis, G., & Davis, F. (2003). User Acceptance of Information Technology: Toward a Unified View. MIS Quarterly, 27, 425–478.

Venkatesh, V., Thong, J. Y. L., & Xu, X. (2012). Consumer Acceptance and Use of Information Technology: Extending the Unified Theory of Acceptance and Use of Technology [SSRN Scholarly Paper]. https://papers.ssrn.com/abstract=2002388

Yusup, F. (2018). Uji Validitas dan Reliabilitas Instrumen Penelitian Kuantitatif. Jurnal Tarbiyah : Jurnal Ilmiah Kependidikan, 7. https://doi.org/10.18592/tarbiyah.v7i1.2100

A QUANTITATIVE ANALYSIS OF FACTORS AFFECTED THE EMPLOYEE'S MOTIVATION ON PT "X" AND THE RECOMMENDATIONS TO SOLVE ITS PROBLEMS

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ABSTRACT

Since there were numerous resignations at PT "X" in 2019, which had consequences for a decline in employee performance, it is important to further investigate the decline in employee work motivation. The study aims to confirm the elements that affect employee motivation at PT "X" which will then be suggested as a guide and recommendation for the company in formulating its human resources policy. Quantitative methods were used in the investigation. By giving out questionnaires to 94 field employees of PT "X", the research's data was collected. After getting the data, the SEM-PLS statistical approach was used to process and evaluate it. The results of the study indicate that the two elements that positively affect employee motivation at PT "X" the most are employee development and work environment. Research also shows that management leadership is a factor that has a negative and significant impact on work motivation. There are also some very interesting findings which show that salary and benefits have no effect on work motivation. Further research is needed to determine how crucial it is to keep employees' motivation in PT "X" and other similar companies.

Keywords: motivation, employee, performance, SEM-PLS.

1. INTRODUCTION

The decrease in employee motivation is a very important issue at PT "X", which is a coal fired power plant operator, since there have been many mass resignations in 2019. As listed in table 1, based on the results of preliminary interviews conducted on 10 respondents, placing the employee motivation in a weak state has the highest number. It shows that the work motivation of employees at PT "X" needs to be improved, so it is always maintained in optimal conditions.

Table 1. Interview Result About Motivation Scale

No.	Position	Motivation Scale		
		Weak	Fair	Strong
1	Planner/Scheduler	X		
2	Techop 1	X		
3	Planner/Scheduler		X	
4	Techop 2	X		

5	Techop 1		X	
6	Planner/Scheduler			X
7	Engineer	X		
8	Techop 1	X		
9	Techop 1	X		
10	Techop 1		X	

Employee motivation itself is an important thing that must be considered because it is one of the factors that affect employee performance. Research by Riyanto et al. (2021) states that work motivation has a positive and significant influence on employee performance. In other study, Moodley (2018) also stated that motivation directly affected the performance of an organization. In addition, the higher the motivation of employees, the better their productivity will be. This is a finding in a study conducted by Nimusima and Tumwine (2016). Of course, this means companies need to maintain that their employees are always well-motivated because the company's goal to maintain and increase productivity will be increasingly helped by employees' good motivation.

The company's efforts to increase employee motivation need to be stated in its company policies. To find out what policies need to be taken in order to increase motivation, it is necessary to identify the factors that might be influencing an employee's motivation. These factors can be identified through literature study and preliminary interviews.

The factors obtained then need to be validated and further analyzed to determine whether they really have a positive and significant effect on employee motivation at PT "X". The results of the analysis will then become recommendations as an input for improving human resource management policies at PT "X", so the policies that will be considered to maintain employee motivation at PT "X" have a stronger basis. This research has not only become a reference for PT "X" but also for the other coal-fired powerplant companies with similar condition.

2. LITERATURE REVIEW

2.1. Motivation

Mensah et al (2016) states that motivation can be interpreted as a psychological process that is able to provide purpose, goals and direction for a person to behave which can provide energy to achieve certain goals. Tangem (2018) states that the energy from this motivation is able to generate forces that play a role in changing the direction, quality, and intensity of an employee's work. This will be very important in an organization or company because it is directly related to the achievement of its goals.

2.2 Factors Influencing Motivation.

Several previous studies have investigated the factors that can affect employee motivation. These factors are used as a reference to observe the work motivation of employees at PT "X". The identified factors include wages and benefits, employee development, management leadership, and work environment. Pham et al (2020) stated that there are several important factors that influence motivation, including the work environment, wages, and opportunities for promotion or employee development. In another journal compiled by Saputra (2021), it is stated that management leadership is one of the important things for companies and organizations in achieving their goals. In this study, management leadership is used as one of the variables tested to determine its effect on employee motivation at PT "X".

Moodley's research (2018) proves that if the company motivates employees by providing an increase in wages or benefits, then the employees will respond with enthusiasm and improve their performance in the company.

Employee development plays an important role in increasing employee motivation. This is illustrated in the research conducted by Lubis et al. (2018), which succeeded in proving that employee training and development are really effective in increasing employee motivation and productivity.

The research conducted by Bawa (2017) states that management leadership will affect employee work motivation, so management needs to pay attention to how to manage human resources in their company.

The last factor that will be observed for its influence on motivation is the work environment. Riyanto et al. (2021) found that environmental conditions are one of the factors that increase employee satisfaction, which is the most influential factor in increasing employee motivation and productivity.

3. METHODS

This research was conducted quantitatively using the SEM-PLS statistical method. This method was chosen because the variables and indicators used in the model were quite large, but the number of respondents in the field was very limited. The respondents used in this study were 94 field employees at PT "X" who had a working period of more than 2 years. Due to the small number, the SEM-PLS method was chosen because Hair et al. (2019) stated that this method has high flexibility and is very reliable for analyzing a limited amount of data compared to other methods.

The data from the questionnaire distributed to the respondents is then expected to represent the population, namely all steam power plant companies in Paiton Powerblock. So that the results of the hypothesis analysis are not only used as an internal reference for PT "X" but can be used as a reference for other similar companies.

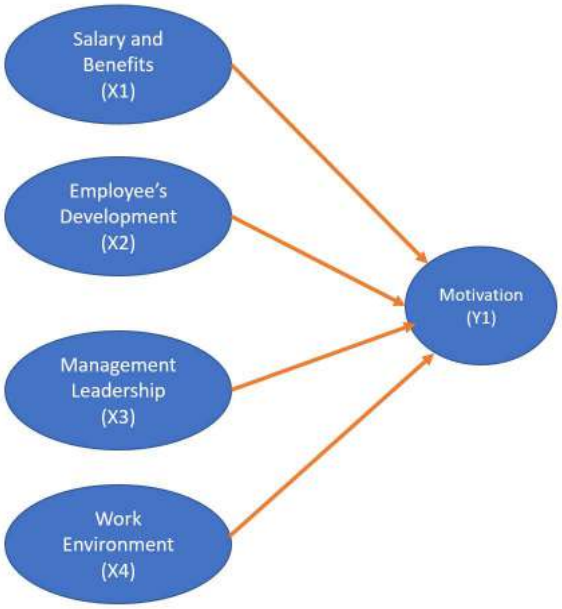


Figure 1. Critical Framework

The critical framework that will be used as a research model is as shown in Figure 1. This framework then used as a hypothesis to be tested as follows:

H1 : Salary and benefits have a positive and significant effect on employee motivation at PT "X"

H2 : Employee development has a positive and significant effect on employee motivation at PT "X"

H3 : Management leadership has a positive and significant effect on employee motivation at PT "X"

H4 : The work environment has a positive and significant effect on employee motivation at PT "X"

4. RESULTS

4.1 Outer Model Evaluation

Based on the data depicted in the figure 2, it can be seen that the results of the outer loading data processing for all variables have a value > 0.5, so it can be concluded that all variables meet the criteria in the outer loading convergent validity test and there is no construct for the variables that need to be eliminated from the model.

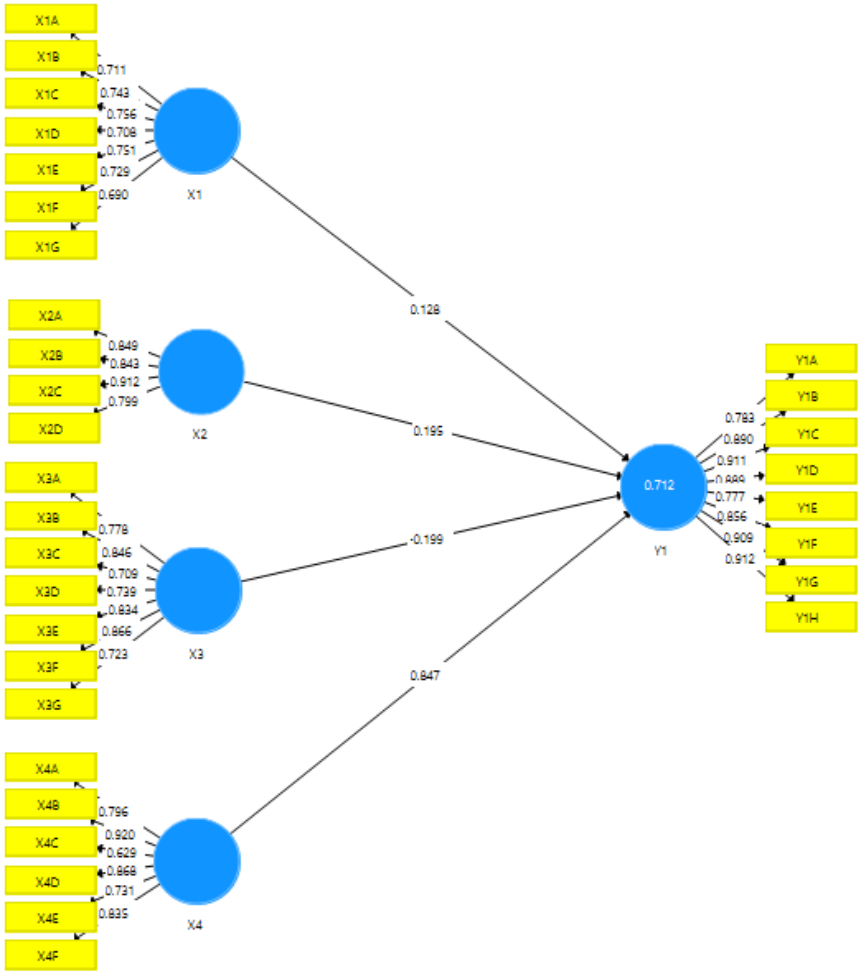


Figure 2. Outer Model Evaluation

The value of each indicator, as shown in table 2, in the construct variable is greater than the cross-loading value of the other variables. This shows that all constructs have good discriminant validity and meet the criteria.

Table 2. Cross-loading Analysis Results

Variable		X1	X2	X3	X4
Salary and Benefits	X1A	0.711	0.147	0.444	0.454
	X1B	0.743	0.155	0.429	0.489
	X1C	0.756	0.172	0.601	0.534
	X1D	0.707	0.002	0.402	0.480
	X1E	0.751	0.014	0.530	0.545
	X1F	0.730	0.096	0.393	0.524
	X1G	0.689	0.157	0.519	0.470
Employee Development	X2A	-0.031	0.848	0.011	0.045
	X2B	0.167	0.843	0.162	0.146
	X2C	0.165	0.912	0.123	0.077
	X2D	0.203	0.800	0.131	0.024
Management Leadership	X3A	0.506	0.034	0.778	0.578
	X3B	0.613	0.028	0.845	0.602

	X3C	0.453	0.230	0.710	0.413
	X3D	0.359	0.179	0.738	0.368
	X3E	0.550	0.090	0.834	0.572
	X3F	0.538	0.176	0.866	0.593
	X3G	0.481	0.002	0.723	0.692
Work Environment	X4A	0.634	-0.006	0.637	0.796
	X4B	0.579	-0.012	0.553	0.920
	X4C	0.421	0.024	0.620	0.629
	X4D	0.504	-0.005	0.532	0.868
	X4E	0.523	0.232	0.647	0.731
	X4F	0.627	0.159	0.523	0.835

The next data validity test was carried out by analyzing the AVE (Average Variance Extracted) value. As shown in table 3, the AVE value for each variable shows a value higher than 0.5, so that all variables are considered valid and can be continued at the next research stage.

Table 3. AVE Analysis Results

Variable	AVE	Role of Thumb	Result
Salary and Benefits (X1)	0.529	> 0.5	Valid
Employee Development (X2)	0.725	> 0.5	Valid
Management Leadership (X3)	0.619	> 0.5	Valid
Work Environment (X4)	0.643	> 0.5	Valid
Motivation (Y1)	0.753	> 0.5	Valid

The next testing stage is reliability testing, which is carried out by observing the value of composite reliability and Cronbach's alpha and comparing it with the value of the rule of thumb, which is > 0.70. The test results show that all variables are reliable and can be used in further research.

Table 4. Reliability Test Results

Variable	***Composite Reliability***	***Cronbach's Alpha***	***Rule of Thumb***	***Result***
Salary and Benefits (X1)	0.887	0.854	>0.70	*Reliable*
Employee Development (X2)	0.913	0.873	>0.70	*Reliable*
Management Leadership (X3)	0.919	0.898	>0.70	*Reliable*
Work Environment (X4)	0.914	0.887	>0.70	*Reliable*
Motivation (Y1)	0.960	0.952	>0.70	*Reliable*

4.2 Inner Model Evaluation

Based on the results of data processing, the coefficient of determination (R-square) result is 0.712. It is interpreted that the salary and benefits, employee development, management leadership, and work environment are able to explain the motivation variable of 0.712, or 71.2%. while the remaining 29.6% is explained or influenced by other variables outside the study.

The results of the predictive relevance value test (Q-square) generated by the research construct are 0.510 on the motivation variable. The value indicates greater than the value of 0 and so that the model used in the study has good predictive relevance.

Table 5. AVE and R-Square Results Average

Variabel	***Average Variance Extracted* (AVE)**	**R^2**
Salary and Benefits (X1)	0.529	
Employee Development (X2)	0.725	
Management Leadership (X3)	0.619	
Work Environment (X4)	0.643	
Motivation (Y1)	0.753	0.712
Average	**0.654**	**0.712**

$$GoF = \sqrt{AVE\ x\ R^2}$$
$$= \sqrt{0.654\ x\ 0.712}$$
$$= 0.682$$

The results of the above calculations show that the GoF value generated by this research model is 0.682 so it can be concluded that the overall performance of the prediction model that is reviewed at the level of conformity between the inner model and the outer model has a high level of feasibility because it produces a GoF value >0.36. This means that the model that has been designed for this research can observe the phenomena that occur at PT "X".

4.3 Hypothesis Test

The last test carried out to prove the conditions in the field with the theory that has been formulated is the hypothesis test. This test will confirm the effect of the determined factors on the employee's work motivation at PT "X". The test is carried out by observing the significance value between the construct variables, p-value, and t-statistics. This value was obtained through bootstrapping analysis performed with the SEM-PLS method. The rules of thumb used in this study are p-value with a significance of 0.05 (5%) and t-statistic > 1.96.

Table 6. Hypothesis Test Result

Code	Hypothesis	*Original Sample*	T *statistics*	P *values*	Result
H1	Effect of Salary and Benefits (X1) on Motivation (Y1)	0.128	1.286	0.199	Rejected
H2	The Effect of Employee Development (X2) on Motivation (Y1)	0.195	2.574	0.010	Accepted
H3	The Effect of Management Leadership (X3) on Motivation (Y1)	-0.199	2.492	0.013	Accepted
H4	Effect of Work Environment (X4) on Motivation (Y1)	0.847	11.397	0.000	Accepted

h

The first hypothesis examines the effect of salary and benefits (X1) on motivation (Y1). The results show that there is no significant effect of salary and benefits on employee motivation. The t-statistic value obtained is smaller than the rule of thumb (1.96) and the p-value is higher than 0.05, so that the first hypothesis (H1) is rejected. Conditions on the field state the same thing, where the salaries and benefits received by PT "X" field workers are the highest if compared to other industrial fields in the surrounding area. So that policy updates no longer need to focus on these policies and can still apply existing policies consistently.

The second hypothesis examines the effect of employee development (X2) on motivation (Y1). The results of data processing show that the t-statistic value is 2.635, or higher than the t-table (1.96) and the p-value also shows results that are smaller than 0.05, namely 0.009. Thus, it can be concluded that the second hypothesis (H2) is accepted. This means that employee development variables have a positive and significant effect on employee motivation at PT "X". Conditions in the field do show that the employees of PT "X" want employee development to be better. Enthusiasm for the training programs and educational scholarships provided by the company is quite high and attracts many employees to participate. In the future, the company's policy regarding employee development can be further developed into a superior program to motivate employees to be more productive.

Then, the third hypothesis tests whether management leadership (X3) has an influence on motivation (Y1). The test results show that the t-statistic is 2.522 and the p-value is 0.012, so that the third hypothesis (H3) is accepted. These results prove that management leadership has a significant effect on employee work motivation because the t-statistic value is > 1.96 and the p-value is 0.05. However, the original sample shows a negative value, which proves that the effect is also negative on employee motivation. Some management decisions are unsatisfactory for most employees. This was identified during the preliminary interview. The leadership that began to change in 2019 also made several changes that were considered to have too high and unrealistic targets, so many employees complained. This then causes a decrease in employee motivation, which has an impact on decreasing employee performance. In the future, management is

recommended to start rearranging the targets, objectives, and change plans to become suitable for the field conditions so that the decisions given can be well received by all field workers.

The fourth hypothesis examines the effect of the work environment (X4) on motivation (Y1), and the test results show that the t-statistic value is much higher than the t-table, namely 10,447, and the p-value is 0.0001 less than 0.05. This proves that the fourth hypothesis (H4) is accepted, which means that there is a significant influence of the work environment on employee motivation. The original sample value shows a positive value, indicating that it has a positive effect on employee motivation at PT "X". In general, the majority of field employees admit that PT "X" has a good work environment, supportive coworkers, and comfortable working conditions. This is recognized as being able to increase motivation and reduce employee stress and fatigue under work pressures given by superiors. In the future, the company's policy is to maintain this condition and create a better work environment, for example, by holding family gathering programs, lunches, outbound and other activities that can improve the close relationships between employees. Spatial planning also needs to be considered so that employees can work comfortably.

Further research that investigate the impact motivation has on employee performance and loyalty at PT "X" are still required to strengthen this study because it only looks at the elements that influence employee motivation at PT "X". This study may be used in the future to inform decisions on how crucial it is for PT "X" and other businesses of a similar nature to sustain employee motivation.

6. CONCLUSIONS

The study's findings suggest that employee development and work environment are the two factors that have the greatest positive impact on employee motivation at PT “X”. Then managerial leadership is a factor that significantly yet adversely influences job motivation. Additionally, there are some very intriguing results showing that the compensation and benefits factors had no impact on the job motivation of field workers at PT "X".

Then, according to PT "X”, the emphasis should be on enhancing the standards of the laws governing personnel management, employee development, and the workplace. As a result, field staff will be more motivated to work. This study suggests changing the way management leads since it doesn't cost a lot of money, and the company can then concentrate on staff development for the following. If management must select which one to develop first, this study suggests doing so. Because external reasons other than the work environment are the strongest element that drives employees to quit, according to the hypothesis presented by Da Camara et al. (2015), the development of the work environment can be put off until the next implementation.

To strengthen this study, additional research on the impact of motivation on staff performance and loyalty at PT "X" is still required. This study may be used in the future to inform decisions on how crucial it is for PT "X" and other businesses of a similar nature to sustain employee motivation.

REFERENCES

PHAM, T.-V., HUANG, Y.-F. and DO, M.-H. (2022). The Effect of Critical Work Factors on Job Motivation and Satisfaction: An Empirical Study from Vietnam, The Journal of Asian Finance, Economics and Business, Korea Distribution Science Association 9 (1), 399–408.

Farhan Saputra. (2021). Leadership, Communication, and Work Motivation in Determining the Success of Professional Organizations, Journal of Law, Poliitic and Humanities, 1(2), 59-70

Setyo Riyanto, Endri Endri and Novita Herlisha (2021), Effect of Work Motivation and Job Satisfaction on Employee Performance: Mediating Role of Employee Engagement, Problems and Perspectives in Management, 19 (3), 162-174

Lubis, F. M., Asmawi, M., & Tunas, B. (2020), Motivation vs. Demotivation of Employees Work: An Empirical Study Post Organizational Changes, Scitepress. 616–622.

Hair, J. F., Risher, J. J., Sarstedt, M., & Ringle, C. M. (2019), When to Use and How to Report the Results of PLS-SEM, European Business Review.

Moodley, S., & Hove, G. (2018), The Factors Affecting Employee Motivation and its Impact on Organisational Performance at an Engineering Supplies Company in Durban, Kwa-Zulu Natal, Kuwait Chapter of the Arabian Journal of Business and Management Review, 7 (4), 55.

Nimusima, P., & Tumwine, J. F. (2017), Assessing the Relationship Between Employee Motivation and Productivity in Rwanda's Nyagatare District, 221–235.

Siddiqi, T., & Tangem, S. (2018), Impact of Work Environment, Compensation, And Motivation on The Performance of Employees In The Insurance Companies of Bangladesh, South East Asia Journal of Contemporary Business, Economics and Law, 15 (5), 153–162.

Kuranchie-Mensah, Elizabeth Boye; Amponsah-Tawiah, Kwesi (2016), Employee Motivation and Work Performance: A Comparative Study of Mining Companies in Ghana, Journal of Industrial Engineering and Management (JIEM), ISSN 2013-0953, OmniaScience, Barcelona, 9 (2), 255-309.

Bawa, M. A. (2017), Employee Motivation and Productivity: A Review of Literature and Implications for Management Practice, International Journal of Economics, Commerce and, Management., V (12), 662–673.

Da Camara, N., Dulewicz, V., & Higgs, M. (2015), Exploring the Relationship between Perceptions of Organizational Emotional Intelligence and Turnover Intentions Amongst Employees: the Mediating Role of Organizational Commitment and Job Satisfaction, In New Ways of Studying Emotions in Organizations, Emerald Group Publishing Limited.

Customer Churn Analysis of Telecommunication Services using Logistic regression methods

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ABSTRACT

Berdasarkan riset tingkat kepuasan pelanggan terhadap kualitas internet, Perusahaan telekomunikasi di Indonesia masih memiliki nilai yang kurang memuaskan padahal faktanya kepuasan pelanggan rata-rata global meningkat.. Berdasarkan survei yang dilakukan oleh Asosiasi Provider Jasa Internet Indonesia (APJII), Pertumbuhan Populasi penduduk di Indonesia yang berkorelasi dengan proporsi pertumbuhan pengguna internet dibandingkan populasi penduduk di Indonesia pada tahun 2017-2019 : 54,68% dari 262 juta penduduk, 64,80% dari 264,2 juta dan 73,7% dari 266,91 juta penduduk (APJI, 2020). Hal itu menjadi peluang bagi perusahaan jasa penyedia internet di Indonesia yang berkompetisi untuk mendapatkan pelanggan terbanyak. Efek dari kompetisi itu adalah customer churn yang mana seorang pelanggan memutus layanan lalu berpindah dari suatu penyedia jasa ke penyedia jasa lain. Hal tersebut tentunya berpengaruh bagi keuangan perusahaan. Perusahaan Telekomunikasi di Kota Surabaya, PT X harus memberi perhatian khusus pada data customer churn yang terjadi setiap bulan. PT X melakukan klasifikasi terhadap pengguna yang mempunyai kecenderungan untuk berhenti berlangganan. Tujuan dari penelitian ini yaitu mengidentifikasi faktor apa saja yang mempengaruhi meningkatnya risiko seorang pelanggan memutuskan layanan pada sebuah produk perusahaan telekomunikasi. Selanjutnya PT X diharapkan dapat merumuskan strategi tindakan preventif maupun kuratif untuk mencegah seorang pelanggan memutuskan layanan pada sebuah produk perusahaan telekomunikasi. Metode yang digunakan adalah membuat model klasifikasi dengan metode regresi logistik untuk mengetahui karakteristik suatu pelanggan yang memiliki risiko untuk memutus layanan. Pada penelitian ini kami mendapatkan faktor yang mempengaruhi customer churn yaitu segmentasi pelanggan, jenis layanan lokasi dan lamanya tunggakan internet.

Keywords: Perusahaan Telekomunikasi; Customer Churn; klasifikasi

1. INTRODUCTION

Based on research on the level of customer satisfaction on internet quality, telecommunication companies in Indonesia still have unsatisfactory scores despite the fact that global average customer satisfaction is increasing (Hidayat, 2020). Low customer satisfaction with internet quality can trigger customer churn, which means that customers are no longer using the service or not subscribing to the products that provided by a company. In fact, getting new customers is more expensive than retaining those customers (Hanif, 2020).

In the globalization era and massive digitalization happening today, telecommunications has become a primary need for all people. This is evidenced by 2017 that almost 75% of the world's population is connected by mobile devices (Calzada-Infante, et al., 2020). Everyone interacts with each other also using social media (Uner, et al., 2019). Based on a survey conducted by the Association of Indonesian Internet Service Providers (APJII), Population Growth in Indonesia which is correlated with the proportion of growth in internet users compared to the population in Indonesia in 2017-2019: 54.68% of 262 million people, 64.80% of 264.2 million and 73.7% of the 266.91 million population (APJI, 2020). The increase from year to year shows that people in Indonesia are starting to make the internet a basic need for communicating and exchanging information. This is an opportunity for internet service companies in Indonesia that compete to get the most customers. The effect of the competition is customer churn in which a customer disconnects from service and then switches from one service provider to another..

As a telecommunications company, PT X must pay special attention to customer churn data that occurs every month. When a company allows a customer to switch to a competitor, it can cause huge potential losses because the nature of the customer is to subscribe to a service from time to time. The causes of customer churn must be analyzed so that companies know how to retain a customer. Churn management is currently a priority for managers in the telecommunications and wireless internet industry (Ferreira & Telang, 2019).

Based on PT X's customer data from January 2010 – December 2020, it was found that of 6625 subscribers, 333 people decided to unsubscribe from the internet. If the average income of 1 person per month is IDR 300 thousand, then within 1 year the company loses revenue of almost IDR 1 billion. Customer Churn causes increased costs and lost revenue from the company, previous research stated that retaining 5% of customers can increase profit 60% (Yeboah-Asiamah, 2018)

One last year, predicting customer churn is important in order to grow profit change and reduce the risk of company losses (Jain, Khunteta and Srivastava, 2020). This is an important issue in the field of customer relationship management due to market competition and the development of easy access to information for competitors (Zhu & Baesens, 2017). There are 2 approaches in overcoming the problem of customer churn, first by understanding the factors that influence churn and predictions to identify the possibility of churn (Backiel & Baesens, 2016). The task of a company is to classify users who have a tendency to unsubscribe. These predictions can be made by machine learning, one of which is the Logistic Regression method, an algorithm that applies supervised learning to classify whether customers tend to churn or not. This algorithm does not work well for unbalanced data classes, which means that one class has a greater classification value than the other (Hanif, 2020).

Research conducted by (Jain, Khunteta and Srivastava, 2020) who predicts customer churn in the internet service industry using logistic regression and logit boost methods shows that the logistic regression method has better accuracy than logit boost.

In this study, we will look for factors that affect customer churn, which can be seen from the length of the subscription, the number of years in arrears in months & rupiah, the number of services, the type of service and so on. This is needed by the company as a preventive measure in tackling the risk of a customer disconnecting the service.

2. LITERATURE REVIEW

Logistics Regression method is used to predict each binary classification class (Li, et al., 2021). Logistic regression is an analytical model of supervised learning, using labeled data to train the model, predict outcomes, and compare whether the results are as desired (Fan, et al., 2020).

This algorithm is an empirical model that classifies independent variables or identifies independent variables that have an influence on the dependent variable (Mustafa, et al., 2018). Suppose X is the explanatory variable and y is the binary response, logistic regression performs a classification that predicts the probability of a success condition at the value of x (Ebbutt, 2008).

$$\text{Logit}[\pi(x)] = \log\left(\frac{\pi(x)}{1-\pi(x)}\right) = \alpha + \beta \qquad (2.1)$$

Logistics Regression in the world of statistics is used in making models that have two possible classes (K = 2), namely y = 1 or y = 0 (Whitaker, 2021). In this case, the explanation is as follows: y=1 indicates churn and y=0 non churn. This logit function has a range from 0 to 1. Prediction 1 when the hypothesis 0.5 and prediction 0 when the hypothesis ≤ 0.5 .. The value of this hypothesis produces predictions in the form of 1 and 0 which will then be compared with actual data or testing data with predicted data or data training (Hanifa, Adiwijaya and Al-Faraby, 2017). In making a regression model it is better to use 80% of the total amount of data (Silva, et al., 2020).

3. METHODS

The object that will be observed is customer data from PT X from January 2019 - December 2020. The data shows a customer using what type of service, how long he has used the service, the amount of arrears in rupiah, the length of arrears and the type of customer. The data taken from this research is billing data from PT. X is 6625 records. This study uses a model based on that used for prediction and regression. The type of data for the predictive variable X is in the form of quantitative and qualitative data, while for the response variable Y is in the form of quantitative or qualitative data (numeric or categorical). The method used in this study is the logistic regression method, which is a statistical model to see the relationship between the dependent and independent variables where the dependent variable is categorical. The result of the regression analysis is to determine what factors influence a customer to disconnect or unsubscribe the service. From this analysis, it is hoped that PT X can make a strategy to keep a customer from using its services and products.

4. RESULTS

4.1 Eksplorasi Data

From Figure 1 below it shows that for data on the classification of the Y variable, the proportion of data is 95% or 6292 data that has category 0 and the proportion of data is 5% or 333 data that has category 1. There is a data imbalance, it is necessary to have handling.

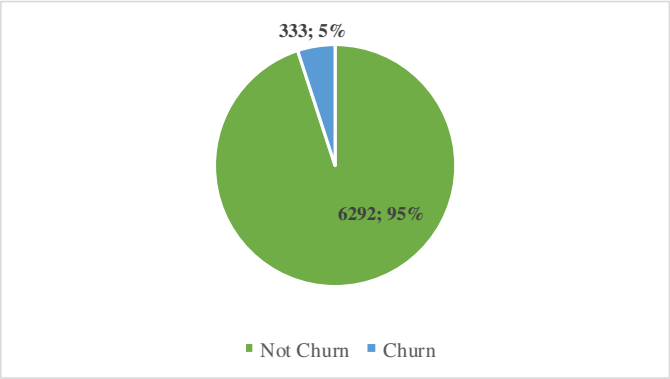


Figure 1. The comparation of Dependent Variabel before SMOTE (Non SMOTE)

4.2 Penanganan Data tidak seimbang menggunakan SMOTE

From Figure 2 below, it shows that after handling with the SMOTE method, for category 0 the proportion of data changed to 51% while still having 6292 data, while category 1 had a proportion of 49% with a total of 5994 data. The difference in the number of values 0 (not churn) and 1 (churn) between variables is no longer too large between classifications on variable Y.

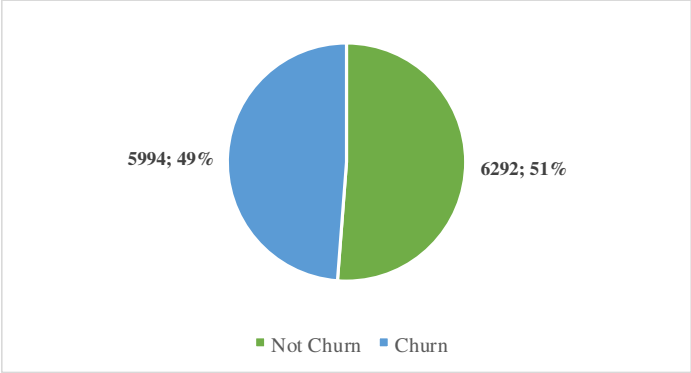


Figure 2. The comparation of Dependent Variabel SMOTE

4.3 Goodness of Fit

In the analysis using a significance level (α) of 5% and the p-value obtained from the results in the output above in the bottom row of the p-value section, the p.value for is 0.1339. Because the p-value (0.1984) > 0.05 = , H0 is not rejected. So it can be concluded that the model has sufficiently explained the data (Model fit).

4.4 Hasil analisis Regeresi Logistik SMOTE

In table 1 below (LAKARSANTRI),(BAMBE), (RPTGK_INT), and (LAMA_AKTIF), because the p-value > 0.05 = , H0 is not rejected. So it can be concluded that the variables (LAKARSANTRI),(BAMBE), (RPTGK_INT), and (LAMA_AKTIF) do not affect the dependent variable (Y). For the rest of the other variables, because the p-value < 0.05 = , H0 is rejected. So it can be concluded that the rest of the other variables affect the dependent variable (Y) on the balanced data.

Tabel 1. Hasil uji regresi logistik

Variable	Description Variable	P-value	Keterangan
X1	(DCS)	$7{,}69 \times 10^{-8}$	Signifikan
	(DBS)	$1{,}23 \times 10^{-6}$	Signifikan
	(DES)	2×10^{-16}	Signifikan
X2	(duaP:TELP+INET)	2×10^{-16}	Signifikan
	(duaP:INET+IPTV)	$< 2 \times 10^{-16}$	Signifikan
X4	(LAKARSANTRI)	0,14918	Tidak Signifikan
	(TANDES)	0,022481	Signifikan

	(KAPASAN)	$2{,}55 \times 10^{-16}$	Signifikan
	(MERGOYOSO)	2×10^{-16}	Signifikan
	(KEBALEN)	$1{,}05 \times 10^{-13}$	Signifikan
	(KANDANGAN)	$8{,}77 \times 10^{-6}$	Signifikan
	(KARANGPILANG)	$1{,}12 \times 10^{-10}$	Signifikan
	(KALIANAK)	0,000509	Signifikan
	(BAMBE)	0,489000	Tidak Signifikan
X6	(JTGK_INT)	$< 2 \times 10^{-16}$	Signifikan
X5	(RPTGK_INT)	0,335482	Tidak Signifikan
X3	(LAMA_AKTIF)	0,324760	Tidak Signifikan

4.5 Akurasi

The result of model accuracy for unbalanced data (non SMOTE) is 95%, however, when viewed from the Sensitivity and Specificity they are 99% and 1%, respectively. This means that the model generated from non-SMOTE data cannot predict customers who have the potential to churn well.

Meanwhile, for data that has been handled with SMOTE, the accuracy has decreased to 73%. Even though the accuracy is decreased, the Sensitivity and Specificity are 70% and 77% respectively. This makes the model generated by the SMOTE method more relevant because it can predict customers who have the potential to cut service quite well.

4.7 Implikasi Manajemen

- Variables that describe (X1) Customer Segmentation DCS, DBS, and DES all affect a customer in terminating service, therefore this is a concern for management so as not to discriminate in treatment of types of customers.
- Variables that describe the type of service (X2) all types affect a customer in terminating the service, therefore management should also not differentiate treatment between types of services.
- Based on (X4) location affects a customer to disconnect service, all locations except the Lakarsantri and Bambe sub-districts affect a customer to disconnect the service, therefore almost all sub-districts can be a special concern for management in making promotions or treatment to customers.
- Based on variable duration of arrears (X6), Total (Rp) length of arrears (X5) and active subscription period (X3); what affects the most is the length of time in arrears, therefore management pays special attention to customers who have not paid for a long time, this can be done by:
    - ✓ Approach the customer directly by asking the reason why he did not pay the bill, identify the root of the problem ut.
    - ✓ Giving a discount if a customer wants to pay off a large amount and the reasons given by the customer are indeed the fault of the company.
    - ✓ Periodically flagging (marking) customers with these characteristics in order to receive

special attention to protect customers.

6. CONCLUSIONS

The conclusion obtained from the results of the analysis and discussion that has been carried out is from the data that has been carried out in the balanced data process. The variables that influence a customer to decide on a service are: :

a. Customer Segmentation : DCS, DBS, dan DES
b. Type of Service : duaP:TELP+INET dan duaP:INET+IPTV
c. Service Location : Tandes, Kapasan, Mergoyoso, Kebalen, Kandangan , Karangpilang dan Kalianak
d. The number of customer arrears (in month).

REFERENCES

A. et al., 2017. Churn Prediction on Fixed broadband Internet using Combined Feed-Forward Neural Network and SMOTEBoost Algorithm. *Fifth International Conference on Information and Communication Technology,* pp. 1-6.

Admin, A. et al., 2016. Customer Churn Prediction in Telecommunication Sector using. *Neurocomputing.*

Agrawal, S. & Das, A., 2018. Customer Churn Prediction Modelling Based on Behavioural Patterns Analysis using Deep Learning. *International Conference on Smart Computing and Electronic Enterprise.,* pp. 1-6.

Backiel, A. & Baesens, B., 2016. Predicting time-to-churn of prepaid mobile telephone customers using social network analysis. *Journal of the Operational Research Societ (2016),* pp. 1 - 11.

Bou-Hamad, I., 2016. Bayesian Credit Ratings: A Random Forest Alternative Approach. *Communications in Statistics - Theory and Methods,* pp. 1-20.

Cafri, g., Li, L., Paxton, E. W. & Fan, J., 2017. Predicting risk for adverse health events using. *Journal of Applied Statistics.*

Calzada-Infante, L., Óskarsdóttir, M. & Baesens, B., 2020. Evaluation of customer behavior with temporal centrality metrics for churn. *Expert Systerms with Applications.*

Chabumba, R., Ajoodha, R. & Jadhav, A., 2021. Predicting Telecommunication Customer Churn. Dalam: s.l.:Taylor and FrancisGroup, p. 12.

Do, D., Huynh, P., Vo, P. & Vu, T., 2017. Customer Churn Prediction in an Internet Service Provider. *IEEE International Conference on Big Data (BIGDATA),* pp. 3928 - 3933.

Fan, Y., Bai, J. & Lei, X., 2020. Privacy preserving based logistic regression on big data. *Journal of Network and Computer Applications.*

Fatian, M. & Minaei, B., 2016. Offering a hybrid approach of data mining to predict the customer churn based on bagging 1. *Emerald Group Publishind Limited,* 45(5).

Ferreira, P. & Telang, R., 2019. Effect of Friends' Churn on Consumer Behavior in Mobile Networks. *Journal of Management Information Systems,* 36(2), pp. 355-390.

Han, C., Ma, T. & Xu, G., 2020. Intelligent decision model of road maintenance based on improved weight random forest. *International Journal of Pavement Engineering,* pp. 1-10.

Hanif, I., 2020. Implementing Extreme Gradient Boosting (XGBoost) Classifier to Improve Customer Churn Prediction. *Research Gate.*

Huang, B., Kechadi, M. T. & Buckey, B., 2011. Customer churn prediction in telecommunications. *Expert Systems with Applications,* pp. 1414-1425.

jain, H., Khunteta, A. & Srivastava, S., 2019. Churn Prediction in Telecommunication using Logistic Regression. *International Conference on Computational Intelligence and Data Science,* pp. 101-112.

Khan, A. A. & Jamwal, S., t.thn. Applying Data Mining to Customer Churn Prediction in an Internet Service Provider. *International Journal of Computer Applications,* Volume 9, p. 7.

Kriti, 2019. Customer Churn: A Study of Factors Affecting Customer Churn using Machine Learning. *Iowa State University,* pp. 1- 30.

Li, Y., adams, N. & Belotti, T., 2021. A Relabeling Approach to Handling the Class Imbalance Problem for. *JOURNAL OF COMPUTATIONAL AND GRAPHICAL STATISTICS,* pp. 1 - 13.

Mustafa, A., Rienow, A. & Saadi, I., 2018. Comparing support vector machines with logistic regression for calibrating cellular automata land use change models. *European Journal of Remote Sensing,* Volume 51, pp. 391-401.

Parmar, P. & Serasiya, S., 2021. Telecom Churn Prediction Model using XgBoost Classifier and Logistic Regression Algorithm. *International Research Journal of Engineering and Technology,* pp. 1100-1105.

Rachmi, A. N., 2020. *IMPLEMENTASI METODE RANDOM FOREST DAN XGBOOST PADA KLASIFIKASI CUSTOMER CHURN,* s.l.: Universitas Islam Indonesia.

Silva, E., Lopes, I. C. & Correia, A., 2020. A logistic regression model for consumer default risk. *JOURNAL OF APPLIED STATISTICS,* April.

sjarif, N. N. A. et al., 2019. A Customer Churn Prediction using Pearson Correlation Function and K Nearest Neighbor Algorithm for Telecommunication Industry. *Int. J. Advance Soft Compu,* Volume 11, p. 2.

Uner, M., Guven, F. & Cavusgil, S., 2019. Churn and loyalty behavior of Turkish digital natives: Empirical insights and managerial implications. *Telecommunications Policy.*

Upadhyay, A., 2020. Random forest based classification of seagrass. *Journal of Information and Optimization Sciences,* 41(2), pp. 613-620.

Whitaker, T., 2021. Logistic Regression Models for Aggregated Data. *Journal of Computational and Graphical Statistics,* pp. 1049-1067.

Yeboah-Asiamah, E., 2018. Preventing Customer Churn in the Mobile Telecommunication Industry: Is Mobile Money Usage the Missing Link?. *Journal of African Business.*

Y. G., Malicdem, A. R. & Cruz, J., 2019. Using Big Data Analysis to Retain Customers for Telecom Industry. *ICCAI'19,* pp. 1-6.

Zhang, H., Zimmerman, J., Nettleton, D. & Nordman, D. J., 2019. Random Forest Prediction Intervals. *The American Statistician.*

Zhu, B. & Baesens, B., 2017. Benchmarking sampling techniques for imbalance learning in churn prediction. *Journal of the Operational Research Society (2017)*

ANALYSIS OF THE INFLUENCE OF WORKLOAD ON WORK MOTIVATION AND LOYALTY AND THE IMPACT ON EMPLOYEE PERFORMANCE BPJS KETENAGAKERJAAN BRANCH OFFICE SIDOARJO

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ABSTRACT

The company in carrying out its vision and mission requires quality human resources and has high integrity. Workload is one of the influential points for BPJS Ketenagakerjaan employees to improving work quality. The workload which is considered quite worrying for the company because it can reduce motivation and loyalty, and even affect the performance of BPJS Ketenagakerjaan employees, is of particular concern to management.

This case study was conducted at one of the BPJS Ketenagakerjaan branch offices, namely the Sidoarjo Branch Office, which is one of two Main Class B branch offices in East Java with the highest level of customer service density and the highest number of memberships in the East Java region. The high density causes the phenomenon of employee complaints about the workload at BPJS Ketenagakerjaan Sidoarjo. The complaint is supported by the difficult reality and the failure to achieve the branch office's performance targets. Therefore, in this case, several variables that affect workload are investigated, including motivation, loyalty and employee performance.

This research was conducted by collecting data from all employees of the BPJS Ketenagakerjaan Sidoarjo, both permanent and outsourced employees. Data was obtained through the distribution of online questionnaires to 56 respondents, and processed using the Partial Least Square (PLS) method. The results of the processed data answer the purpose of this research, which is to become input and advice for BPJS Ketenagakerjaan Sidoarjo in developing the quality of human resources working in the agency.

Keywords: BPJS Ketenagakerjaan, employee loyalty, employee perfomance, workload, work motivation

1. INTRODUCTION

Human resources have an important role as thinkers, movers and planners in order to achieve the company's goals and vision and mission. The formation of optimal employee performance, of course, requires motivation and loyalty as the underlying factors. The high motivation and loyalty of employees to the company, it will facilitate the company in achieving its goals, and vice versa. However, the formation of employee motivation and loyalty today is often associated with the workload given by the company.

According to Koesomowidjojo (2017: 21), workload is the amount of work given to employees to be completed within a certain period of time. The workload is an indication of the problems found, namely the density of work and the company's target which is increasing every year. This condition is felt to be unbalanced with the number of employees being relatively the same each year. This causes an increasingly heavy workload, and even creates a sense of saturation in employees because of the additional workload and the incompatibility of work with the job description that should be.

Table 1.1 Target of BPJS Ketenagakerjaan Sidoarjo 2018-2020 along with data of employees

	2018	2019	2020
Target revenue contribution	336.238.678.200	412.252.325.575	483.981.572.960
Active workforce target	253.521,00	309.865,00	372.398,00
Workforce acquisition target	52.170,00	71.436,00	92.668,00
Claim settlement	100%	100%	100%
Number of employees	44	46	45

Source: Data of BPJS Ketenagakerjaan Sidoarjo 2018-2020

The next problem indication is the work motivation variable. Motivation has a close relationship with employee performance. However, creating high motivation in employees to work optimally is a serious problem faced by companies today. The existence of an indication of problems in the workload borne can be one of the factors that reduce employee performance motivation.

In addition, an indication of the problems studied is employee loyalty. Loyalty is the reciprocity given by the workplace to employees. The incompatibility of the workload received can make employees tired and bored more quickly, so it is difficult for employees to be sincere and loyal to do all the work that should be optimally dedicated to the company.

The influence of the indicators above underlies this research, supported by data on the performance of BPJS Ketenagakerjaan Sidoarjo in 2018-2020 which shows that there are non-optimal results in achieving targets in several indicators. Key Performance Indicator (KPI) shows that the total value of performance in 2018 was 76.58, in 2019 it was 56.59 and in 2020 it was 80.18. The total performance value does not meet the criteria because the target performance value that should be achieved is 100.

This study took a special location at BPJS Ketenagakerjaan Sidoarjo due to the very high activity density in that location. Within the scope of the East Java region, BPJS Ketenagakerjaan only has two Main B branch offices, namely the Sidoarjo and Surabaya Karimunjawa branches. Main branch office B is the branch office with the highest density compared to others. It is proven by the number of guests visiting the Sidoarjo Branch Office reaching 180 - 200 people per day.

The explanation of several aspects of the background above is the result of analysis of company data and subjective assumptions of the problem. To strengthen the data analysis and assumptions, a mini survey was conducted to 22 employee representatives through the distribution of online questionnaires consisting of five categories of questions and processed using the NASA TLX method with the AHP Online System application. The results of the mini survey state that there is a negative effect of workload on employee performance at BPJS Ketenagakerjaan Sidoarjo. In the mini survey, the results obtained from 22 respondents stated that as many as 6 people felt a high workload and 16 people felt a very high workload.

2. LITERATURE REVIEW

a.Company profile

BPJS Ketenagakerjaan is a public legal entity in charge of providing employment social protection to all workers in Indonesia. BPJS Ketenagakerjaan's vision is to create reliable and sustainable employment social security and the welfare of all Indonesian workers. Meanwhile, BPJS Ketenagakerjaan mission is to: (1) Protect, serve, and prosper workers and their families (2) Provide a sense of security, ease, and comfort to increase the productivity and competitiveness of participants (3) Contribute to the development and economy of the nation with good governance.

BPJS Employment divides the segmentation of participants into four segments, namely: wage recipients, non-wage recipients, construction services and Indonesian migrant workers.

b. Human resource management concept

According to Hasibuan (2016: 1), management is a process to organize and utilize human resources and other resources through science and art effectively and efficiently in order to achieve the desired goals. Human resource management functions are managerial functions and operational functions.

c. Workload

According to Meskhati in Widyanti et al (2010: 1) defines workload as the difference between accepted job demands and the abilities possessed by employees who work in an organization. Workload indicators include working conditions, use of time and targets to be achieved.

d. Work motivation

According to Hasibuan (2006: 141), motivation questions how to direct the power and potential to work to achieve the specified goals. according to Uno (2008: 112), work motivation appears through: responsibility in doing work, achievements achieved, self-development and independence in acting.

e. Employee loyalty

According to Agus (2016: 17), employee loyalty is a sense of loyalty or awareness of an employee towards his company, this sense of loyalty can be seen from the aspects of work discipline, responsibility, and attitude while working at the company. Aspects of employee loyalty were put forward by Saydam in Zahroh (2018: 32), which focuses on the implementation of work carried out by employees, including obedience and obedience, responsibility, dedication, honesty and work attitude.

f. Employee performance

According to Hasibuan (2006: 94) explains that "Performance is the result of work achieved by a person in carrying out the tasks assigned to him based on skills, experience, sincerity and time". According to Nitisemito (2001: 109), there are various factors of employee performance, including the amount and composition of the compensation given, proper job

placement, training and promotions, a sense of security in the future (severance pay and so on), relationships with coworkers and relationships. with the leader.

g. Partial Least Square (PLS)

According to Jogianto (2009: 11), the Partial Least Square (PLS) method is a multivariate statistical technique that uses a comparison between multiple dependent variables and multiple independent variables. According to Ghozali (2011: 10), parameter estimation in the PLS method includes three aspects, including weight estimate, path estimate, means or parameter location. According to Yamin (2011: 23-26), the steps in the Partial Least Square (PLS) method are designing a structural model (inner model), designing a measurement model (outer model), constructing a main function path diagram, weighting selection scheme, goodness of fit, and hypothesis testing and interpretation.

3. METHODS

This type of research uses quantitative research with the use of questionnaires as a data collection method. The variables in this study are workload, work motivation, work loyalty and employee performance. Where the variables are divided into two, namely workload as an independent variable/independent variable, while motivation, loyalty, and employee performance are the dependent variable/bound variable.

The following is a research model of the indicators of each variable:

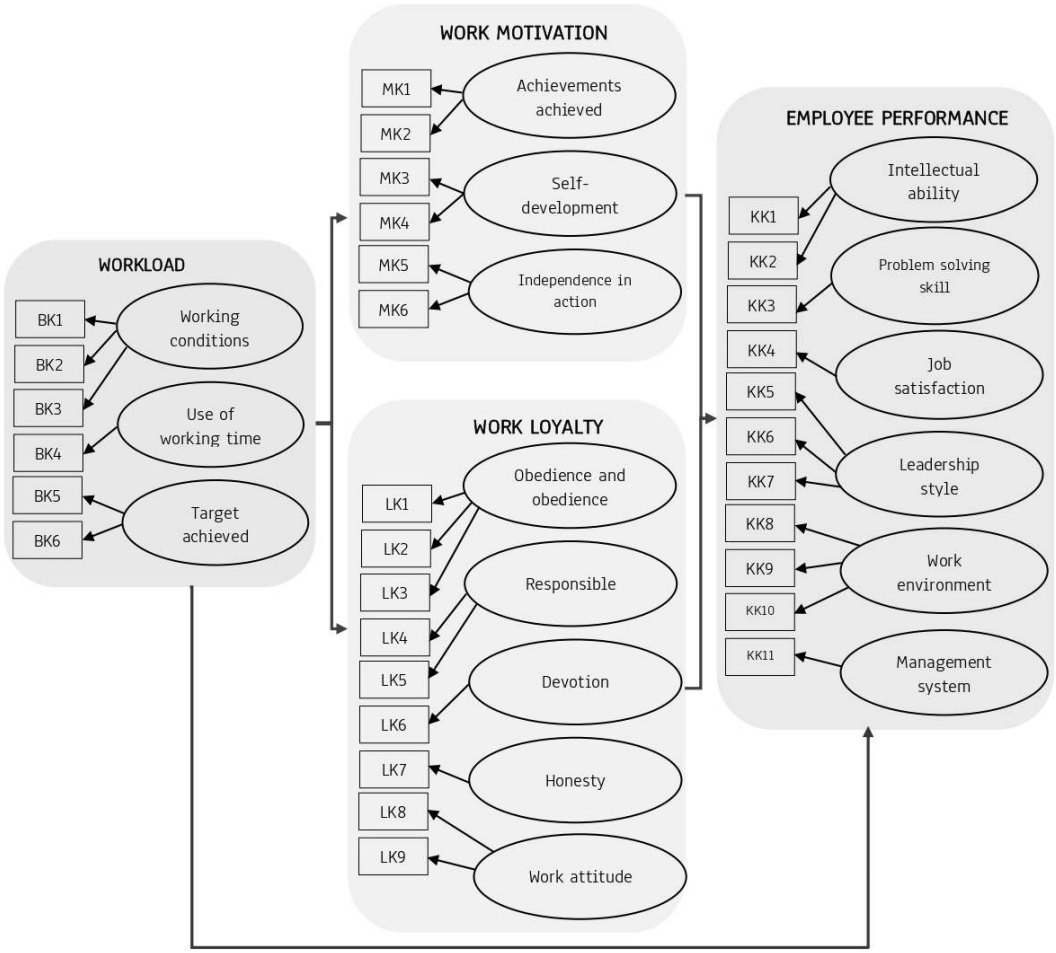


Figure 3.1 Research model with variable indicators
Source: Results of personal analysis

In this study, the population was 56 employees of BPJS Ketenagakerjaan Sidoarjo. The type of questionnaire used is an online questionnaire, namely Google Form with a total of 32 questions. The results of filling out the questionnaire will be collected automatically in a Google Spreadsheet, then will be processed using the SmartPLS software.

This study used a questionnaire method containing questions that became the main variables. In weighting the score using a Likert scale with 5 categories of answers, namely the scale strongly agree (score: 5), agree (score: 4), neutral (score: 3), disagree (score: 2) and strongly disagree (score: 1).

The method used in this research is to use Partial Least Square (PLS) as a tool to analyze the relationship between each variable and indicator. The indicators determined in the PLS modeling are in accordance with the responses to each question given and interpreted into numbers, and then analyzed using SmartPLS software.

4. RESULTS

a. Respondent data

Research questionnaires were distributed to all employees of BPJS Ketenagakerjaan in Sidoarjo, totaling 56 samples. The data is collected automatically in Google Spreadsheet, then processed using SmartPLS software and obtained respondent data including gender, age and education level as follows:

Table 4.1 Respondent's gender

Gender	Amount	Percentage (%)
Male	22	39%
Female	34	61%
Total	**56**	**100%**

Table 4.2 Respondent's age

Age	Amount	Percentage (%)
20 – 25 years	13	23 %
26-30 years	21	37%
31-45 years	10	18%
46-50 years	6	11%
51-55 years	4	7%
56-60 years	2	4%
Total	**56**	**100%**

Table 4.3 Respondent's education level

Educational Stage	Amount	Percentage(%)
SMA	5	9 %
Diploma	7	13 %
S 1	36	64 %
S 2	8	14 %
Total	**56**	**100 %**

Source: Primary data processed in 2022

b. Measurement Model

A loading factor value of 0.50 or more is considered to have a strong enough validation to explain the latent construct. The initial outer loading value for workload, work motivation, work loyalty and performance variables has an outer value of more than 0.70 so that these variables are considered sufficient to explain the latent construct.

Table 4.4 Outer loading factor

Question	Workload	Work motivation	Work loyalty	Performance
BK1	0,721			
BK2	0,859			
BK3	0,873			
BK4	0,802			
BK5	0,793			
BK6	0,772			
MK1		0,736		
MK2		0,788		
MK3		0,845		
Mk4		0,731		
MK5		0,750		
MK6		0,843		
LK1			0,810	
Lk2			0,789	
LK3			0,749	
LK4			0,751	
LK5			0,716	
LK6			0,745	
LK7			0,815	
LK8			0,821	
LK9			0,768	
KK1				0,841
KK2				0,807
KK3				0,785
KK4				0,902
KK5				0,877
KK6				0,933
KK7				0,869
KK8				0,912
KK9				0,940
KK10				0,927
KK11				0,713

Table 4.5 Construct reliability and validity

	Cronbach's Alpha	Rho_A	Composite Reliability	Average Variance Extracted (AVE)
Workload	0,893	0,909	0,917	0,648
Work loyalty	0,966	0,969	0,971	0,751
Work motivation	0,916	0,923	0,931	0,600
Performance	0,874	0,889	0,905	0,614

Table 4.6 Cross loading analysis results

Question	Workload	Work motivation	Work loyalty	Performance
BK1	**0,721**	-0,157	-0,089	-0,157
BK2	**0,859**	-0,379	-0,246	-0,368
BK3	**0,873**	-0,319	-0,153	-0,305
BK4	**0,802**	-0,386	-0,325	-0,344
BK5	**0,793**	-0,399	-0,136	-0,319
BK6	**0,772**	-0,369	-0,145	-0,222
MK1	-0,266	**0,736**	0,658	0,363
MK2	-0,338	**0,788**	0,458	0,454
MK3	-0,379	**0,845**	0,526	0,605
MK4	-0,359	**0,731**	0,523	0,403
MK5	-0,301	**0,750**	0,660	0,556
MK6	-0,390	**0,843**	0,653	0,644
LK1	-0,301	0,733	**0,810**	0,554
LK2	-0,202	0,640	**0,789**	0,545
LK3	-0,143	0,521	**0,749**	0 ,507
LK4	-0,135	0,453	**0,751**	0,442
LK5	-0,231	0,552	**0,716**	0,453
LK6	-0,163	0,459	**0,745**	0,447
LK7	-0,218	0,586	**0,815**	0,683
LK8	-0,185	0,578	**0,821**	0,505
LK9	-0,105	0,570	**0,768**	0,615
KK1	-0,238	0,542	0,616	**0,841**
KK2	-0,199	0,492	0,477	**0,807**
KK3	-0,332	0,554	0,597	**0,785**
KK4	-0,328	0,649	0,593	**0,902**
KK5	-0,326	0,678	0,586	**0,877**
KK6	-0,388	0,618	0,636	**0,933**
KK7	-0,275	0,545	0,676	**0,869**
KK8	-0,432	0,645	0,658	**0,912**
KK9	-0,295	0,509	0,596	**0,940**
KK10	-0,348	0,553	0,594	**0,927**
KK11	0,361	0,475	0,534	**0,713**

Source: Research Results, processed with Smart PLS 3.0, 2022

In the table above, it can be concluded that all latent variables in the study have good construct validity and discriminant validity.

Table 4.7 R Square

	R Square	Adjusted R Square
Performance	0,547	0,521
Work Loyalty	0,060	0,042
Work Motivation	0,191	0,176

Table 4.8 Multicollinearity test

	Workload	Performance	Work Loyalty	Work Motivation
Workload		1,256	1,000	1,000
Performance				
Work Loyalty		2,228		
Work Motivation		2,589		

Based on the table above, it can be seen that the variables of workload, work motivation, work loyalty and performance have values below 3.5, which means that the questionnaire data does not occur multicollinearity and is suitable for use in research.

Table 4.9 Path coefficient results

	Original sample (O)	Sample average (M)	Standard deviation (STDEV)	T Statistics (I O/STDEV I)	P Value
Workload -> Performance	-0,150	-0,141	0,076	1,987	0,047
Workload -> Loyalty	-0,244	-0,270	0,117	2,088	0,037
Workload -> Motivation	-0,437	-0,458	0,093	4,707	0,000
Loyalty -> Performance	0,475	0,500	0,113	4,217	0,000
Motivation -> Performance	0,245	0,250	0,108	2,280	0,023

Source: Research Results, processed with Smart PLS 3.0, 2022

From the path coefficient above, it can be seen that the original sample value, p value or t statistics are used as a reference to make a decision whether the hypothesis is accepted or the hypothesis is rejected.

6. CONCLUSIONS

The results of this study are the influence of workload on employee performance, workload on work motivation, workload on employee loyalty, work motivation on employee performance and work loyalty on employee performance. Suggestions given from the results of this study to BPJS Ketenagakerjaan Sidoarjo, include: (1) evaluation and adjustment of man power, where man power is a program that regulates the suitability of the number of employees to the number of workloads or targets in each branch, (2) optimization of the system, both internal data systems and support systems that can be accessed by external parties. By strengthening the system function, the workload can be optimized in terms of processing time, (3) strengthening appropriate managerial roles can be done to increase employee motivation and loyalty.

REFERENCES

Agustini, Fauzia (2010) *Manajemen Sumber Daya Manusia Lanjutan*. Medan: Medanatera.

Alex Soemadji Nitisemito (2001) *Manajemen Personalia*. Jakarta: Ghalia Indonesia.

Ambarini, dkk (2014) *Upaya Peningkatan Kepuasan Pelanggan Indosat Berdasarkan Telecommunication Service Quality Dengan Menggunakan Structural Equation Modeling (SEM). Jurnal Online Institut Teknologi Nasional.*

Anwar Prabu Mangkunegara (2007) *Manajemen Sumber Daya Manusia Perusahaan.* Bandung: PT. Remaja Rosdakarya.Adiwibowo.

Ginting, Dahlia (2009) *Structural Equation Modeling (SEM).* Bandung: Jurnal Sekolah Tinggi Manajemen Informatika dan Komputer LIKMI.

Koesomowidjojo,Suci R.Mar'ih (2017) *Paduan Praktis Menyusun Analisis Beban Kerja*. Jakarta: Raih Asa Sukses.

Nawawi, Hadari (2006) *Evaluasi dan Manajemen Kinerja di Lingkungan Perusahaan dan Industri*. Yogyakarta: Gadjah Mada Univercity Press.

Preko, Alexander, dan John Adjetey (2013) A Study on the Concept of Employee Loyalty and Engagement on the Performance of Sales Executives of Commercial Banks in GHANA. *International Journal of Business Research and Mana gement (IJBRM).* Vol. 4 Issue (2).

Robbins, Stephen P. dan Judge, Timothy A. (2008) *Perilaku Organisasi*. Jakarta: Salemba Empat. Robbins, Stephen P. and Mary Coulter. 2016. *Manajemen, Jilid 1 Edisi 13*, Alih Bahasa: Bob Sabran Dan Devri Bardani P. Jakarta: Erlangga.

Sarwono, Jonathan (2010) *Pengertian Dasar Structural Equation Modeling (SEM).* Jakarta: Universitas Kristen Krida Wacana.

Saydam, Gouzali (2005) *Manajemen Sumber Daya Manusia Suatu Pendekatan Mikro*. Jakarta: Djambatan.

Sedarmayanti (2001) *Sumber Daya Manusia dan Produktivitas Kerja*. Bandung : Mandar Maju.

Siagian, Sondang. (2008) *Manajemen Sumber Daya Manusia (cetakan 15).* Jakarta: Bumi Aksara.

Sugiyono (2004) *Metode Peneltian Bisnis*. Bandung : Alfabeta.

Uno, Hamzah B. (2014) *Teori Motivasi dan Pengukurannya*. Jakarta: Bumi Aksara.

A STUDY OF RISK MANAGEMENT USING FMEA APPROACH AND MEAN TIME TO FAILURE

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ABSTRACT

In recent years, more emphasis has been placed on risk management in project construction. There are numerous risk systematizations and methods for risk identification, analysis, and evaluation. Failure Mode and Effects Analysis (FMEA) approach is one of the most important and widely used techniques for risk identification and analysis. FMEA is a technique that can be employed to determine how a component of a piece of equipment, a facility, or a system fails. Utilizing a risk priority number (RPN) to assess the impact of failures, FMEA is commonly employed to improve product quality and system reliability. This research purpose is a study of risk management to determine the critical component of overhead crane components using FMEA, RPN, and mean time to failure (MTTF). Wire rope components with a broken wire rope failure mode have the highest RPN of 160 and the shortest MTTF of 478.65, indicating that the component has a short interval between damage. Suppose the component has a high RPN value. In that case, it must be prioritized in conducting maintenance activities, as it poses a high risk of endangering the safety of workers and causing a significant financial loss to the company.

Keywords: risk management, FMEA, MTTF, risk priority number, overhead crane

1. INTRODUCTION

Indonesia's construction sector is expected to record growth of 7.2% in real terms in 2022, which is higher than pre-epidemic results. This will significantly increase compared to the 3.1% growth rate recorded in 2021. With such a significant development rate, the need for concrete, the primary material for constructing public facilities and infrastructure, is also significant. Therefore, the company must have an excellent process to meet the needs of concrete materials.

This research studies the Precast concrete company, a subsidiary of a state-owned construction company. The company is carrying out the production process and is assisted by several types of equipment such as wire caging machines, wire cutting machines, overhead cranes, spinning machines, and others. Based on historical data on equipment failure, it can be seen that the equipment that often experiences damage is the overhead crane. An Overhead crane is a tool for moving materials such as reinforcing iron or piling shoes, lifting molds filled with a concrete mix to the spinning machine. If in

the implementation of the production process there is one machine that is damaged, the production process is disrupted, and the target is not optimal. there is one machine that is damaged, the production process is disrupted, and the target is not optimal (Maghfiroh, Juniani, & Arumsari, 2018; Rosiawan, Singgih, & Widodo, 2019).

In the production process, tools and machines have a significant role in achieving production targets. If there is damage or failure in one of the components of the equipment or machine, it will disrupt the production process so that the achievement of production targets is not optimal. Failure analysis on the overhead crane component must be done to prevent material losses and maintain workplace safety and health. This research proposes a study of risk management using the FMEA (Failure Mode and Effect Analysis) method to identify the component failure and component criticality analysis. Reliability analysis also supports this risk management implementation by calculating Mean Time to Failure (MTTF) to determine the criticality of components by knowing the distance between failures.

Consequently, risk management aims to enhance product and system performance by systematically identifying and evaluating their risks, developing strategies to reduce or avoid risks, and maximizing opportunities. This paper is structured as follows: In section 2, the literature review. In section 3, the research methodology. In section 4, the results and discussion based the most prevalently used approaches. Finally, in section 5 conclusions and make suggestions for future research.

2. LITERATURE REVIEW

2.1. Risk Management

Risk is the deviation from expectations that may occur in a given situation. In the meantime, the ISO 31000 framework states that risk results from uncertainty, which will have an effect in the form of target deviations. The risk associated with an activity is frequently interpreted as having negative consequences (Prabowo, Setiawan, Juniani, Wiediartini, & Erawati, 2018; Rosiawan et al., 2019). A risk can present two opportunities, a positive impact known as an opportunity and a negative impact known as a threat.

Risk management is a technique used in risk management which is carried out with a coordinated and economical application of resources with a process of identification, assessment and prioritization of risk so that it can used to minimize, monitor and control the frequency of risk events and risk impacts. In general, the existence of risk management aims to determine how many significant risks are and find ways to manage the risks that arise. In its application, risk management does not mean avoiding risk but quantifying risk to get an appropriate return from the emergence of risk so that the company's operations will be more stable and optimal.

2.2. Functional Block Diagram (FBD)

Description step of a system is needed to find out the components contained in the system and how these components work according to the function. Function data of the equipment and how it operates, used to create a definition and basis for determining the preventive maintenance activities (Moubray, 1997). The benefits of describing the system are as follows:

a. As a basic information and systems about design and operation, which are used as a reference for taking preventative maintenance actions in the future.
b. System knowledge can be obtained thoroughly.
c. Required in the process of identifying operating parameters that cause system failure.

2.3. Failure Mode and Effect Analysis (FMEA)

FMEA is an engineering technique used to establish, identify, and to eliminate known failures, problems, errors, and its kind from a system, design, process, and or service before reaching consumers (Pradana, 2018). FMEA's primary purpose is to evaluate the causes and consequences of failure modes and to identify potential failure modes. Utilizing a risk priority number, FMEA evaluates risk. Involves conducting numerous reviews of components, assemblies, and subsystems to identify potential failure types, as well as the causes and effects of each failure. On the FMEA form that has been created, for each component, each failure type and its impact on the system will be detailed.. Examples of FMEA forms used are as in Table 1.

Table 1. FMEA Form (Moubray, 1997)

System :				*Fasilitor :*	*Date:*	RPN		
Sub System :				*Auditor :*	*Years :*			
NO	*Equipment*	*Functional*	*Functional Failure*	*Failure Mode*	*Failure Effect*	S	O	D

2.4. Risk Priority Number (RPN)

RPN (Risk Priority Number) is a technique used to analyze risk by linking potential problems identified in the Failure Mode and Effect Analysis (FMEA). FMEA is used to identify potential causes of failure in a process (Sanditya, Juniani, & Amrullah, 2019). This RPN method will be used by researchers to be able to use the experience they have and their engineering capabilities to provide decisions in determining the level of potential problems in accordance with the 3 RPN rating scales as follows:

a. Severity is the severity of the potential effects of the form of failure (potential failure mode) experienced.
b. Occurrence is a level that states the possibility of a failure will occur throughout the system design period.
c. Detection is a level that states the possibility of a failure mode can be detected by applying a detection method or by taking current control before reaching the end-user before leaving the production facility.

After the rating is determined, each subject matter is calculated by multiplying severity, occurrence and detection. The RPN value that appears indicates the level of importance to the attention given to the area / component contained in the system.

2.5. Reliability and Mean Time to Failure

Numerous tools for reliability analysis have been proposed, and a substantial body of literature is available on these tools. To predict the reliability of a system, however, these tools require extensive quantitative data. In general, it is argued that conventional reliability calculations during the conceptual design phase have limited utility. The reliability value of the component provides an opportunity reliability data of a component in the interval of t (time) hour.

Failure rate (λ) is the number of failures per time unit. The failure rate can be expressed as a comparison between the number of failures that occur during a certain time interval with the total operating time of a component or system (Prabowo et al., 2018). In some cases, the failure rate can be shown as an Increase or Increasing Failure Rate (IFR), as a Decreasing Failure Rate (DFR), and as a

constant or Constant Failure Rate (CFR), when the failure rate function λ (t) is a function addition, decrease or constant. (Ebeling, 1997)

1. Failure Rate Distribution:
   a. Normal Distribution
      Normal distribution which is often called the Gaussian distribution is one of the types of distribution most often used in explaining the distribution of data. If the time distribution between failures of a component or system follows the normal distribution, then MTTF is given as : (Ebeling, 1997).

$$\text{MTTF} = \mu \quad (2)$$

   b. Lognormal Distribution
      Lognormal distribution characteristics have two parameters, the first is the location parameter (μ) and the second is the scale parameter (σ), equal to the standard deviation.

$$MTTF = \exp\left(\mu + \frac{\sigma^2}{2}\right) \quad (3)$$

   c. Weibull Distribution
      Weibull distribution has been used extensively in reliability techniques. The characteristics of a weibull distribution are if the time distribution between failures of a component or system follows the weibull distribution, the weibull distribution is divided into 2:
      Weibull Distribution 3

$$MTTF = \gamma + \eta\Gamma\left(1 + \frac{1}{\beta}\right) \quad (4)$$

      Weibull Distribution 2

$$MTTF = \eta\Gamma\left(1 + \frac{1}{\beta}\right) \quad (5)$$

   d. Exponential Distribution

$$\text{MTTF} = \frac{1}{\lambda} \quad (6)$$

3. METHODS

The initial identification phase of the study included a literature review and field study. The next step is problem identification, which determines the purpose of the research. Continue after that with the data collection phase. The collection of data is accomplished by directly observing and collecting data. This study collected two types of data: primary data and secondary data. Interviews and focus group discussions provided the primary sources of information for this study's data collection. Whereas secondary data consists of data collected from the literature and relating to the historical failure record, primary data consists of data collected from PT. Precast in the form of company profiles and data on the number of employees. After data processing, analyze the information and draw conclusions and recommendations.

4. RESULTS & DISCUSSION

4.1. Functional Block Diagram (FBD)

This FBD (Functional Block Diagram) aims to understand and know the main components contained in the work system and how the components of the overhead crane work in accordance with their functions.

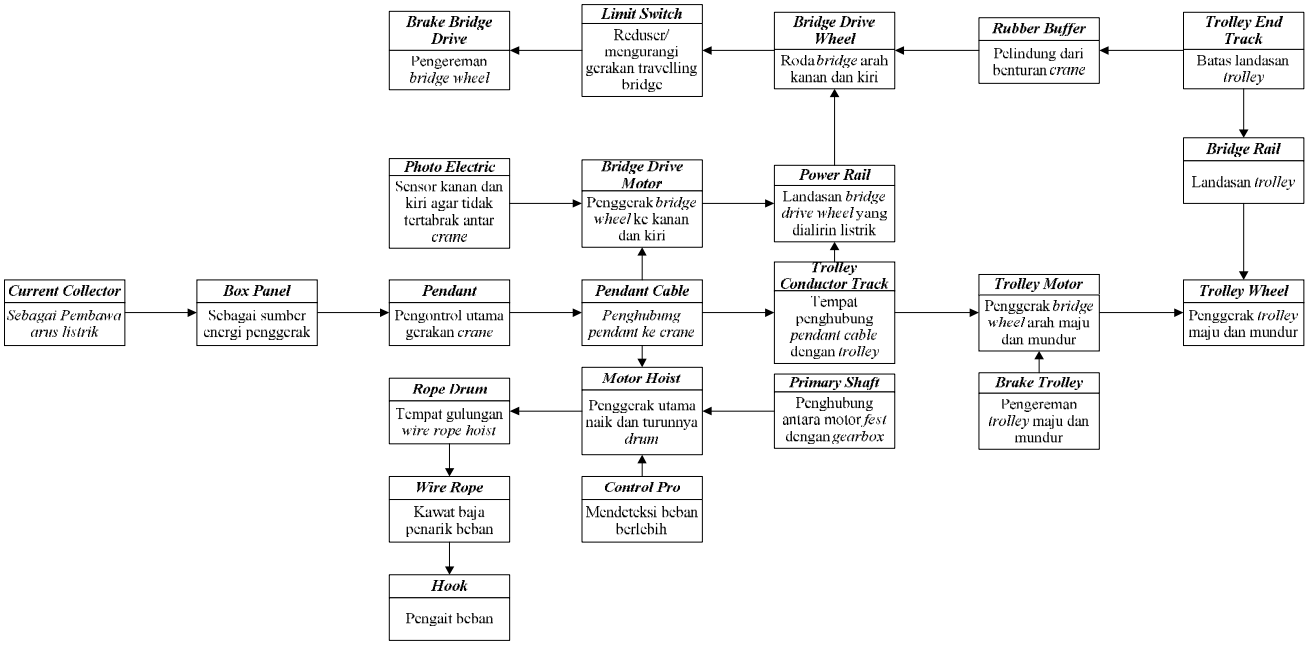


Figure 1. Functional block diagram *overhead crane*

4.2. FMEA (*failure mode and effect analysis)*

FMEA (Failure Mode and Effect Analysis) is used to identify the form of malfunction that occurs in the components or supporting equipment of overhead cranes that can result in a disrupted production process.

Table 1. Failure mode and effect analysis overhead crane

Equipment	Functional	Functional Failure	Functional Mode	Functional Effect	S	O	D	RPN
1 Box panel	The main source of electricity supply	Cannot distribute source for drive overhead crane	Panel box burned/ short circuit	overhead crane can not function	8	6	3	144
2 Pendant Cable	Connector of the pendant with the hoisting motor, trolley motor, and bridge drive motor	Pendant cable broke	Pendant cable broke	Overhead crane can not function	2	3	4	24
		Pendant cable burned	Pendant cable burned	Short circuit in the pendant	3	2	4	24

3	Wire Rope	Steel strap for pulling weights	Steel ropes cannot pull weights	Wire rope worn-out	If it breaks when loading a load, the load will immediately fall and injure people below it	5	4	3	60
				Wire rope broken		8	4	5	160

4.3. Risk Priority Number (RPN)

The identification of the failure of the overhead crane component, in FMEA, will be continued with the determination of risk priority / risk assessment of the failure of the overhead crane component function using RPN (Risk Priority Number). This risk assessment is based on 3 categories of assessment namely severity (how severe the damage is), the value of occurrence (how often the damage occurs), and detection (how likely the failure detection is). The assessment of the value of the RPN is obtained through adjustment and agreement with expert judgment.

4.4. Determining Component Distribution

Software Weibull ++6 is used to determine whether the distribution follows the damage data. Output generated from this test produces an alternative distribution with ranking order, where the distribution with the best and exact ranking order will be chosen. Apart from the output of this software, it will produce a distribution parameter which will be used to determine the expected time between damage to components of the equipment (MTTF).

Table 2. Distribution parameter results

No	*Equipment*	*Failure Mode*	β	η
1	*Sling/wire rope*	*Wire rope* broken	1,905	4395,615
		Wire rope worn-out	3,398	5015,591
2	*Box panel*	Contactor changes	4,913	2714,017
3	*Pendant Cable*	*Pendant cable* broken	0,955	1941,228
		Pendant cable burned	1,462	5596,002

4.5. Calculating MTTF

The calculation below determines the results of the MTTF (Mean Time To Failure) calculation of one component, it is the box panel of overhead crane. Table 3 presents the MTTF results with gamma function nilai Γ (1,68) = 0,90300.

$MTTF = \eta\Gamma\left(1+\frac{1}{\beta}\right)$; It is weibull 2 distribution

$$MTTF = 5596{,}002\ \Gamma\left(1+\frac{1}{1{,}462}\right)$$

$$MTTF = 5596{,}002\ \Gamma\ (1{,}68)$$

$$MTTF = \ 5596{,}002\ \ (0{,}90300)$$

$$MTTF = 5053{,}18$$

Tabel 3. MTTF calculation result

No	*Equipment*	*Failure Mode*	Distribution	MTTF
1	*Sling/wire rope*	*Wire rope* broken	Weibull 2	478,65
		Wire rope worn-out	Weibull 2	4509,22
2	*Box panel*	Contactor changes	Weibull 2	2491,92
3	*Pendant Cable*	*Pendant cable* broken	Weibull 2	1975,35
		Pendant cable burned	Weibull 2	5053,18

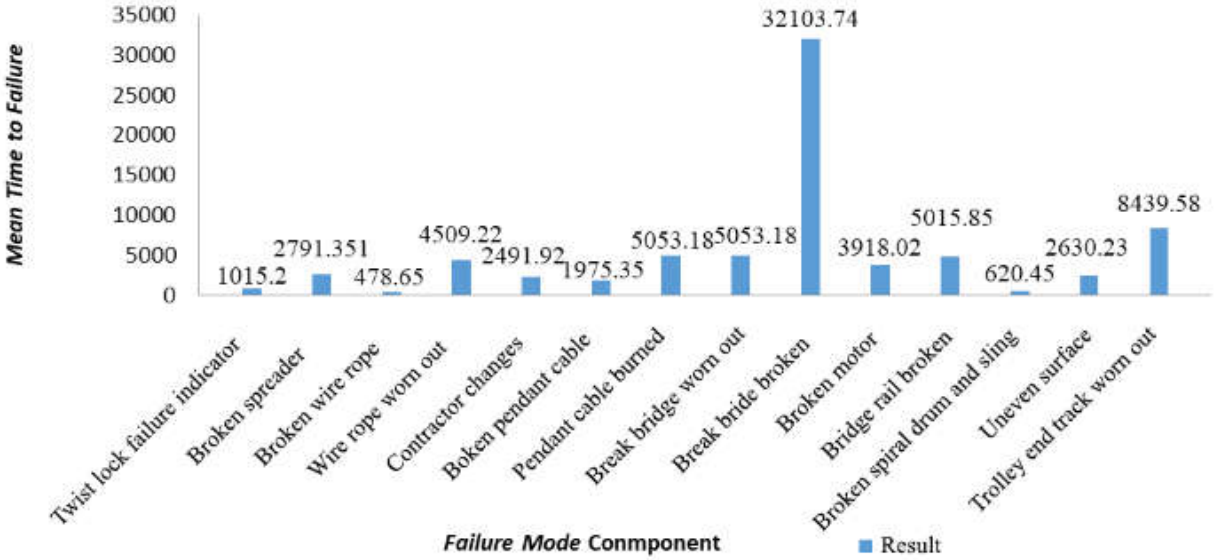


Figure 2. Distribution of Failure Mode Component

MTTF shows that the greater the MTTF value of a component shows, the component has a long the time interval of damage. Vice versa, if the component has a small MTTF value, then the component has a short time between the damage.

6. CONCLUSIONS

According to the findings of FMEA (Failure Mode and Effect Analysis), there are 32 types (failure modes). The risk assessment reveals that wire rope components with an RPN value of 160 have the highest risk priority, while bridge wheel drive components with an RPN value of 12 have the lowest risk priority. Moreover, the Mean Time To Failure (MTTF) result can indicate the importance of components. Components with high MTTF values have a long distance between failures; the brake bridge with a broken bridge drive failure mode has an MTTF of 32103.74 hours, whereas the wire rope with a broken wire rope failure mode has an MTTF of 478.65 hours. By understanding the criticality level of components, maintenance priorities can be established.

REFERENCES

D.H, 1995. *Failure Mode and Effect Analysis: FMEA from Theory to Execution*. Milwauke ASQC Quality

Ebeling, C. (1997). *An Introduction to Reliability and Maintanibility Engineering* . Singapore : The McGraw-Hill Companies .

Maghfiroh, S., Juniani, A. I., & Arumsari, N. (2018). Identifikasi Kegagalan Mesin CNC JOBS LINX 30 COMPACT menggunakan Metode Root Cause Analysis dan Failure Mode and Effect Analysis. *ProceedingsConference on Design ManufactureEngineeringand Its Application*, (2654). Retrieved from http://journal.ppns.ac.id/index.php/CDMA/article/view/582

Prabowo, R. S., Setiawan, P. A., Juniani, A. I., Wiediartini, & Erawati, I. (2018). Reliability analysis of hanger shot blast KAZO machine in foundry plant. *MATEC Web of Conferences*, *204*. https://doi.org/10.1051/matecconf/201820403007

Rosiawan, M., Singgih, M. L., & Widodo, E. (2019). Measurement of Cost & Benefit for Implementation of Risk Management in the Production Process. *IPTEK Journal of Proceedings Series*, *0*(5), 546. https://doi.org/10.12962/j23546026.y2019i5.6428

Sanditya, R., Juniani, A. I., & Amrullah, H. N. (2019). *Integrated Risk Assessment on Argon Purification Unit Based on FMECA and Fuzzy-*. *2019* (IConBMT).

Central Java Electricity Load Forecasting with LSTM: The Case of the Central Java Electricity System

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ABSTRACT

Short-term load forecasting is a very important activity in system operators in terms of planning and operating electric power systems. The purpose in forecasting electric load is to improve efficiency and provide reliable electric power. The characteristics of the electricity load in Central Java on national holidays, especially Eid al-Fitr are not certain, it is a challenge to get the best forecasting results. By using the history of central Java electricity load per 30 minutes (within 24 hours) for the period 01 January 2018 to 31 December 2021, the LSTM method is used in forecasting loads on national holidays in Central Java, especially Eid al-Fitr. With the LSTM method, short-term load forecasting on Eid al-Fitr resulted in a root mean square error (rmse) value of 361.0572 and a Mean absolute percentage error (mape) of 0.07866206. It can be concluded that the LSTM method can be used by electric power system operators in forecasting short-term load needs in Central Java on national holidays, quickly and accurately to answer the challenges of operating efficiency and meet the reliability of electricity supply.

Keywords: Load forecast,Holydays, LSTM Methods

1. INTRODUCTION

Electric Power System Operator Companies require accurate load forecasting to achieve the operating goals of Economical, Reliable and Quality electric power systems. Electric Power System Operators are obliged to provide continuous electric power to consumers with good quality and reliability [1]. Electricity demand in Indonesia is divided into household, commercial, public and industrial consumers, factors such as activities, weather or climate, economy, social activities, industrial estate planning and demographics will be very influential in electricity load planning. Electric power production cannot be stored on a large scale every year, so load forecasting is needed according to consumer needs. Forecasting load needs related to the operation of the power system such as scheduling plant operations, planning maintenance of generating and distribution units, and reliability of the power system. If there is an imbalance between the plant and the load, there is waste so that the plant has an excess supply of electrical energy and it is possible to have a rotating outage. Therefore, load forecasting has an important role in maintaining the availability of electric power continuously, and forecasting can be carried out based on continuous realization and observation to improve accuracy because load forecasting is periodic.

Electrical load forecasting based on timeframe is grouped into:

1. Very short-term load forecasting, to be used under certain conditions, within a period of hours, minutes
2. Short-term load forecasting, for daily, weekly to monthly timeframes

3. Medium-term load forecasting, for a period of months to two years to come
4. Long-term load forecasting, for a period of more than one to ten years to come

The character of electrical loads is distinguished by the pattern of workload on weekdays (Monday – Friday), the pattern of weekend loads (Saturdays and Sundays) and the pattern of loads on special days, such as on Eid al-Fitr [2]. The characteristics of the load on special days are different from ordinary days due to changes in consumption behavior compared to weekdays so that the load tends to decrease [3, 2]. On holidays, electricity consumption in the industry will decrease, while changes in demand for loads on home consumers will be greatly influenced by activities. Changes in policies related to homecoming activities on Eid al-Fitr, this can affect the pattern of electricity consumption in central Java in 2022.

Several previous studies on short-term electrical load forecasting were carried out by Hidayatullah Nurohmah, et al with the conclusion that the use of the interval type-2 fuzzy interference system method had better results in conducting short-term load forecasting in the Java Bali system than the type 1 fuzzy interference system [3]. Linda Faridah, et al. developed an artificial neural network method with a multilayer feed forward approach to provide the best results on load forecasting on national holidays and joint leave [4]. Tifani Handayani, et al performed load forecasting using the Artificial Neural Network method with the traincgb training function to get accurate results [2]. Heru Purnomo, et al conducted research on short-term load forecasting of batu city electricity system using deep learning Long Short-Term Memory (LSTM) [5].

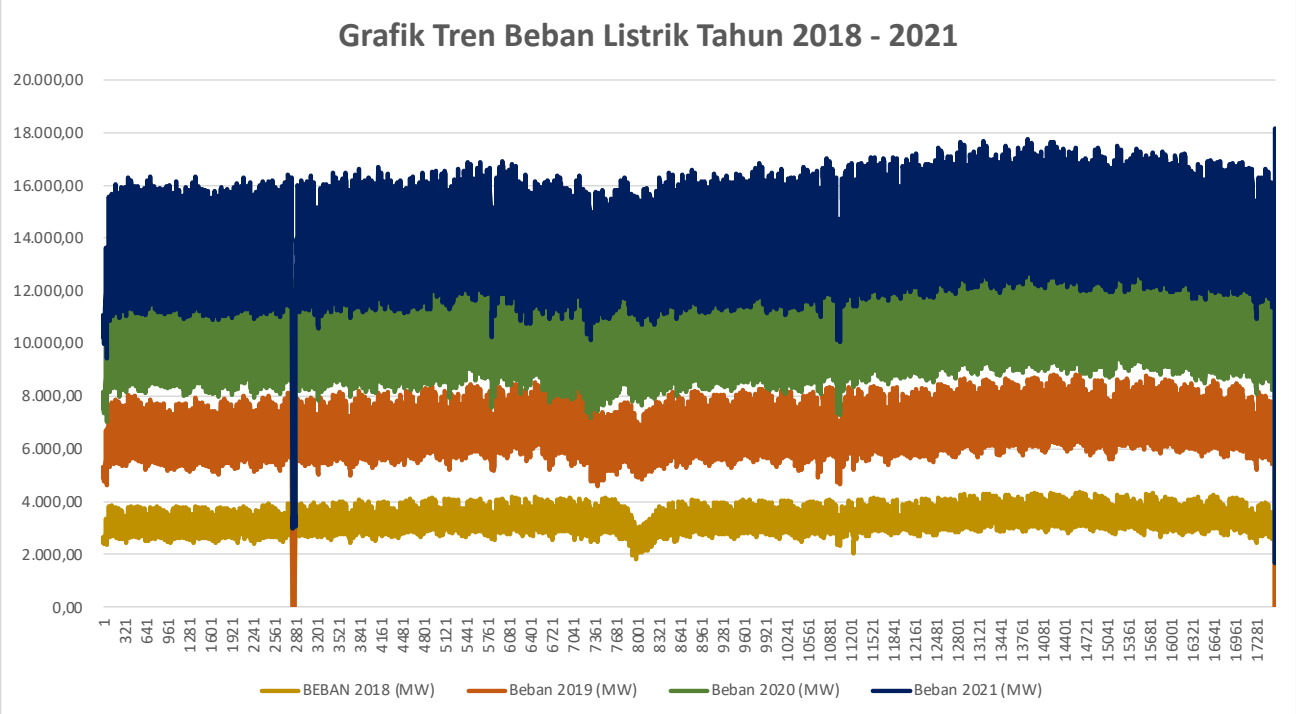


Figure 1. Central Java electricity load curve period 01 January 2018 - 31 December 2021

The Long Short-Term Memory method in this study was used in predicting the short-term lysric load on national melting day, especially the Eid al-Fitr in Central Java. The LSTM method has advantages in generalization and good learning in the set of large and small amounts of data and non-linear data, and can be used in improving the accuracy of load forecasting. The historical

data used in this study is data on the electrical load on the Central Java electricity system in Mega Watts (MW) and the time of occurrence of the load in each day (24 hours) from 00:0 to 24:00 per 30 minutes in the time period 01 January 2018 to 31 December 2021. To analyze the forecasting results measured using the Root Mean Square Error (RMSE) and Mean Absolute Percentage Error (MAPE) methods [2, 3, 4, 5, 6, 7, 8]. From the results of this study, it is hoped that it can be used as a consideration of the methods used for load deepening so that it can increase the effectiveness of electricity supply and can help in improving services to customers in Central Java, Indonesia.

2. METHODS

Penelitian ini menggunakan metode kuantitatif dalam peramalan time series, dengan menggunakan pola data historis yang dimiliki dari perusahan operator sistem kelistrikan pada provinsi Jawa Tengah, Indonesia. Adapun data time series pembebanan berupa pencatatan beban yang dilakukan setiap 30 menit dalam kurun waktu 24 jam, dengan panjang data dari 01 Januari 2018 sampai dengan 31 Desember 2021. Pada penelitian ini metode peramalan dilakukan dengan Long Short Term Memory (LSTM), untuk melakukan peramalan beban pada hari libur hari raya Idul Fitri yang akan terjadi di tahun yang akan datang. Untuk menentukan kinerja akurasi peramalan beban dilakukan Analisa terhadap hasil penelitian menggunakan RMSE dan MAPE.

2.1. Research Diagram

At the data collection stage, the load history data is carried out cleansing and normalizing the dataset to ensure that there is no missing value. In data processing with LSTM 68000 load data history is taken, taking into account that the iteration process is easy in the proposed portion. After that, it is determined that 51000 data will be used as training data and 17000 data will be used as testing data. The formation and test of the LSTM model is used to input with the hard sequential model.

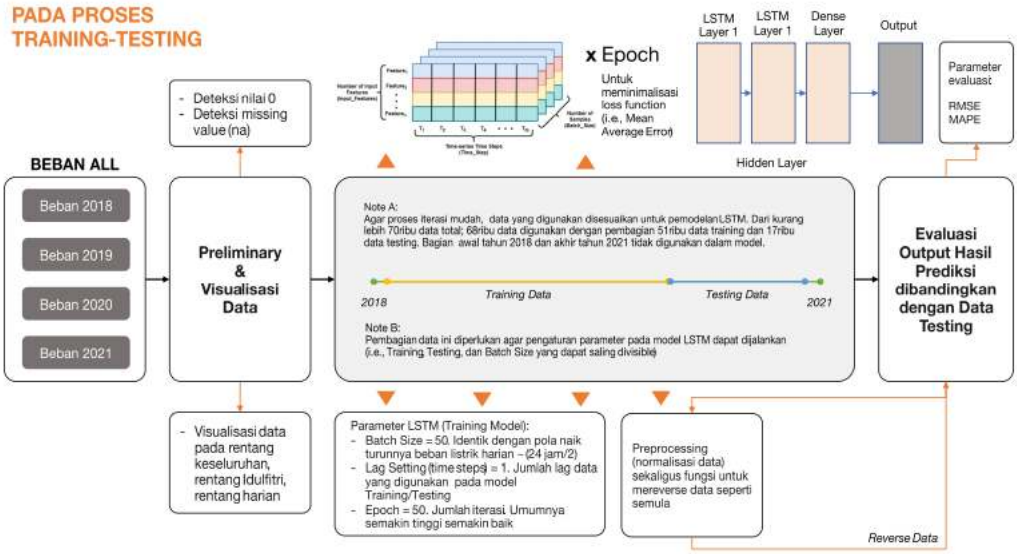


Figure 2. Graphics Data Training and Testing research method using LSTM

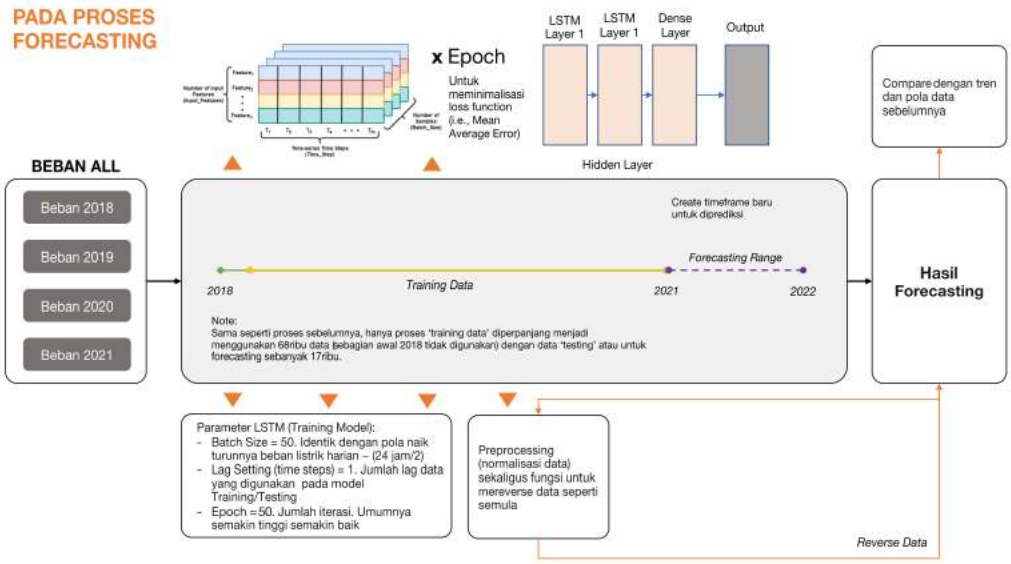


Figure 3. Graphics Forecasting Research Method using LSTM

At the data collection stage, the load history data is carried out cleansing and normalizing the dataset to ensure that there is no missing value. In data processing with LSTM 68000 load data history is taken, taking into account that the iteration process is easy in the proposed portion. After that, it is determined that 51000 data will be used as training data and 17000 data will be used as testing data. The formation and test of the LSTM model is used to input with the keras sequential model.

2.2. Error Analytical

In this study, the model performance evaluation process used the Root Mean Square Error (RMSE) and Mean Absolute Percentage Error (MAPE) methods. Both evaluation methods are techniques that are easy to implement and have been widely used [2, 3, 4, 5, 6, 7, 8].

2.2.1. Root Mean Square Error (RMSE)

Root Mean Square Error (RMSE) is the magnitude of the level of satisfaction of the prediction result, where as small as (close to 0) the RMSE value, the prediction result will be more accurate. The RMSE value can be calculated by the following equation.

2.2.2. Mean Absolute Percentage Error (MAPE)

Mean Absolute Percentage Error (MAPE) calculates the absolute error value in each period divided by the actual value for that period, then calculates the presentation average of that absolute value. The selection of this method is because MAPE can provide relatively accurate results [6], mape values can be calculated using the following equation.

3. RESULTS

Short-term load forecasting in the electricity system of Central Java, Indonesia on the national holiday of Eid al-Fitr is carried out using the LSTM method. The forecasting accuracy performance of this method is measured by evaluating the values of Root Mean Square Error (RMSE) and Mean Absolute Percentage Error (MAPE). The data used is historical data on daily electrical load (24 hours) per 30 minutes for four years (01 January 2018 – 31 December 2021).

At this stage, preprocessing and evaluating the initial data with the aim of ensuring that there is no missing value. From table 1, it can be concluded that the data are complete.

Table 1. Summary Preprocessing and Data Analytical

	Beban (MW)			
	2018	2019	2020	2021
Min.	1786,11	1879,3	1659,64	2184,89
1st Qu.	2941,525	3076,468	3075,507	3246,412
Median	3238,12	3397,24	3385,035	3577,28
Mean	3249,81	3403,294	3404,395	3584,958
3rd Qu.	3531,673	3705,235	3730,12	3912,385
Max.	4371,38	4550,03	4504,01	4721,45

From the data on the trend of electrical loads that occur every year for the period 2018 - 2021. There is an increase in electricity load every year, but there is an anomaly of decreased load that occurs every year during the Eid al-Fitr period.

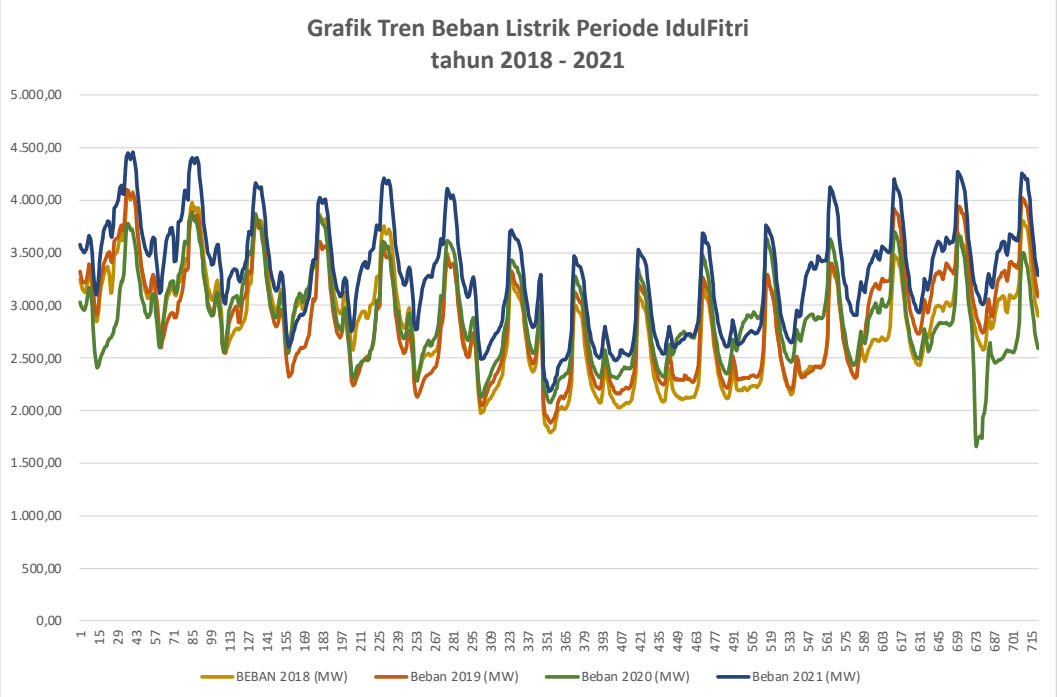


Figure 4. Grafik Tren Beban Listrik (MW) periode Idul Fitri tahun 2018 – 2021

In building the LSTM model, it is necessary to denormalize observations for uniformity of data in forecasting modeling. The already normalized mean and standard deviation values of the electrical load in the table.

Table 2. Results Value Mean and Standart Deviation for Preprocessing data

Mean	58.27686
Standar Deviasi	3.79710

In building an LSTM model, the values of the main input parameters are specified as follows:

Table 3. Main Input Parameter for LSTM model

Lag_setting	17000
Batch_size	50
Train_length	51000
Tsteps	1
epochs	50

- lag_setting = the amount of testing data to be used. The requirement of the testing data in this analysis is that the time span must include the Eid al-Fitr period.
- bath_size = number of sample examples to be used for training (from training data) in one forward/backward stage. This amount can be taken from the plot picture in section B.2.4 which describes the daily pattern. With a total daily hours of 24 and an observation time span of once every 30 minutes, it is estimated that the number = 50 ~ (24*2). The number is rounded up in order to perfectly divide the training and testing data.
- train_lenght = amount of training data
- tsteps = the amount of lag that will be used in the training and testing process. In this section, lag = 1 is used, which means that based on previous observations
- epoch = total iterations.

The simulation was carried out by the proportion of training data of 51000, and to see the trend of Eid al-Fitr, the proportion of training data used was quite large. Hard Squential models are used in forming LSTM.

Table 4. Keras Model Squential for LSTM model

Model : "Sequential_1"

Layer (type)	Output Shape	Param #
lstm_3 (LSTM)	(50, 1, 5)	140
lstm_2 (LSTM)	(50, 5)	220
lstm_1 (Dense)	(50, 1)	6

Total params : 366

Trainable params : 366

Non-trainable params : 0

With the number of iterations of 50 times, the resulting loss value is at the level of 0.58. Then a prediction is made on the testing data with results in the form of standard values that need to be returned to their original form. As a result of the prediction of testing data, there is a phenomenon of decreasing electricity load that occurs during the Eid al-Fitr period.

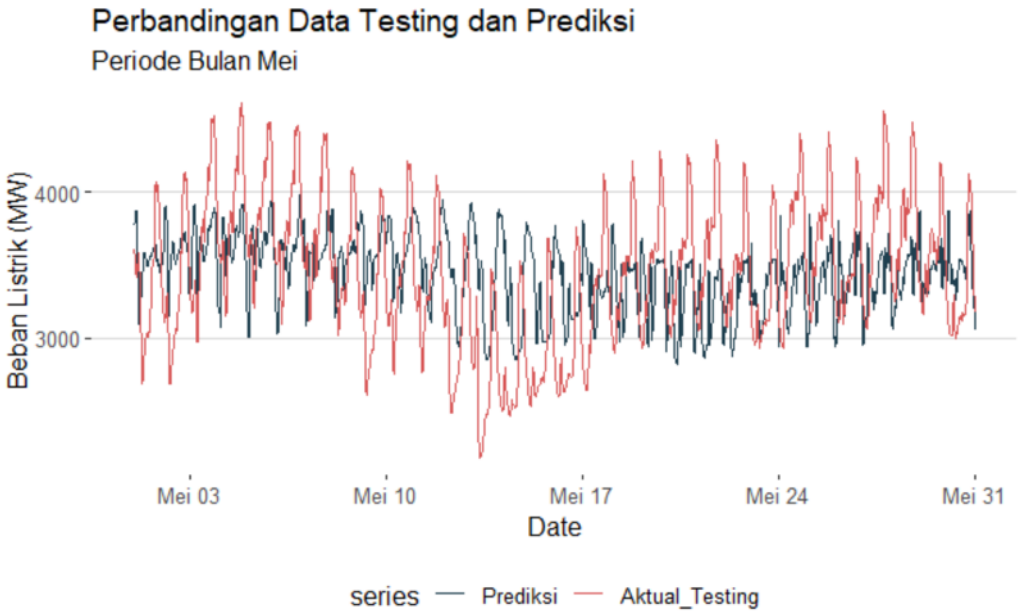


Figure 5. comparison of testing data and predictions in the Eid al-Fitr period in May 2021

Table 5. Keras Model Squential for Idul Fitri load Forcasting in 2022 with LSTM methods

Model : "Sequential_4"

Layer (type)	Output Shape	Param #
lstm_9 (LSTM)	(50, 1, 5)	140
lstm_8 (LSTM)	(50, 5)	220
lstm_4 (Dense)	(50, 1)	6

Total params : 366

Trainable params : 366

Non-trainable params : 0

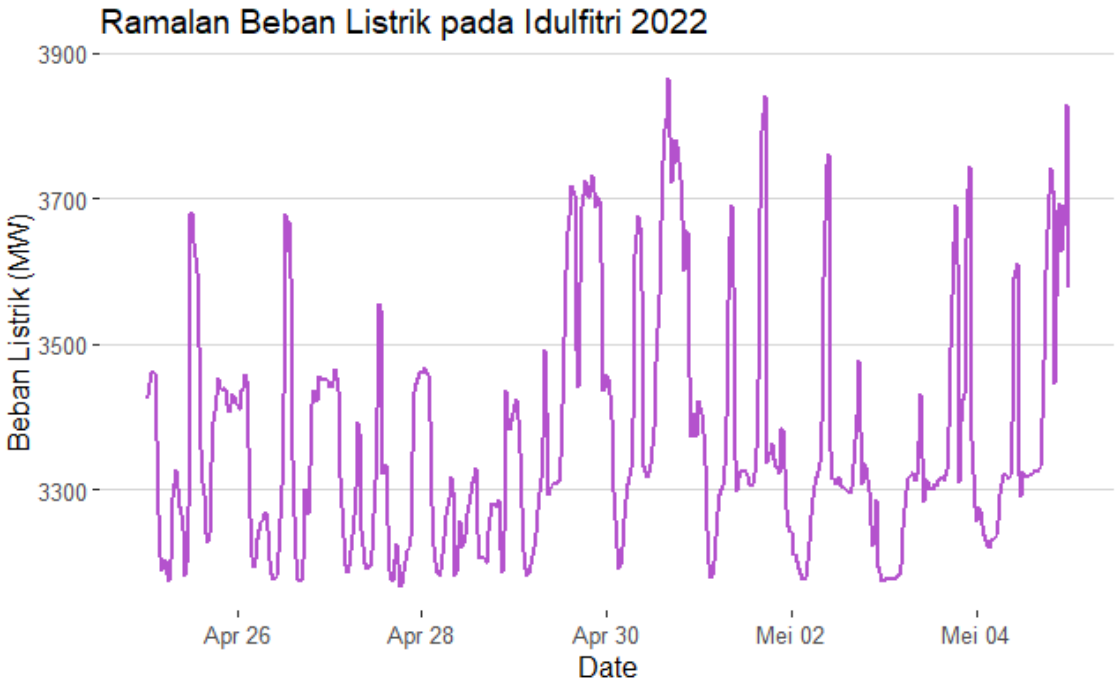


Figure 6. Graphics Result for Load Forcasting periode in Idul Fitri 2022 using LSTM method

The results of the forecasting accuracy test on the testing data with Root mean Square Error (RMSE) of 361.0572 and Mean Absolute Percentage Error (MAPE) 0.07866206. In the upcoming Eid al-Fitr period the LSTM model used, . with the same number of iterations, the

resulting loss value of the model is 0.63 lower compared to the testing data of 0.58. The results of short-term load forecasting in the Eid al-Fitr period with the LSTM method in the form of curves can be seen in figure 4.

4. CONCLUSIONS

From the results of this study, the results of predicting the short-term burden of national holidays, the Eid al-Fitr period with the LSTM method have been obtained with quite good results. Model testing was conducted using the best model, referencing epoch values with a root mean square error (rmse) value of 361.0572 and a Mean absolute percentage error (mape) of 0.07866206. In line with the business plan of electric power system operators in the use of technology in efficient electric power regulation, reliable electricity supply so that it can be concluded that the LSTM method can be used by electric power system operators in forecasting electricity loads in Central Java. The LSTM method can be used by electric power system operators in responding to the challenges of operating efficiency and the reliability of electricity supply can be met, in forecasting short-term load needs is carried out as quickly and accurately.

Researchers realize that of course, there is a certainty in this study, especially in the use of methods and variations in data. Thus, in future research, studies can be carried out with a longer variety of data, as well as supporting devices so that better results are obtained.

REFERENCES

[1] Pemerintah Republik Indonesia, "Undang Undang Republik Indonesia Nomor 19 tahun 1989 tentang Penyediaan dan Pemanfaatan tenaga Listrik," Pemerintah epublik Indonesia, Jakarta, 1989.

[2] D. P. A. T. Tifani Handayani, "Proyeksi Kebutuhan Energi Listrik Jangka Pendek di Area Pengatur beban Jawa Tangah-DIY," in *Seminar Nasional Riset Teknoloi Terapan*, Indonesia, 2021.

[3] D. A. I. R. Hidayatul Nurohmah, "Peramalan Beban Jangka Pendek Hari Libur Nasional dengan Interval Type-2 Fuzzy Inference System pada Sistem Jawa-Bali," *SENTIA,* pp. 49-55, 2015.

[4] L. Faridah, "Aplikasi Alogaritma Feed Forward Backpropagation untuk Beban Listrik Hari Libur Tipe Beban Anomali," *Journal of Energy and Electrical Engineering (JEEE),* vol. 2, no. 1, pp. 10-15, 2020.

[5] H. S. R. N. H. Heru Purnomo, "Peramalan Beban Jangka Pendek Sistem Kelistrikan Kota Batu Menggunakan Deep Learning Long Short-Term Memory," *TRANSMISI : JURNAL ILMIAH TEKNIK ELEKTRO,* pp. 97-102, 2021.

[6] N. U. M. H. A. A. Fahriza Novianti, "Prediksi Penggunaan Bahan Bakar pada PLTGU Menggunakan Metode Support Vector Regression (SVR)," *Techno.COM,* vol. 21, no. 2, pp. 249-255, 2022.

[7] A. S. R. S. W. Januar Adi Perdana, "Peramalan Beban Listrik Jangka Pendek Menggunakan Optimally Pruned Extreme Learning Machine (OPELM) pada Sistem Kelistrikan Jawa Timur," *JURNAL TEKNIK ITS,* pp. 64-69, 2012.

[8] I. M. Mataram, "Peramalan Beban Hari Libur Menggunakan Artificial Neural Network," *Teknologi Elektro,* pp. 53-56, 2008.

[9] Pemerintah Indonesia, Rencana Usaha Penyediaan Tenaga Listrik PT PLN (persero), Jakarta: Kementrian Energi dan Sumber Daya Mineral, 2021.

[10] A. D. I. M. M. Juniar Doan Wihardono, "Peramalan Beban Jangka Pendek pada Hari Libur di Bali Menggunakan Metode Generalized Regression Neural Network (GRNN)," *E-Journal SPEKTRUM,* pp. 71-76, 2016.

[11] M. H. L. D. D. P. Suhartono, "Two levels ARIMAX and Regression Models for Forecasting Time Series data with Calender Variation Effects," *AIP Conference Proceedings,* pp. 1-8, 2015.

[12] R. Yanto, "Implementasi Data Mining Prediksi Kebutuhan Tenaga Listrik di Kota Lubuklinggau," *Techno.COM,* vol. 19, no. 2, pp. 197-206, 2020.

[13] D. C. R. N. W. D. U. P. K. I. Uswatun Khasana, "Analisis Peramalan Beban Listrik Jangka Pendek Menggunakan Metode Adaptive Neuro Fuzzy Inference System (Studi kasus : PT PLN (persero) Area Pengatur Distribusi Jawa Timur)," *Jurnal Matematika,* vol. 1, no. 1, pp. 17-24, 2019.

[14] W. S. P. Marita Saptyani, "Peramalan Penggunaan Beban Listrik Jangka Pendek Gardu Induk Bawen dengan DSARIMA," *Media Statistika,* vol. 8, no. 1, pp. 41-48, 2015.

[15] M. S. Laras Wiranda, "Penerapan Long Short Term Memory pada Data Time Series untuk Memprediksi Penjualan Produk PT Metiska Farma," *Jurnal Nasional Pendidikan Teknik Informatika,* vol. 8, no. 3, pp. 184-196, 2019.

[16] J. A. Perdana, A. Soeprijatno and R. S. Wibowo, "Peramalan Beban Lostrik Jangka Pendek Menggunakan Optimally Pruned Extreme Learning Machine (OPELM) Pada Sistem Kelistrikan Jawa Timur," *JURNAL TEKNIK,* vol. 1, no. 1, pp. B-64-69, 2012.

[17] M. t. Wikarsa, "Studi Analisis Program Percepatan 10.000 MW Tahap I Pada Operasi Sistem Tenaga Listrik Jawa Bali," *Jurnal Departemen Teknik Elektro Fakultas Teknik Universitas Indonesia,* 2010.

RECOMMENDATIONS ON POST-PANDEMIC FINANCING STRATEGY FOR INDONESIAN ISLAMIC BANKS USING VECTOR REGRESSION AND FINANCIAL ANALYSIS

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ABSTRACT

COVID-19 pandemic has impacted the growth and profitability of the Indonesian banking industry, including Islamic banking, that currently only has a market share of 6.5% of the entire banking industry. A proper strategy for financing growth as the primary source of revenue growth is needed for Islamic banks to continue to grow after the pandemic. Through time-series forecasting using vector autoregression with vector error correction model (VECM), based on historical data during 2015-2021, predictive analytics on financing growth strategy for Islamic banks in Indonesia after the pandemic was conducted. Combined with constraints based on banking regulations to make sure the model can be implemented in real situations, the research resulted in recommendations on financing products focus. The research recommendations resulted in a 46% profit increase, even better than pre-pandemic performance and total banking industry. The recommendations are expected to be useful for Islamic banks to have better positioning in the Indonesian banking industry and to gain more market share.

Keywords: Islamic banking, bank strategy, COVID-19 pandemic, vector autoregression

1. INTRODUCTION

As well as other industries, COVID-19 pandemic also has impacted Indonesian banking industry growth for the first time in the last few years. Based on data from the Financial Services Authority or Otoritas Jasa Keuangan (OJK, 2021), total commercial banks' loan portfolio decreased by 2.41% year-on-year in 2020, even dropped to -3.77% in March 2021, although increased slightly to 0.59% in June 2021. Meanwhile, Islamic banks' financing (Islamic banking term for loan) growth in 2020 fell to 8.10% compared to 10.93% in 2019, and dropped to 6.54% year-on-year in March 2021, before rising slightly to 7.35% year-on-year in June 2021. Deposits growth for total commercial banks showed the opposite trend, which rose from 6.37% in 2019 to 11.27% in 2020, and stable at 11.32% in March 2021 and 11.28% year-on-year in June 2021. Deposits in Islamic banks was also not impacted by pandemic, as shown by growth at 11.86% in 2020, a slight decrease compared to 12.03% in 2019, and to 11.66% year-on-year in March 2021, and recorded the highest growth of 16.54 % year-on-year in June 2021.

Started with the establishment of Bank Muamalat Indonesia in 1991 and followed by the increasing number of Islamic banks in the following years, market share of Islamic banks until June 2021 has only reached 6.55% of the total commercial banks' assets (OJK, 2021), with slight increase compared to 6.48% in 2020 and 6.17% in 2019. Compared to 87% contribution of Muslim population in Indonesia as Islamic banks' main target market, Islamic banks in Indonesia still have big opportunity to grow. In terms of income, dependency of Islamic banking on financing is much higher than total banking industry. In 2020, Islamic banking income from financing, known as margin income, contributed 79.67% of total income, decreased to 72.31% in March 2021 and 70.33% in June 2021, compared to total banking industry with income contribution from loan was only 48.37% in 2020, decreased to 42.42% in March 2021 and 45.81% in June 2021. The rest of income is contributed by fee-based income and other income. With the situation, Islamic banks in Indonesia faced bigger challenges in financing strategy compared to conventional banks. However, there is an opportunity for Islamic banks to catch up. Islamic banks have better positioning in some financing products. If Islamic banks implement right strategy, they may get better income after pandemic, which will result in profitability increase and have better positioning in the banking industry.

This research is intended to achieve two objectives. First, it is aimed to conduct predictive analytics through time-series forecasting of Islamic banks' financing portfolio using vector autoregression with vector error correction model (VECM). Second, this research will provide strategic recommendations to increase income for Islamic banks in Indonesia after the COVID-19 pandemic, including financing products that can be increased or need to be avoided, through financial analysis of the VECM forecasts.

2. LITERATURE REVIEW

Besides government-issued acts, there are several Indonesian banking regulations that need to be considered in this research, in order to have applicable recommendations on the strategy. Some regulations were released by Otoritas Jasa Keuangan (OJK) as Indonesian financial services authority, including credit or financing-related and financial ratios. Other regulations are issued by Bank Indonesia (BI) as Indonesian central bank and monetary authority. According to Act No. 10 of 1998 regarding Banking (OJK, 2021), the banking sector has a strategic position as an intermediary and supporting institution in the economic sector in Indonesia. More specific for Islamic banking, according to Act No. 21 of 2008 regarding Islamic Banking (OJK, 2021), Islamic banking is part of Islamic rules implementation to the economy, through application of principles in Islamic economics, such as prohibition of usury and implementation of profit sharing. Through this concept, Islamic banks are expected to create a healthy and fair economy. More importantly, in addition to regular bank's function of collecting and distributing funds, Islamic banks also have social function, i.e., to receive and distribute zakat, charity, and alms for social welfare.

OJK has released some regulations (Peraturan Otoritas Jasa Keuangan or POJK) that will be used in this research as references (OJK, 2021). POJK No. 16/POJK.03/2014 and POJK No. 40/POJK.03/2019 related to Islamic and commercial banks' asset quality, stated that bank's credit quality is a very important indicator of bank's health and will impact on bank's minimum capital. Regarding risk management, there is POJK No. 18/POJK.03/2016 for mandatory implementation of risk management and reporting. Related to COVID-19 pandemic, OJK has issued POJK No. 11/POJK.03/2020 and POJK No. 48/POJK.03/2020 related to COVID-19 pandemic stimulus for banks. BI also has regulated banks with Peraturan Bank Indonesia (PBI), such as PBI No. 23/2/PBI/2021 related to limitation of loan or financing to value ratio (LTV/FTV) that encourage

banks to maintain NPL/NPF at less than 5%. Other important regulations are PBI No. 20/4/PBI/2018 related to macroprudential intermediation ratio that has to be maintained by the banks and PBI No. 23/13/PBI/2021 regarding macroprudential inclusive credit ratio that has to be maintained by the banks with focus on Micro, Small and Medium Enterprises (MSME) loans or financing, in line with government focus to develop MSME sector (BI, 2021). All regulations mentioned in this section will be used as constraints in this research.

One of the methods used for predictive analytics is time-series forecasting (Adhikari, et al, 2013 and Athiyarath, et al, 2020). This method is commonly used in predicting the future from a number of historical data in the past. One of time-series forecasting techniques is autoregressive integrated moving average (ARIMA), with assumption that time series is linear and has common statistical distribution, such as normal distribution. ARIMA has other model variances, such as autoregressive (AR), moving average (MA), dan autoregressive moving average (ARMA). Another time-series forecasting technique is vector autoregression (VAR), which is a statistical model in a stochastic process that is used to detect the multivariate relationship between several variables in line with changes in time without calculating a moving average (Luetkepohl, 2011). VAR model has several advantages compared to other models, e.g., simpler compared to other models and provides better estimation (Gujarati, 2003). One of the developments of this model is vector autoregression with exogenous input (VARX), by adding exogenous factors to the variables being measured. VAR and VARX techniques are commonly used in econometrics, and can be used for predictive analytics of pandemic impact to Islamic bank's profitability (Sohibien, et al, 2022). Another form of VAR is vector error correction model (VECM), which is application of error correction in VAR model with cointegrated variables for econometrics (Winarno, et al, 2021 and Andrei, et al, 2014). The VAR model can be described as a model with two or more time series that influence each other.

Time-series forecasting using the VARX model can be used as a basis for conducting financial analysis, to produce the best strategic recommendations for Islamic banking after the COVID-19 pandemic. Because the data used in this study fits with VARX requirements, the VARX model can be used. However, since there are many variables involved and there is possibility for cointegration, VECM may be applied to the model. Calculating the income from financing of Islamic banks in Indonesia and analyzing the results of time-series forecasting based on VARX model can be conducted by financial analysis. In order to calculate income from loan or financing, the forecasted volume of financing will be multiplied by the yield of each product, resulting in income prediction (Shelagh, 2005).

In this study, margin income is defined as income from financing for Islamic banks and yield is defined as annualized percentage of margin income from total financing portfolio of Islamic banks. Related to time-series forecasting using VARX and VECM model in econometrics, Sohibien, et al (2022) concluded that COVID-19 pandemic has significantly affected the Return on Assets (ROA) of Indonesia Islamic banks and VARX in time-series forecasting is better than spline regression, indicated by smaller root mean square error (RMSE). Warsono, et al (2019) and Hendayanti, et al (2018) also concluded that VARX model explains impact of endogenous and exogenous variables better than other models. Athiyarath, et al (2020) emphasized that the characteristics of the data determine which model is more appropriate to use, and a more complex model does not necessarily give better results because there are overfitting problems for models that are too complex. Widarjono (2018) conducted application of Autoregressive Distributed Lag Model (ARDL) method resulted in impact of NPF and exchange rates in Islamic banks' profitability. In VECM, there are studies from Andrei, et al (2014) and Winarno (2021) that concludes that VECM is suitable for econometrics if there is cointegration between variables. By

combining time-series forecasting and financial analysis for strategic recommendations on financing products to focus or avoid, it is expected that this research will give valuable inputs for Islamic banks in Indonesia on the post-pandemic strategy.

3. METHODS

The research data used is data published by the Financial Services Authority (OJK, 2021), which is monthly historical data up to June 2021, consists of data on financing, yield, and non-performing financing (NPF) based on type of product for Islamic Commercial Banks and Sharia Business Units. Pandemic period as exogenous variable is March 2020 until June 2022. The data structure is as shown in Table 1 for financing by product, with all the data is numerical.

Table 1. Financing Data Definition Based on Type of Product

Product	Unit	Size
Working Capital MSME	IDR billion (Amount)/ % (Yield/NPF)	78 lines (Month) x 8 columns (Product) Pandemic period: Mar-20 to Jun-22
Working Capital Non MSME		
Investment MSME		
Investment Non MSME		
Consumer Mortgage		
Consumer Vehicle		
Consumer Multipurpose		
Consumer Others		

Time-series forecasting was conducted using VARX/VECM, based on endogenous variables of historical financing data of Islamic banks during January 2015 until June 2021 and exogenous variables is COVID-19 pandemic during March 2020 until June 2022. In order to get right model, several steps are applied, including data stationarity test, lag length test, stability test, and Granger causality test. Forecast data from the results of time-series forecasting with VARX/VECM combined with constraints based on regulation and common practices are further simulated with financial analysis, in order to provide recommendations on products focus for Islamic banks after the COVID-19 pandemic. The methodology is described in Figure 1.

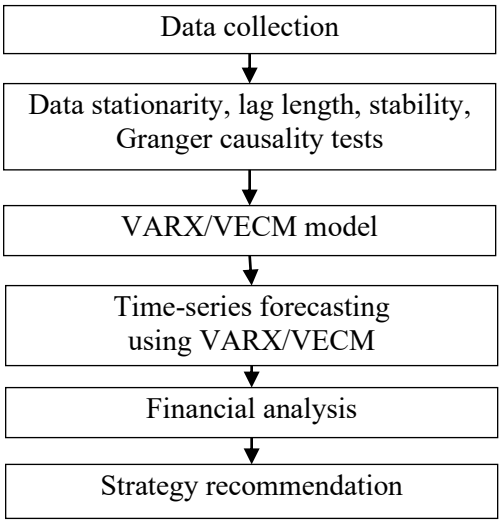


Figure 1. Methodology

The VARX/VECM model is developed based on SPS data, with period until February 2020 is defined as pre-pandemic, March 2020 until June 2022 is defined as pandemic period, and starting July 2022 will be defined as post-pandemic period. Since more than 70% of Islamic banking income comes from financing and financing is the bank's line of business most affected by the pandemic, this research is limited to increasing income from financing. Other income aspects are assumed constants.

Time-series forecasting results from VARX/VECM will be further adjusted based on several constraints. First, considering the credit risk, post-pandemic financing growth should not be higher than pre-pandemic financing growth or under normal conditions. Second, because banks are the most regulated industry, it is necessary to pay attention to the limits set by the regulations. One of the limits is non-performing financing (NPF) that can still be tolerated is 3% (early indicator) and 5% (regulatory). For example, financing product with yield less than 8% and NPF greater than 3% should not be allowed to grow. Other financial ratios also must be maintained according to regulations. Third, risk management principles should be applied, such as limitation of financing growth based on historical performance, so that there is no excessive growth (bubble) in a product and diversification of the portfolio from various products must still be carried out, as a principle of risk distribution. Based on historical data, healthy financing growth was maintained at maximum 20% year-on-year. Fourth, the product that should be avoided will remain in the portfolio for some time, because the runoff or portfolio decline does not happen immediately.

In this study, the discussion focuses on the application of predictive analytics with the time series forecasting method using the VARX model (if there is no cointegration between variables) or VECM model (if there is cointegration between variables), to produce more accurate predictions compared to other models. Financing data based on product is compared alternately with the endogenous dependent variable Operating Income and the COVID-19 pandemic as exogenous variables, which can be seen in Table 1 for financing based on products. Stationarity data checking was conducted to ensure that all data is in a stationary condition, fixed mean and variance over time. Checking can be done with the Augmented Dickey-Fuller (ADF) test, where the null hypothesis is a non-stationary time series, and the null hypothesis is rejected if the p-value is below the significance level. Optimal lag length testing, cointegration test, and Granger causality test were conducted to show whether or not there is a reciprocal relationship between variables. After VARX/VECM modeling with 8 endogenous variables and 1 exogenous variable (COVID-19 pandemic), with first difference data, according to the test results obtained. predictions are made for the period July 2021 – December 2023 (30 months), where the impact of the pandemic is estimated still exist until June 2022, and will return to normal since July 2022.

The goal of financial analysis is to make strategic recommendations for Islamic banks in Indonesia to improve competitiveness after the COVID-19 pandemic. The financial analysis carried out includes adjustment of predictive analytics results through time series forecasting using VARX/VECM, calculation of income from the results of selecting the optimal value from the Islamic banking income statement, and recommendations on appropriate strategies from the simulation results to maximize income and profitability of Islamic banks.

4. RESULTS

Time-series forecasting method using VARX/VECM model was preceded by the stationarity test to ensure data stationarity, optimal lag length test and cointegration test, as well as the Granger causality test to show whether or not there is a reciprocal relationship between variables. Before performing time-series forecasting, the data is divided into variables that have

0% growth constraint and variables without 0% growth constraint, to minimize cointegration between variables. Financing by Product without 0% growth constraint (referred as FP1 data) are: Working Capital MSME; Working Capital Non MSME; Investment SME; Investment Non MSME; Consumer Mortgage; Consumer Multipurpose. Financing by Product with 0% growth constraint (referred as FP2 data) are: Consumer Vehicle; Consumer Others. In presenting the results of this time-series forecasting, the results of FP1 data processing are presented successively, while FP2 results are carried out the same modeling, but only shown in forecasting results because growth is limited by 0% growth constraints.

At stationarity test stage, first testing is carried out at the data level using the Augmented Dickey-Fuller technique, where the data is declared to meet the requirements if Prob < 0.05. If the data level does not produce Prob < 0.05, then proceed with the first difference level. From the stationarity test at the first difference level, all data resulted in Prob < 0.05, thus fulfilling the requirements for the VAR model. The lag length criteria can be tested using several criteria, such as the Akaike Information Criterion (AIC), Schwarz Information Criterion (SC), and the Hannan-Quinn Information Criterion (HQ). The test results show the optimal lag length 6 for FP1 and 4 for BF1 using AIC. A stability test is carried out to ensure whether or not this model passes, then, namely inverse roots from AR characteristics polynomial. This test results in the conclusion that the model is stable, because all modulus values are below +/- 1.

The next step is a cointegration test using Johansen trace statistics test, which shows that if the cointegration test passes, the VARX model can be used. If the cointegration test does not pass, the VARX model can still be used using logarithmic (log) calculations, or VECM may be chosen. The results of the cointegration test are pass for hypothesized number of cointegration equations of 4 or more. In this case, VARX or VECM may be used. Granger causality test shows the presence or absence of a reciprocal relationship between variables. The expected result of this test is that there is no reciprocal relationship between variables, which are assumed to be unrelated, marked by a Prob value > 0.05. The test results show that there is no reciprocal relationship between variables, so the model can be continued.

Based on the results of the stationarity, lag length, and Granger causality tests that have been carried out, VARX modelling can be carried out with 8 endogenous variables and 1 exogenous variable. The VAR residual test results show that all variables are significant, so the model can be used. VEC estimates in Table 2 show that dependent variable is income (first column with biggest R-squared and highlighted in bold) and independent variables are financing by product. Based on the VAR estimates results, forecasting can be applied.

Table 2. VEC Estimates

	D(LOG (INC)	D(LOG (INV_NON)	D(LOG (INV_MSM)	D(LOG (MORT)	D(LOG (WC_NON)	D(LOG (WC_MSM)	D(LOG (MULTI)
R-squared	**0.540728**	0.109276	0.168455	0.199948	0.121889	0.252345	0.043538
Adj. R-squared	**0.478100**	-0.012186	0.055062	0.090850	0.002147	0.150392	-0.086889
Sum sq. resids	**0.480440**	0.090533	0.193499	0.003198	0.081631	0.086680	0.125169
S.E. equation	**0.085319**	0.037037	0.054146	0.006961	0.035169	0.036240	0.043549
F-statistic	**8.633969**	0.899669	1.485590	1.832741	1.017926	2.475116	0.333808
Log likelihood	**84.58457**	148.0062	119.1430	275.0454	151.9395	149.6588	135.6960
Akaike AIC	**-1.962752**	-3.631742	-2.872183	-6.974878	-3.735250	-3.675231	-3.307788
Schwarz SC	**-1.656076**	-3.325067	-2.565508	-6.668203	-3.428574	-3.368556	-3.001113
Mean dependent	**0.004804**	0.013100	0.004900	0.011569	0.007199	0.001840	0.016931
S.D. dependent	**0.118101**	0.036813	0.055701	0.007301	0.035206	0.039317	0.041772

After the model is accepted, time-series forecasting is carried out for the period of July 2021 – December 2023. In this case, it is determined that the exogenous variable for the COVID-19 pandemic occurred during the period March 2020 – June 2022. Forecasting of financing by product can be seen on Figure 2.

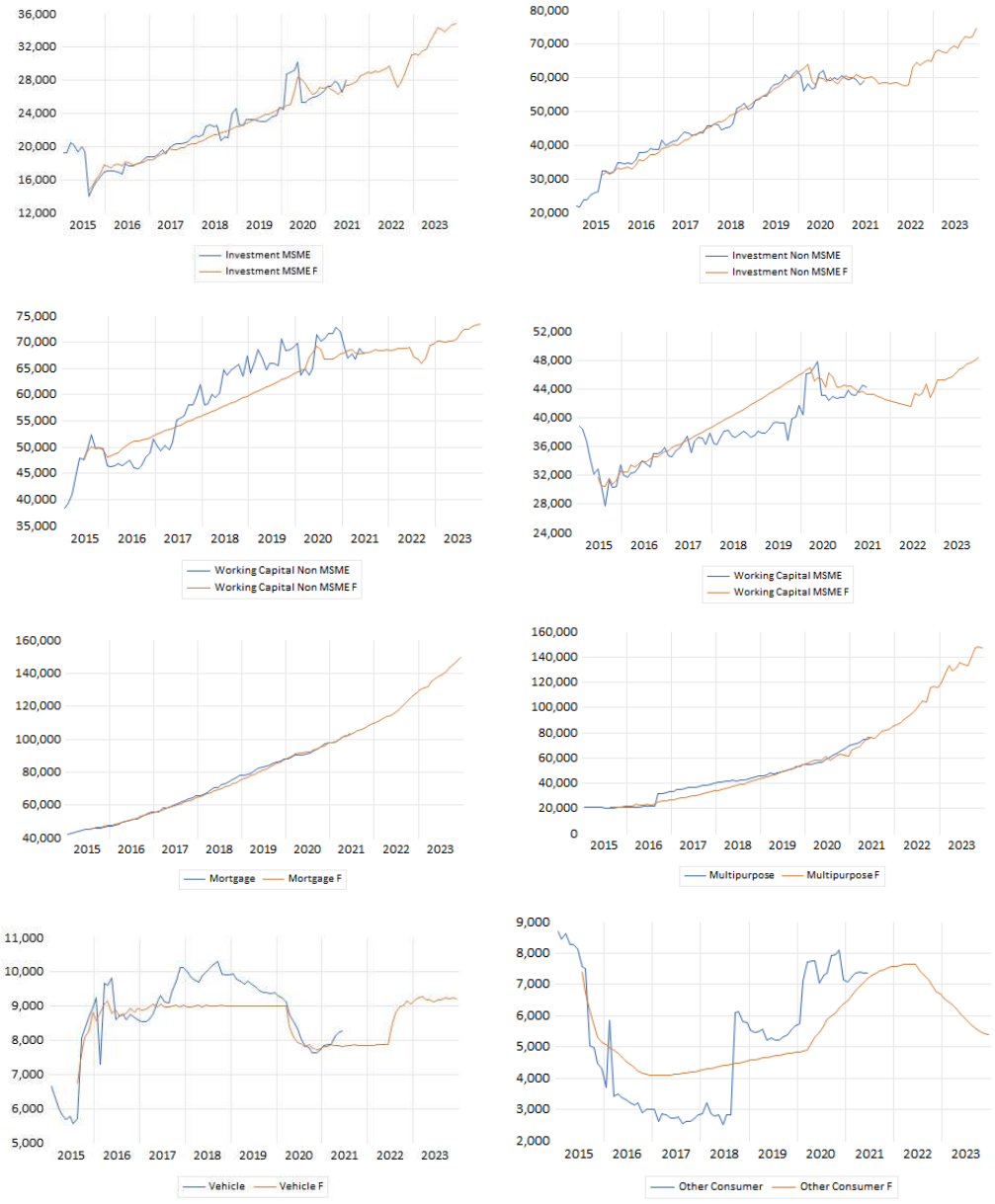


Figure 2. Forecasts of Financing by Product

Based on the forecast, financing products that are expected to continue to grow are Working Capital MSME; Working Capital Non MSME; Investment MSME; Investment Non MSME; Consumer Mortgage; and Consumer Multipurpose. However, in financial analysis section, the results have to be further adjusted with growth constraints to get more applicable results for strategic recommendations.

After forecasting, we need to conduct a financial analysis on simulation of income and profitability of Islamic banks during and after the COVID-19 pandemic. First, adjustments of forecasting results with growth constraints. Table 3 shows the results of VECM forecast for financing by product. By adjusting with growth constraints, financing products that are expected to continue to grow are as follow: Working Capital MSME; Working Capital Non MSME; Investment MSME; Investment Non MSME; Consumer Mortgage; and Consumer Multipurpose. It is important to note that growth of Consumer Vehicle and Consumer Others have to be adjusted with constraints due to risk concerns.

Table 3. Financing by Product and Growth Forecasts

Product	Growth	Projected Growth			
	Constraint	Jul-21 to Jun-22	Dec-21 to Dec-22	Jul-22 to Jun-23	Dec-22 to Dec-23
Working Capital MSME	Max 20%	2.51%	0.60%	5.87%	9.21%
Working Capital Non MSME	Max 20%	-6.00%	-4.21%	0.75%	6.51%
Investment MSME	Max 20%	8.46%	7.40%	12.34%	12.04%
Investment Non MSME	Max 20%	-2.84%	11.12%	19.68%	14.83%
Consumer Mortgage	Max 20%	12.76%	16.77%	19.12%	17.11%
Consumer Vehicle	Max 0%	0.97%	15.88%	15.80%	1.54%
Consumer Multipurpose	Max 20%	27.66%	35.74%	39.63%	27.44%
Consumer Others	Max 0%	-16.45%	-21.20%	-12.11%	9.67%
Total	**Max 12%**	**7.83%**	**13.48%**	**18.76%**	**16.44%**

After determining growth by financing product, calculation of projected income is conducted in next step. Operating income for Islamic banks is referred as operating income after revenue sharing. Operating income after revenue sharing is sum of margin income from financing and other margin income, subtracted by margin expense from deposits. Since more than 70% of Islamic bank income was contributed by financing, if assumed that other margin income has zero growth, the projection resulted in 19.19% margin income growth is shown in Table 4.

Table 4. Projection of Annual Operating Income After Revenue Sharing

Indicator (Annual in IDR billion)	2018-2019	Jan-Jun 2021	Projection		Annual Growth
			2022	2023	
Op. income financing (margin income)	52,356	56,424	62,406	69,854	11.27%
Revenue sharing (margin expense) *	27,388	24,496	24,496	24,496	0.00%
Op. income after revenue sharing	**24,968**	**31,928**	**37,910**	**45,358**	**19.19%**

*) assumed constant

There is another opportunity to increase operating income after revenue sharing, i.e., lowering revenue sharing for deposits customers. Since Bank Indonesia's 7-day repo rate (BI7DRR) has decreased by 0.25% and IDR deposit insurance rate has decreased by 0.50% during first half of 2021 (LPS, 2021), operating income could be even better if this strategy is implemented. If assumed that fee-based income, other income, and operating expenses follows total banking industry growth, calculation of profit/loss after pandemic results in Table 5, with significant profit growth of 46.37%. In terms of Return on Assets (ROA), with assumption that

assets growth is the same as financing growth, i.e., 11.25%, the model will result in ROA of 2.81% in 2022 and 3.55% in 2023.

Tabel 5. Projection of Annual Profit/Loss

Indicator (Annual in IDR billion)	2018-2019	Jan-Jun 2021	Projection		Annual Growth
			2022	2023	
Operating income after revenue sharing	24,968	31,928	37,910	45,358	19.19%
Fee-based and other income *	9,018	13,472	13,472	13,472	0.00%
Operating expenses *	26,033	33,624	33,624	33,624	0.00%
Total profit	**7,953**	**11,776**	**17,758**	**25,206**	**46.37%**

*) assumed constant

Based on the financial analysis, it can be concluded that financing products that are expected to continue to grow are: Working Capital MSME; Working Capital Non MSME; Investment MSME; Investment Non MSME; Consumer Mortgage; and Consumer Multipurpose. It is also important to note that Consumer Vehicles and Consumer Others product have potential to grow but needs to be taken care, based on risk constraints.

6. CONCLUSIONS

Based on the time-series forecasting and financial analysis conducted, recommendations for Islamic banks' financing strategy came up, i.e., to focus on the right type of products, i.e., working capital financing and investment for MSMEs and non MSMEs, and consumer financing Mortgage and Multipurpose products. The strategic recommendations will result in asset growth of at least 12%, profit growth of 46.37%, and return on assets (ROA) of 2.81% in 2022, much higher than the current total ROA of commercial banks of 1.87%, with margin expense, other income, and operating expenses were assumed constant. Even though not covered in this study, from management point of view, Islamic banks need to minimize margin expense from deposits by adjusting to the decreasing trend in the benchmark interest rate and to follow strategy of Indonesian commercial banks to conduct efficiency programs for operational cost savings. Since this study only covers financing strategy for Indonesian Islamic banking industry with COVID-19 pandemic impact, more comprehensive study for Islamic banking strategy is expected. Economic changes including impact of interest rate, digitalization trend in the banking industry, spin off and conversions from conventional banks to Islamic banks, and other recent aspects in banking may be considered to get broader insights of the Islamic banking strategy.

REFERENCES

Adhikari, Ratnadip, Agrawal, R. (2013). An Introductory Study on Time-series Modeling and Forecasting. 10.13140/2.1.2771.8084.

Andrei, D. M., Andrei, L. C. (2014). Vector Error Correction Model in Explaining the Association of Some Macroeconomic Variables in Romania. 2nd International Conference 'Economic Scientific Research - Theoretical, Empirical and Practical Approaches', ESPERA 2014, 13-14 November 2014, Bucharest, Romania.

Athiyarath, S., Paul, M., Krishnaswamy, S. (2020). A Comparative Study and Analysis of Time Series Forecasting Techniques. SN COMPUT. SCI. 1, 175, 2020. https://doi.org/10.1007/s42979-020-00180-5).

Azhari, D.R., Fasa, M.I., Junaedi, D., Arsyad, M.R. (2020). Impact of Covid-19 on Financing Islamic Bank in Indonesia. Jurnal Kajian Ekonomi dan Bisnis Islam, Vol 3 No 2 (2020) 144-155 P-ISSN 2620-295 E-ISSN 2747-0490 DOI: 1047467/elmal.v3i1.507.

Badan Pusat Statistik (BPS): Website (2022). Publications. Badan Pusat Statistik: https://www.bps.go.id.

Bank Indonesia (BI): Website (2022). Press Release. Bank Indonesia: https://www.bi.go.id.

Gujarati, D.N. (2003). Basic Econometrics: Fourth Edition. McGraw-Hill Higher Education. International Edition. ISBN 0-07-112342-3.

Heffernan, Shelagh. (2005). Modern Banking. John Wiley & Sons Ltd. ISBN 0-470-09500-8.

Hendayanti, N.N.P., Nurhidayati, M. (2018). Permodelan Inflasi, Uang Beredar, dan Nilai Tukar Rupiah dengan VARX. Seminar Nasional Sistem Informasi dan Teknologi Informasi, SENSITEK, Juli 2018.

Iswanaji, C. (2018). Challenges Inhibiting Islamic banking Growth in Indonesia using the Analytical Hierarchy Process. Journal of Islamic Economics Lariba (2018). vol. 4, iss 2, pp. 97-107. DOI : 10.20885/jielariba.vol4.iss2.art4.

Lembaga Penjamin Simpanan (LPS): Website. (2022). Deposit Insurance Rates. Lembaga Penjamin Simpanan: https://www.lps.go.id.

Luetkepohl, Helmut. (2011). Vector Autoregressive Models, EUI ECO, 2011/30. http://hdl.handle.net/1814/19354.

Luqmanulhakim, Rulindo, R. Anwar, S. (2021). Stability Analysis of Islamic Banking in Indonesia, Malaysia, and Pakistan. IQTISHADUNA: Jurnal Ilmiah Ekonomi Kita, Vol.10, No.1: 125-143, June 2021. https://doi.org/10.46367/iqtishaduna.v10i1.326.

Otoritas Jasa Keuangan (OJK). (2021). The Indonesian Financial Services Sector Master Plan 2021-2025. https://ojk.go.id/id/berita-dan-kegiatan/publikasi.

Otoritas Jasa Keuangan (OJK): Website (2021). Indonesian Banking Statistics and Indonesian Islamic Banking Statistics. Otoritas Jasa Keuangan: https://www.ojk.go.id.

Rifqi, M., Condro, T. (2019). Analysis of Islamic Banking Financial Performance Before, During and After Global Financial Crisis. Jurnal Ekonomi dan Keuangan Islam, [S.l.], p. 80-86, july 2019. ISSN 2614-6908.

Sohibien, G.P.D.; Laome, L.; Choiruddin, A.; Kuswanto, H. (2022). COVID-19 Pandemic's Impact on Return on Asset and Financing of Islamic Commercial Banks: Evidence from Indonesia. Sustainability 2022, 14, 1128. https://doi.org/10.3390/su14031128.

Warsono, Edwin, R., Wamiliana, W., Mustofa, U. (2019). Vector Autoregressive with Exogenous Variable Model and Its Application in Modeling and Forecasting Energy Data: Case Study PTBA and HRUM Energy. International Journal on Energy Economics and Policy, 9(2), 390-398, DOI: https://doi.org/10.32479/ijeep.7223, January 2019.

Widarjono, A. (2018). Estimating Profitability of Islamic Banking in Indonesia. Journal of Finance and Banking, ISSN 1410-8089, Online 2443-2687. https://doi.org/10.26905/jkdp.v22i3.2197.

Winarno, S., Usman, M., Warsono, Kurniasari, D, and Widiarti. (2021). Application of Vector Error Correction Model (VECM) and Impulse Response Function for Daily Stock Prices. Journal of Physics: Conference Series: 1751 012016.

ANALYSIS OF TECHNOLOGY COMMERCIALIZATION IN INDONESIAN UNIVERSITIES

AN INITIAL STUDY: CATALYST MERAH PUTIH INSTITUT TEKNOLOGI BANDUNG

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ABSTRACT

The process approach is an attempt to see how the commercialization of technology is successful or not carried out by a university. This study explores the technology commercialization process at Institut Teknologi Bandung (ITB) Indonesia by focusing on the agents involved in it using an actor networks perspective. This research takes a sample from commercializing a specific research output technology, catalyst Merah-Putih. Using the Actor-Network Theory (ANT) approach, we found several interesting findings from exploring how the configuration of the researcher in commercializing their technology from a laboratory to the market. From the analysis, we found that the durability of the strong relationship between the researcher and the catalyst occurred before the establishment of a spin-off company, namely PT Katalis Sinergi Indonesia (KSI). Since the beginning of research in catalyst technology, the researcher has actively associated with industrial persons, so the catalyst development path followed the researcher's will. Since the existence of PT KSI, the agencies have formed their association (grouping) with their respective interests. Actions here are taken seriously from the ITB researcher's interest into the company shareholders' interest. It makes a change of vision in the commercialization of the products. We use a qualitative study with grounded theory principal to conclude that conclusion.

Keywords: Technology commercialization, spin-off, catalyst merah putih, Institut Teknologi Bandung, Actor-Network Theory (ANT)

1. INTRODUCTION

The university has taken on a new mission by contributing to economic and social development (Schmitz et al., 2017) since the Bayh-Dole Act of 1980 in America. The university,

which is an essential source of technological innovation (Shah & Pahnke, 2014), has expanded its function from just a teaching and research function (Etzkowitz, 2004) to an entrepreneurial mission by becoming an entrepreneurial university (Etzkowitz et al., 2000; Etzkowitz, 2004). This mission allows the university to actively support entrepreneurial activities such as technology commercialization (Rasmussen et al., 2006).

The commercialization of technology can be interpreted as an effort to bring innovative ideas and inventions to the market where they have the potential to be a source of higher education income, create research links between academia and industry, and increase regional economic growth and development (Bradley et al., 2013). Although the process is associated with a black box (Bradley et al., 2013) due to its complexity, commercialization is a critical stage of the innovation process because it is risky and high cost (Chiesa & Flattini, 2011). Meanwhile, evaluation of the success of technology commercialization is a question that continues to be asked by academics, managers, and policymakers (Dziallas & Blind, 2019).

The process approach is an attempt to see how the commercialization of technology is successful or not carried out by a university. This study explores the commercialization process of technology at ITB by taking one case, namely the red and white catalyst of Institut Teknologi Bandung (ITB), by focusing on the agents involved in it. We will show how these agent steps can shape the configuration. This study aims to explore the influence of human and non-human agencies on the success of technology commercialization in universities.

The research objectives can be reduced to the following questions: (1) how is the influence of human and non-human agents in the commercialization of red and white catalysts at ITB? (2) how are the interactions between these agencies intertwined to support the commercialization of red and white catalysts? Moreover, (3) what innovation lessons can be drawn from the commercialization of red and white catalysts at ITB?

2. LITERATURE REVIEW

How is process of technology commercialization in university?

Commercialization activities in universities are generally divided into formal and informal mechanisms. The formal mechanism in technology commercialization is the technology transfer process through formal intermediaries (Link et al., 2007), such as through the office of University Technology Transfer (TTO). This formal mechanism ensures that commercialization efforts are regulated by the university so that optimal financial benefits can be obtained (Link et al., 2007). In comparison, the informal mechanism is an effort to facilitate the flow of technological knowledge through informal communication processes, such as technical assistance, consultation, and collaborative research (Link et al., 2007). This mechanism bypasses the UTTO process by interacting directly with industry without the rigid UTTO bureaucracy (Bradley, 2013).

Commercialization at universities can take the form of licensing, the creation of spin-off companies, and the transfer of know-how. A *license* is a right granted by a patent owner that allows another party to act under all or part of the owner's rights, usually under a written license agreement. This license agreement specifically describes the rights and responsibilities associated with using and exploiting intellectual property. Meanwhile, the formation of spin-off companies involves academics who participate in research and development programs that create technologies (Brown, 1985) that can be derived from university patents (Rasmussen et al., 2006). The founder of this company is very likely the inventor of the new technology (O'Shea et al., 2008).

Absorption activities in universities are managed by the University Technology Transfer Office (UTTO) in the form of patents, licenses, and incubation (Etzkowitz, 2008). In general, the function of UTTO is to facilitate the transfer of technology from universities to the market or industry. In terms of technology, UTTO plays a role in assisting the patent process in the academic field, both in terms of increasing the number of patents and efficiency in generating new patents (Rothaermel et al., 2007) as well as facilitating technology transfer through licensing to existing or new companies (Siegel et al., 2007). al., 2007). Etzkowitz (2008) revealed that the role of UTTO is to encourage the release of research results from universities and to find its place in the market. The existence of this intermediary organization is significant in increasing the productivity of university patents (Temel et al., 2021).

Apart from UTTO, incubators also play a role in facilitating the commercialization of technology and entrepreneurial activities (McAdam et al., 2006). University Business Incubator (UBI) is an incubator established by universities to provide office space, equipment, mentoring services, and other administrative support to assist in the formation of new companies (Wonglimpiyarat, 2016). Incubators are also innovation centers, science parks, and technology centers.

The commercialization process is fully described by Bradley et al. (2013), who call it an alternative view by considering formal and informal technology commercialization mechanisms. Bradley (2013) criticized the previous linear technological commercialization model, which oversimplifies the process, composition, one-size-fits-all approach, and emphasis on patents. This mechanism is seen as failing to explain the informal mechanism of technology transfer, failing to state the impact of organizational culture, and failing to represent the university reward system in a model.

How are the challenges (controversies) of technology commercialization in university?

Khalil Zadeh et al. (2017) mention weaknesses in the commercialization process which further include the challenges of the business environment, weak organizational structure, inefficient project management, ineffective cooperation with the non-government sector, failure to collaborate with stakeholders, and political conflicts of interest as the leading causes of technology commercialization difficulties. Another challenge is the need for solid financial support (Lee & Gaertner, 1994).

In universities, the commercialization of technology poses challenges as well as traditional activities that university scientists will face (Rasmussen et al., 2006) as well as efforts to determine appropriate business models (Pries & Guild, 2007). Furthermore, Dorf and Worthington (1990) revealed that this commercialization process would be complicated if interaction with external networks such as industry, market, and customers is lacking.

On the corporate side, as revealed by Hertzfeld et al. (2006), companies show their most significant difficulties when cooperating with UTTO on intellectual property issues. Disappointed by the inexperience of the TTO staff, their general lack of business knowledge, and their tendency to increase the commercial potential of patents, the company finally made efforts to streamline the flow of commercialization through informal mechanisms by establishing direct contact with university inventors.

According to Alibekova et al. (2019), the main barriers to cooperation between universities and industry are lack of resources to build university-industry relations, lack of time due to high teaching load, poor qualification of technology transfer managers and lack of networking with the industry. Nerkar and Shane (2002) revealed that these commercialization constraints include a lack of understanding of the technology commercialization process, how to assess the

commercialization potential of the technology, the possibilities of the model and the factors that influence the decision to choose the model. The lack of support from the Government is also an obstacle to this commercialization (Nsanzumuhire et al., 2021).

Another challenge developing countries such as Indonesia faces is that they still rely on foreign direct investment and R&D (Dhewanto & Umam, 2009). Most foreign companies in Indonesia only develop factories or set up distribution offices, whereas few of them develop R&D in Indonesia. At the same time, few Indonesian entrepreneurs are developing technology-based companies. Other challenges Indonesia faces are the small available R&D budget and the unsuccessful collaboration between universities and industry (Dhewanto & Umam, 2009).

3. METHODOLOGY

Data Collection

This study is an exploratory study using a single case study, namely the commercialization of catalysts Merah-Putih at Institut Teknologi Bandung (ITB). Primary data was obtained through open interviews with resource persons related to the commercialization of catalysts Merah-Putih. Meanwhile, secondary data from online media is used to complement data analysis.

Tabel 1. List of the interviewee

Affiliation	Position	Media	Date of the interview
RII ITB	Director of RII	Zoom	13 April 2022
Lab TRKK	Head of researcher catalyst	Zoom	13 April 2022

Data Analysis

This study uses inductive reasoning to create a theoretical framework. The reasoning allows this research to be more grounded in theory. Eisenhardt (1989) describes in detail the stages of building a theory in the form of a case study approach, which consists of eight stages starting from asking research questions to concluding (1) starting, (2) selecting cases, (3) developing instruments and protocols, (4) entering the field, (5) analyzing data, (6) forming hypotheses, (7) opening the literature, and (8) reaching closure.

Eisenhardt (1989) identified data analysis as "the heart of theory building from case studies" but also "the most difficult and least codified part of the process." Therefore, he identified two steps in analyzing case study data: (1) in-case analysis and (b) looking for patterns across cases. It depends on what perspective is used to get findings from case study analysis that includes open coding, axial coding, and selective coding. Actor-Network Theory (ANT) identifies and tracks networks by "following actors" (Latour 1996:10) and investigating the main cast suggesting new actors. It means that it is primarily the actors, not the researchers, who determine the direction of the investigation.

Analysis Tool using ANT

Actor-Network Theory (ANT) is not a theory but rather an ontological and methodological orientation, a set of conceptual tools for thinking or even a sense of a way of seeing. ANT adopts an anti-essentialist position in which it denies that there are essential differences between humans and non-humans. ANT regards social and technical determinism as flawed and proposes a socio-technical account (Callon & Latour, 1981; Latour, 1986; Law & Callon, 1988) in which social and technical positions are privileged. ANT refers to the conception of agent (individual) determinism

in which agents with cognitive abilities and independence will exist objectively, regardless of structural influences, through interactions between agents, in pairs and repeatedly.

An actor-network is an entity formed through a fabric of associations - an assembly of human and non-human beings. A network of actors is an entity that moves and thus leaves a trail. To quote Callon (1986b), the translation process in ANT has four aspects or 'moments,' namely:

1. Problematization, where the actor seeks to define the nature of the problem and the roles of other actors to fit the proposed solution.
2. Interest, is a set of processes that seek to impose identities and roles, defined in problematization, on other actors.
3. Registration will then lead to the establishment of a stable alliance network.
4. Mobilization occurs when a proposed solution gains wider acceptance and an even wider network of absent entities is created (Grint and Woolgar, 1997) through several actors acting as spokespersons for others.

Innovation translation will concentrate on issues related to network formation. ANT will investigate the human and non-human alliances and networks built by small businesses, their customers, technology, and other actors involved in implementation. Central to this actor-network approach is a translation (Law, 1992), which can be defined as: “how one entity assigns a role to another” (Singleton & Michael, 1993: 229).

Latour (2007) explains that the actor in ANT is described as everything, both material and immaterial, that changes the situation by making a difference. The task of ANT is to mobilize actors as a mediating network. ANT recognizes that human and non-human participants have 'agency,' which can influence the situation. Meanwhile, the network is a concept, not something out there but a tool to help describe something, not what is being described. It is a trail left by several moving agents. To trace a network of actors, we must add up the many traces left by those actors.

4. RESULTS AND ANALYSIS

Process of Technology Commercialization in ITB

Institut Teknologi Bandung (ITB) is the oldest engineering college in Indonesia, established in 1920, which has 12 faculties, 128 study programs, and 111 expertise groups (KK) with national and international reputations. In 2019, ITB received the best national university award from the Ministry of Research, Technology and Higher Education (Ristekdikti). In 2015, ITB declared itself as a campus towards an entrepreneurial university marked by optimizing the role of LPIK ITB and Rekacipta Innovation in helping ITB academics commercialize the technology.

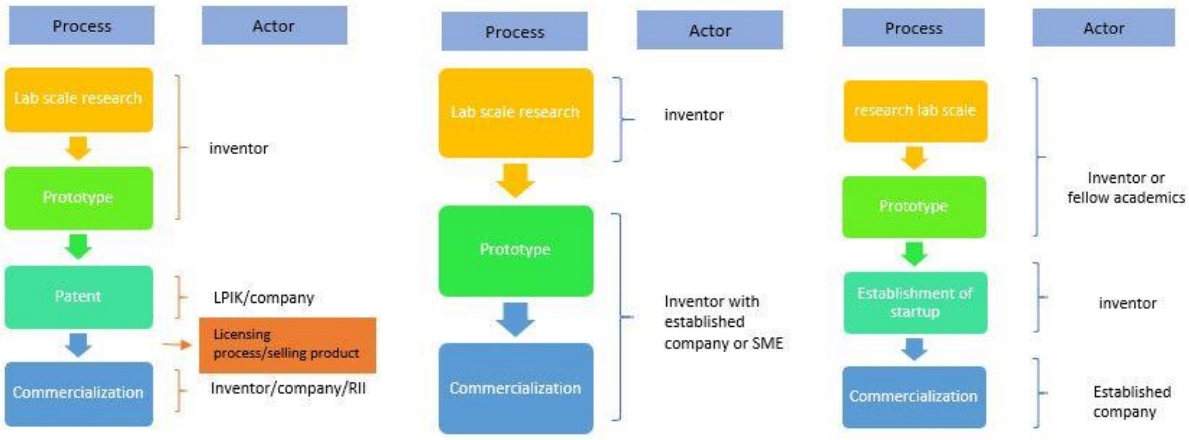


Figure 1. Process of technology commercialization in ITB (licensing process (left), collaboration with company (middle) and establishment new company (right) (Prasetio dan Dzakiy, 2019)

LPIK ITB was established in 2010 to encourage the utilization of ITB research results through innovation and entrepreneurship. Meanwhile PT. Rekacipta Innovation (RII) was established in 2016 to accommodate the profit side of technology commercialization. Initially, it was established to market startups to the right market and facilitate the meeting of startups with capital owners while also carrying out the licensing process for established companies.

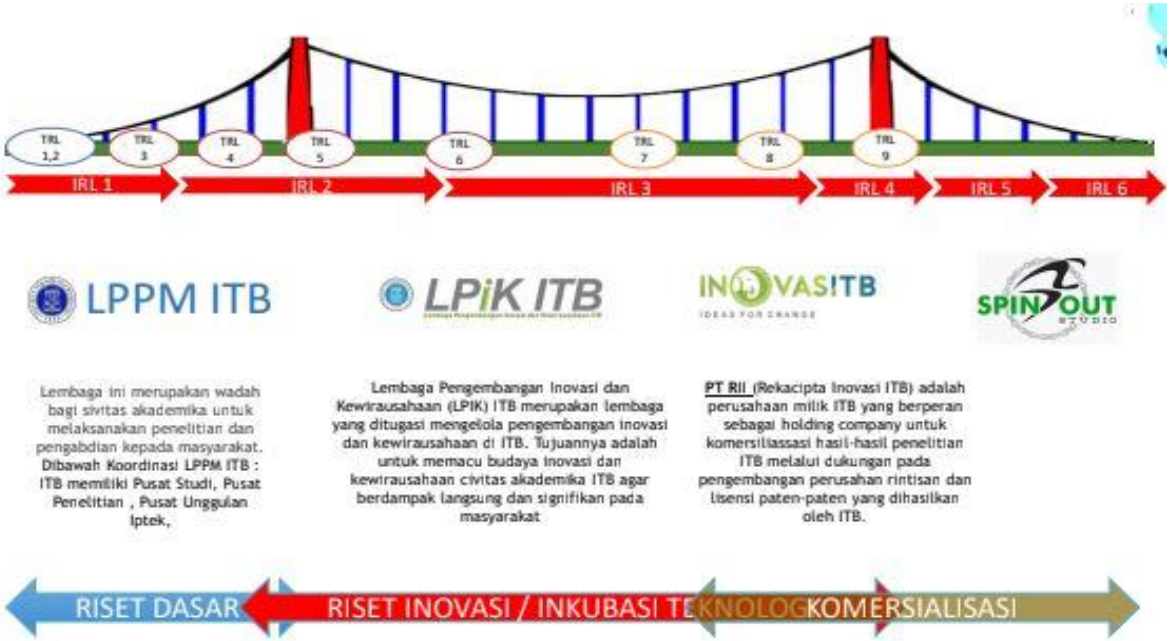


Figure 2. Ecosystem of innovation in ITB (LPIK ITB, 2020)

Commercialization Process of Catalyst Merah Putih

A catalyst is a substance to facilitates a chemical reaction. In the chemical industry, catalysts are used to speed up reactions to separate certain compounds for a specific purpose, where nearly 90 percent of the chemical industry uses catalysts. The catalyst developed in the ITB

TRK lab focuses on catalysts for processing hydrocarbon compounds such as petroleum and zeolite catalysts that convert cooking oil into fuels such as petroleum.

Research on catalysts stems from Mr. S's study in France in 1976, where he studied hydrocarbon catalysts at that time. After returning from France, he continued his research in the same field and expanded to zeolite catalysts. In 1996, he met with Mr. K from Pupuk Iskandar Muda (PIM), who then asked him to do research in the field of H2S absorbance, where in 2009, the factory was built at PIM. This collaboration catalyst with PIM is named PIMITB1. In 2003, research on hydrotreating catalysts was conducted with Lemigas, and two years later, in 2005, Mr. S met with Mr. Sr from Pertamina. This collaboration with Indonesian oil and gas companies continued collaborative research from 2005-2012. In 2021, PT Katalis Sinergi Indonesia was established as a catalyst factory in collaboration with ITB, Pertamina Lubricants, and Pupuk Kujang.

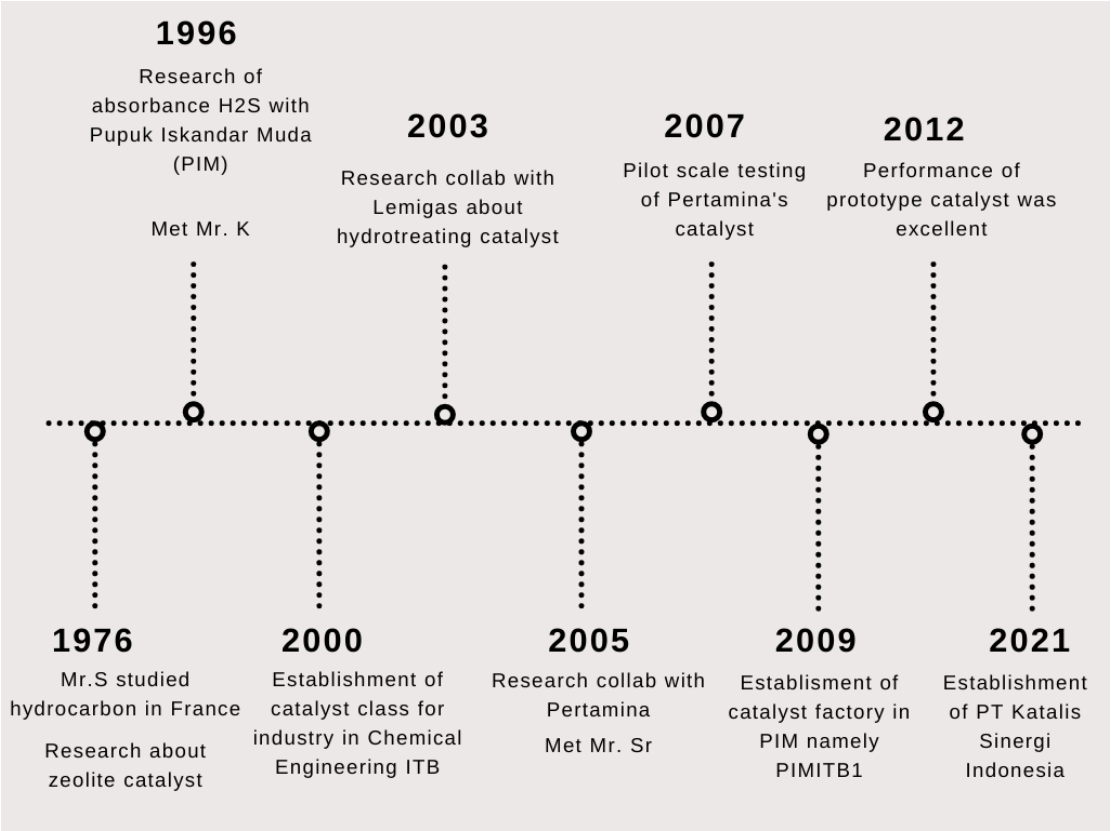


Figure 3. Timeline of development of commercialization of catalyst from ITB

ANALYSIS

The Effect of Human and Non-Human Agency in Commercializing Catalyst Merah Putih ITB

The commercialization of catalysts from TRKK Chemical Engineering ITB cannot be separated from the Mr. S factor as a human agency. Since graduating from his doctoral program in France and being active as a lecturer at ITB, Mr. S has been conducting research in the field of

catalysts. He always associates his research with the industrial world, especially in the chemical field where catalysts are necessary. Mr. S consistently establishes associations with industry players by utilizing his networks, such as ITB Chemical Engineering alumni and former students.

Mr. S actively establishes associations by utilizing a particular class for industrial people held at the Chemical Engineering Study Program, ITB. From this class, he markets catalyst products so that the catalyst is used in industry. This step was successful when Medco used the catalyst from its collaboration with Pupuk Iskandar Muda (PIM). Medco's channel was obtained through the class he taught. An unusual networking step he took was when he got a collaboration with Pupuk Iskandar Muda (PIM) and then Pertamina. Mr. S got the trust to produce catalysts with the two companies after the successful "blusukan" step into the industry after getting essential people in the company to have the same vision as Mr. S. "… Merah-Putih in their chest," said Mr. S.

Mr. S is one of several active lecturers at TRKK who researches catalysts. However, he is the most visible figure or spokesperson for TRKK ITB. It makes Mr. S and the catalyst inseparable. He seemed to be the representative of the ITB catalyst researcher.

Besides the critical role of human agency, namely Mr. S, the role of the non-human agency is also inseparable here. Catalysts are non-human agencies that play a significant role. Catalysts play an essential role in the functions needed by the chemical industry, and their existence is a monopoly of large companies. It made the domestic industry dependent on foreign catalyst companies and unable to be economically empowered because of this monopolistic condition. This condition motivated him to develop a catalyst for Mr. S and his team. The catalyst becomes the agency that influences the human agency (Mr. S) to develop the catalyst from his research to an industrial scale.

Interaction Between Agency in Supporting Commercialization

The interaction between actors in the catalyst commercialization process can be divided into two phases. The first phase is the pre-establishment phase of PT Katalis Sinergi Indonesia (KSI), and the second phase is the post-establishment phase of PT KSI (See Figures 4 and 5). In the first phase, Mr. S's relationship with the catalyst was very intimate, which can be seen from 1976 to the 2010s; several types of catalysts were produced by Mr. S and the TRKK ITB team, which included hydrotreating catalysts, zeolite, H2S, and hydrocarbons. The production of these different catalysts was following the demands of the industry at that time. The production of these different catalysts indicates that Mr. S carries out grouping. In this phase, Mr. S maintained his influence on the production of catalysts even though, at that time, he had not yet received a spotlight in public.

It was different in the second phase when PT KSI was formed. Here Mr. S gets excellent exposure, but instead of being a catalyst expert, he is even more imaged by the media as a biofuel expert, wildly after he and his team succeeded in making a catalyst for the conversion of palm oil into fuel. Catalyst experts and biofuels are two different things. It happened because of the agency that created the grouping whose influence was mutually attracting the catalyst, initially developed by Mr. S. This grouping includes a consortium of PT KSI. This elite includes the Minister of Energy and Mineral Resources, a research group at TRKK, and a catalyst for intellectual property rights.

The interaction between Mr. S and the catalyst are two agencies whose actions are overtaken, thus creating a stable relationship. This relationship is established through the footprint formed by Mr. S by directly assisting the industry to produce catalysts independently. This durability is reflected in the various vaccine variants created in collaboration with various parties.

Here, Mr. S's mission to serve the domestic industry will be fulfilled as a catalyst. The durability of this relationship was disturbed when the interests of various agents in the production of catalysts led to the establishment of PT Katalis Sinergi Indonesia (KSI), which made Mr. S unable to directly become an agent that actively controls the production of catalysts for the benefit of the domestic industry. Here, the action is overtaken by PT KSI, consisting of Directors from Pupuk Kujang, Pertamina, and ITB through PT Rekacipta Innovation (RII). Other actions are overtaken by other parties, such as the media, which portrays Mr. S as a biofuel expert.

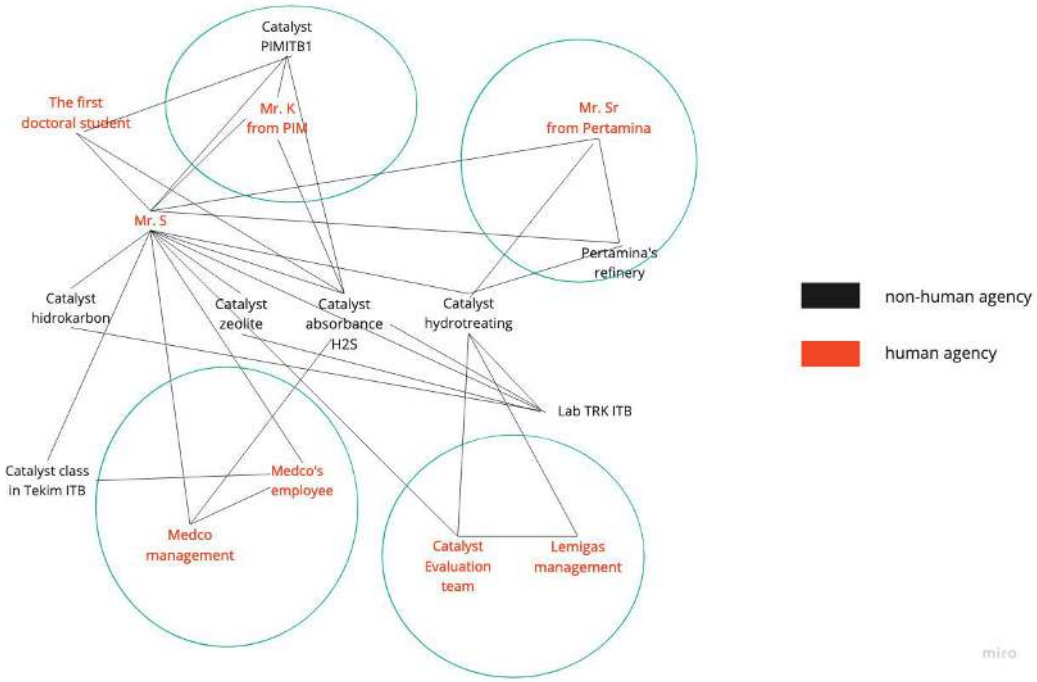


Figure 4. Association before establishment of PT Katalis Sinergi Indonesia (KSI)

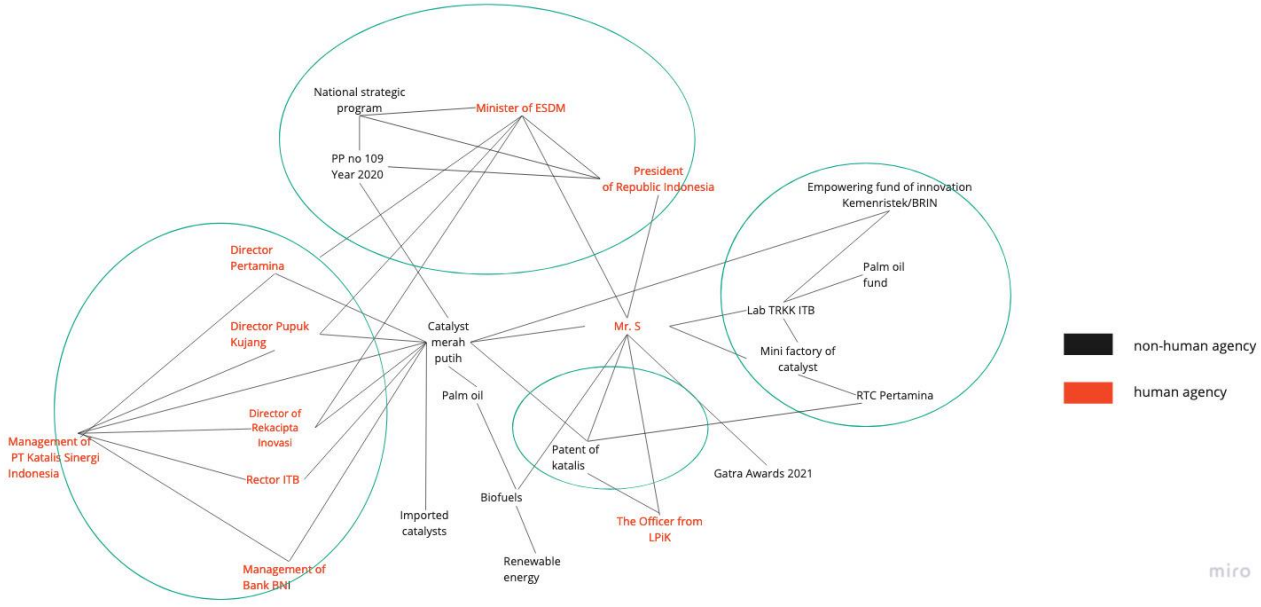


Figure 5. Association after establishment of PT Katalis Sinergi Indonesia (KSI)

6. CONCLUSIONS

The commercialization of technology in universities can be understood by exploring the network of actors from a successful case example. In the case of the red and white catalyst of ITB, the data obtained through interviews with the informants involved and secondary data, we can do analysis through Actor-Network Theory (ANT) by creating a socio-technical network using graph techniques. From this step, several exciting findings can be found, namely how a researcher commercializes the technology produced from his lab, which can be divided into two phases, namely the phase before the establishment of PT Katalis Sinergi Indonesia (KSI) and the phase after the establishment of PT KSI. The analysis found that the durability of the relationship between the researcher and the strong catalyst occurred before the existence of PT KSI because, since the existence of PT KSI, the agencies formed their association (grouping) with their respective interests. Here, the action is overtaken continuously until Mr. S's role as the primary catalyst researcher is not as strong as before PT KSI, which made his vision of juxtaposing his production catalysts with domestic industry even more distant because, in the end, the interests of the Directors of PT KSI will be dominant.

Some engaging lessons can be drawn from the case of the commercialization of ITB's catalyst Merah-Putih technology with the ANT approach. First is the importance of "blusukan" to find the innovation gap. Awareness of the importance of technology to be commercialized for researchers needs to actively campaign in the industry where researchers "pick up the ball" to potential technology users to create awareness for the industry. This association is essential so that the commercialization of specific technologies is a shared desire between developers and technology users. Second, the role of technology itself is significant, especially understanding the usefulness of this technology for solving a problem. The placement of technology in this function encourages the use-value of this technology to be greater so that the potential for using this technology in the future will be even more tremendous.

REFERENCES

Bradley, S. R., Hayter, C. S., & Link, A. N. (2013). Models and methods of university technology transfer. *Foundations and Trends in Entrepreneurship*, *9*(6), 571–650. https://doi.org/10.1561/0300000048

Dhewanto, W., & Umam, K. K. (n.d.). *Technology Commercialisation in Indonesia: Current Condition and Its Challenges*. www.sbm.itb.ac.id/ajtm

Dziallas, M., & Blind, K. (2019). Innovation indicators throughout the innovation process: An extensive literature analysis. In *Technovation* (Vols. 80–81, pp. 3–29). Elsevier Ltd. https://doi.org/10.1016/j.technovation.2018.05.005

Etzkowitz, H. (2004). The evolution of the entrepreneurial university. *International Journal of Technology and Globalisation*, *1*(1), 64–77. https://doi.org/10.1504/IJTG.2004.004551

Etzkowitz, H., Webster, A., Gebhardt, C., Regina, B., & Terra, C. (2000). The future of the university and the university of the future: evolution of ivory tower to entrepreneurial paradigm. In *Research Policy* (Vol. 29). www.elsevier.nlrlocatereconbase

Latour, B. (2007). *Reassembling the Social: An Introduction to Actor-Network-Theory (Clarendon Lectures in Management Studies)*.

Link, A. N., Siegel, D. S., & Bozeman, B. (2007). An empirical analysis of the propensity of academics to engage in informal university technology transfer. *Industrial and Corporate Change*, *16*(4), 641–655. https://doi.org/10.1093/icc/dtm020

Nsanzumuhire, S. U., Groot, W., Cabus, S. J., & Bizimana, B. (2021). Understanding the extent and nature of academia-industry interactions in Rwanda. *Technological Forecasting and Social Change*, *170*. https://doi.org/10.1016/j.techfore.2021.120913

O'Shea, R. P., Chugh, H., & Allen, T. J. (2008). Determinants and consequences of university spinoff activity: A conceptual framework. *Journal of Technology Transfer*, *33*(6), 653–666. https://doi.org/10.1007/s10961-007-9060-0

Pries, F., & Guild, P. (n.d.). *Commercial exploitation of new technologies arising from university research: start-ups and markets for technology*.

Rasmussen, E., Moen, Ø., & Gulbrandsen, M. (2006). Initiatives to promote commercialization of university knowledge. *Technovation*, *26*(4), 518–533. https://doi.org/10.1016/j.technovation.2004.11.005

Rothaermel, F. T., Agung, S. D., & Jiang, L. (2007). University entrepreneurship: A taxonomy of the literature. *Industrial and Corporate Change*, *16*(4), 691–791. https://doi.org/10.1093/icc/dtm023

Schmitz, A., Urbano, D., Dandolini, G. A., de Souza, J. A., & Guerrero, M. (2017). Innovation and entrepreneurship in the academic setting: a systematic literature review. *International Entrepreneurship and Management Journal*, *13*(2), 369–395. https://doi.org/10.1007/s11365-016-0401-z

Shah, S. K., & Pahnke, E. C. (2014). Parting the ivory curtain: Understanding how universities support a diverse set of startups. *Journal of Technology Transfer*, *39*(5), 780–792. https://doi.org/10.1007/s10961-014-9336-0

Siegel, D. S., Veugelers, R., & Wright, M. (2007). Technology transfer offices and commercialization of university intellectual property: Performance and policy implications. *Oxford Review of Economic Policy*, *23*(4), 640–660. https://doi.org/10.1093/oxrep/grm036

Temel, S., Dabi, M., Murat Ar, I., Howells, J., Mert, A., & Baris Yesilay, R. (2021). Exploring the relationship between university innovation intermediaries and patenting performance. *Technology in Society*, *66*, 101665. https://doi.org/10.1016/j.techsoc.2021.101665

Wonglimpiyarat, J. (2016). The innovation incubator, University business incubator and technology transfer strategy: The case of Thailand. *Technology in Society*, *46*, 18–27. https://doi.org/10.1016/j.techsoc.2016.04.002

EVALUATION OF POWER PLANT OPERATION AND MAINTENANCE (O&M) SERVICES USING GAP ANALYSIS AND LEAN SMART MAINTENANCE (LSM)

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ABSTRACT

Consumer satisfaction significantly influenced competition in the market. The SERVQUAL Gap Analysis is used to determine the work according to the contract is the priority characteristic for improvement. Because of recurrent damage to the boiler wall tube, the Equivalent Availability Factor (EAF) and Equivalent Forced Outage Rate (EFOR) have not performed as expected. Using the Lean Smart Maintenance methodology, the maintenance process is examined. Poor maintenance accounts for 41.2% of the total waste, and ineffective maintenance for 30.1%. The risks that are determined to be under/overmaintained are all risks from boiler wall tube, according to the asset prioritization matrix, which compares the values of the Risk Priority Number (RPN) and Direct Maintenance Cost (DMC). After evaluating, it is the design/material of the wall tube whose quality is minimalist that causes repeated damage. As a result, a replacement plan for the wall tube is suggested, one of the investment fund comes from the transfer of over maintenance cost risk. After repair, the Rate of Maintenance Investment (ROMI) climbed from 8.2% to 19.61%.

Keywords: *Asset Prioritization Matrix,* EAF, EFOR*, Lean Smart Maintenance, SERVQUAL*

1. INTRODUCTION

A Business-to-Business organization called The Power Plant Maintenance Company (PPMC) has been operating since 2001. O&M Services have contributed IDR 1.3 trillion, or 81% of the company's revenue, according to the PPMC Annual Performance Report for 2020. However, according to the Customer Satisfaction Index (CSI), O&M service satisfaction in 2018-2020 is always below the Key Performance Indicator (KPI) determined by the Marketing Section through the Service Level Agreement (SLA), which is 85%. CSI assessment is influenced by 5 attributes that have the greatest weight on the reliability (21.1%). PLTU Unit 3 has the lowest CSI compared to other units, which is 67.29%. Based on the interviews obtained several things that contribute to dissatisfaction. One of them is the performance of the Equivalent Availability Factor (EAF) and Equivalent Forced Outage Rate (EFOR) which have not reached the targets listed in Tables 1 and 2. Each hour unit when the generator is ready to operate for a certain period is called EAF, the higher the value, the better. While EFOR is the level of outage in each operating period, the smaller the value, the better.

Table 1. Recap of EAF Value of Each Generating Unit in 2020 (Annual Report PPMC, 2020)

***Equivalent Availability Factor* (EAF)**			
Higher Better			
Description	**RKAP 2020**	**Realization of 2020**	**Achievement (%)**
PLTU Unit 1	74,04	79,55	107,43
PLTU Unit 2	73,50	88,52	120,44
PLTU Unit 3	75,00	59,26	79,01

Table 2. Recap of EFOR Value of Each Generating Unit in 2020 (Annual Report PPMC, 2020)

***Equivalent Forced Outage Rate* (EFOR)**			
Lower Better			
Description	**RKAP 2020**	**Realization of 2020**	**Achievement (%)**
PLTU Unit 1	9,06	4,07	155,11
PLTU Unit 2	9,53	2,30	175,85
PLTU Unit 3	11,96	29,15	0,00

The data suggests that the maintenance method is not sufficiently effective and efficient. Hubert Biedermann invented Lean Smart Maintenance (LSM) in 2016, which combines Lean and Smart Maintenance. LSM not only emphasizes waste reduction but also illustrates the efficiency of maintenance. Asset management, cost analysis, risk analysis, and other elements that affect maintenance will all be assessed for efficiency and effectiveness utilizing the LSM approach.

2. LITERATURE REVIEW

2.1 *Service Quality* (SERVQUAL) *Gap Analysis*

Perceived quality refers to the aspect of service that involves the consumer's subjective reaction to an item (Zeithaml & Berry, 1988). It is measurable with SERVQUAL method. Includes the following 5 dimensions (Zeithaml & Berry, 1988):

1. Reliability : capacity to deliver services accurately and consistently in compliance with the agreement.
2. Empathy : consideration and care shown by service providers to customers.
3. Assurance : Know-how, decorum, and the capacity to be believed.
4. Responsiveness : assisting customers and offering prompt service.
5. Tangibility : observable infrastructure, tools, and employee appearance.

The five dimensions consist of several attributes that are assessed in terms of expectations and perceptions, so that gaps or differences in assessment can be obtained. The gap or difference will represent perceived quality (Q) defined by Equation 1. (Zeithaml & Berry, 1988)

$$\mathrm{Q} = \mathrm{E}(Expectation) - \mathrm{P}(Perception) \quad (1)$$

The scoring or points are given using a Likert scale starting from “Very Good” (5) to “V"ry Bad” (") for ea"h attrib"te. Expectations represent the level of importance of an item for customers, the greater the value, the more important it is. Perception assessment is done by looking at the conditions of reality. A positive Q value indicates that customer expectations are met, whereas a negative Q indicates that customer expectations have not been met. The smaller the gap between expectations and perceptions, the better. However, the determination of improvement priority is not only based on the worst gap. By using 4 quadrants Importance-Performance Analysis (IPA) it is known the relationship between the importance and performance of an attribute. The Cartesian Importance-Performance Analysis (IPA) diagram is described in 4 quadrants as shown in Figure 1. The four interpretations are shown in Table 3.



Figure 1. *Quadrant Analysis* (Supranto, 2001)

Table 3. Interpretation of the Four Quadrants Quadrant Analysis (Suprapto, 2006)

Quadrant	Interpretation	Description
1	Main priority	*High Importance, Low Perception* • Important attributes but not as expected. • Performance must be improved.
2	Maintain	*High Importance, High Perception* • Attributes are important and have been fulfilled. • Performance must be maintained.
3	Low priority	*Low Importance, Low Perception* • improvements are considered by assessing how much benefits the customer.
4	Excessive	*Low Importance, High Perception* • The attribute has excessive-performance because customers do not ask for high expectations.

2.2 *Lean Smart Maintenance*

Lean Smart Maintenance is a maintenance philosophy that blends lean and smart to enhance asset management's effectiveness and efficiency. The goal of lean maintenance is to implement maintenance with less waste. Inefficient maintenance, waiting, centralized maintenance, bad inventory management, wasteful motion, inadequate maintenance, ineffective data management, and under-utilization process are wastes in the maintenance process, according to Davies (2002). Identification of waste can be done by mapping the *Value Stream Maintenance Mapping* (VSMM). According to Biedermann (2016), one of the elements affecting maintenance efficiency is how maintenance costs are used. To compare the Direct Maintenance Cost (DMC) with the Critical Damage Value or Risk Priority Number (RPN), a matrix known as the Asset Prioritization Matrix was created. Starting with an analysis of the risk of damage using the Risk Mode and Effects Analysis (RMEA) which will produce the value of the Risk Priority Number (RPN) through Equation 2.

$$RPN = Severity\ x\ Occurence\ x\ Detection \quad (2)$$

Severity is the loss caused by the risk, Occurrence is the frequency of occurrence of the cause of the risk of damage, and Detection of how easy the cause of the risk is detected. RPN will be compared with Direct Maintenance Cost (DMC) which is stated in Equation 3 by Bieser (2018).

$$DMC = Staff\ Cost + Consumable + Maintenance\ System \quad (3)$$

The purpose of this analysis is to reduce costs without increasing risk. Divided into 4 quadrants whose interpretation is explained in Table 4.

Table 4. Interpretation 4 Quadrant Asset Prioritization Portfolio (Biedermann, 2016)

No	Quadrant	Interpretation
1	I	*High Risk, High Cost* Assets are high risk and have a critical cost.
2	II	*Low Risk, High Cost* Assets are not at risk but have high maintenance. There is a possibility of over-maintenance, but don't let it shift to quadrant 1.
3	III	*Low Risk, Low Cost* Assets are 'ot at risk and the maintenance costs ratio is optimal.
4	IV	*High Risk, Low Cost* High-risk assets but low maintenance costs. There is a possibility of under maintenance, it needs to be repaired.

In LSM, the word "smart" refers to efficiency. Dynamic approaches and ongoing improveme"t are"the major points of smart maintenance. RAMS, which stands for reliability, availability, maintainability, and safety, is the focus of the maintenance management philosophy (Biedermann & Kinz, 2016). According to (Bokrantz et al., 2020) Smart Maintenance is an organizational design to manage maintenance by applying digital technology. Consists of four dimensions, (Bokrantz et al., 2020):

1. Making decisions based on data is known as data-driven decision-making (DDD). Utilizing sensors, machine learning, and data storage.
2. Knowledge, skills, abilities, and other attributes (KSAO) of human capital resources (HCR), which are required for upkeep owing to technological changes
3. Cross-functional cooperation between the maintenance and others through internal integration including synchronization, data, information, and knowledge sharing.
4. External Integration is the sharing of data from the machine to several parties for the implementation of machine learning and linking knowledge from resources.

The implementation of smart maintenance has a focus on companies and plants. The impact of implementing smart maintenance is divided into an individual, plant, and firm levels (Bokrantz et al., 2020). These three levels can be measured using Performance Indicators (PI) Lundgren (2020) states that there are 170 PIs that can be used to measure the implementation of smart maintenance.

3. METHODS

The research begins with a field study. Then service quality analysis is carried out by identifying the reliability attribute dimensions, gathering questionnaire data, testing reliability and validity, calculating gap 5, and mapping on a cartesian diagram. The next step is lean assessment, which begins with determining the risk priority number (RPN) associated with the possibility of component damage. Where occurrence 2 = very rarely to 10 = very often, extent of damage 2 = minimum nominal to 10 = maximum nominal, and detection 2 = easy to 10 = difficult. The RPN and Direct Maintenance Cost (DMC) values are used as input for the asset prioritization matrix. Visualization Value Stream Maintenance Mapping (VSMM) is done to see the flow of value and identify waste. The smart assessment calculated Performance Indicator (PI) Lundgren according to the PPMC's vision-mission and KPIs. The results are then analyzed and proposed'improvements. The research method is depicted in Figure 2.

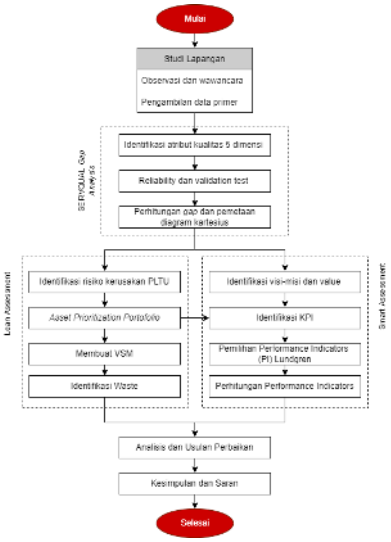


Figure 2. Research Methodology Flowchart

4. RESULTS & DISCUSSION

4.1 SERVQUAL Gap Analysis

From the questionnaire, the average importance and performance of the reliability attributes are summarized in Table 5. Then a Cartesian Importance Performance Analysis (IPA) diagram is formed to group each attribute into 4 quadrants. The results of grouping attributes of reliability are presented in Figure 3 and Table 5.

Table 5. Recapitulation of Average Interest and Performance Score

Code	Reliability Attributes	Importance Level (I)	Performance Level (P)	Quadrant
R1	Readiness of tools	4,11	3,37	III
R2	Readiness of consumable parts	3,86	3,89	IV
R3	Readiness of personnel	4,66	4,17	II
R4	Work according to contract/appointment letter	4,31	4,06	IV
R5	Work result according to contract specifications	4,86	3,76	I
R6	Timeliness of report submission	4,11	3,86	IV
R7	Timeliness BA	4,54	3,77	I
Rata-rata		4,35	3,84	

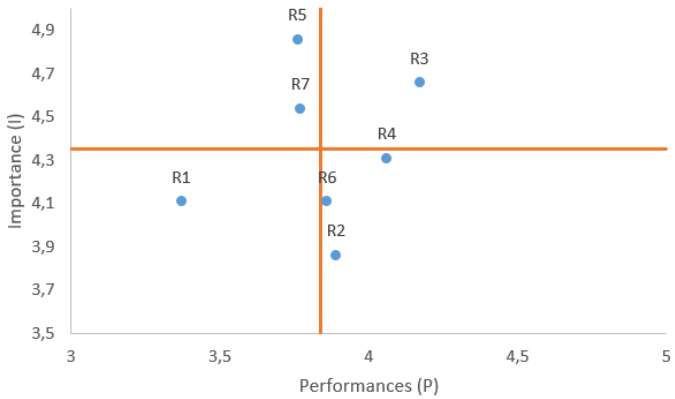


Figure 3. Cartesian Diagram of Importance-Performance Analysis (IPA)

Attributes that must be prioritized in repair are attributes R5 and R7. Both of them then identified the root cause using the 5 why root cause analysis (RCA). The causes of dissatisfaction with the attributes of R5 and R7 are listed in Table 6. An evaluation of the maintenance process was carried out on the boiler. By using the asset prioritization matrix, it can be seen the potential damage to the boiler and the cost limit needed to prevent damage.

Table 6. Root Cause Analysis (RCA) Attribute Priority Improvement

Attribute	Why 1	Why 2	Why 3	Why 4	Why 5
The result of the work is not under the contract	Does not meet the KPI values of EAF (75%) and EFOR (11.96%)	High *forced outage*	High frequency damage to *boiler tube*	The design and quality of the *boiler* are minimalist/standard	
			Rework that increases *outage*	Employee competence is lacking	Employees work not according to SOP
Timeliness in submitting Minutes (BA)	Execution speed is not maximized	Field response is not fast	Fulfillment of supporting documents for administrative processes slow	Need to combine reports from various fields	Lack of discipline from the person in charge of the field

4.2 Asset Prioritization Matrix

The boiler is a critical component that is determined based on the Maintenance Performance Index (MPI) from the Journal of the Electric Power Research Institute (EPRI) in 2012. The boiler consists of 4 sub-equipment namely refractory furnace (R1), platen superheater & re-heater (R2 - R10), and wall tube (R11-R26). The vertical boundary line is the mean of the RPN, which is 33. The horizontal line is the mean of the DMC which is IDR 97,195,931. The results of the mapping are shown in Figure 4 and Table 7.

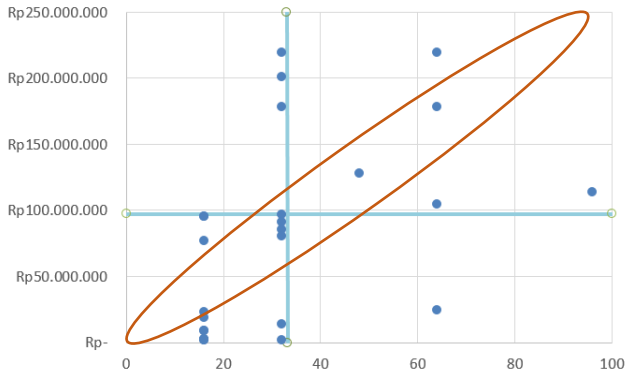


Figure 4. Asset Prioritization Matrix

Table 7. Recap of Asset Prioritization Matrix Result

Quadrant	Risk Code
I (*High risk, high cost*)	R1, R2, R7, R8, R13
II (*Low risk, high cost*)	R11, R12, R23
III (*Low risk, low cost*)	R3, R4, R5, R6, R9, R10, R14, R15, R16, R17, R18, R19, R20, R21, R22, R24, R25
IV (*High risk, low cost*)	R26

4.3 Identification of Value Stream Maintenance Mapping (VSMM)

The four risks, namely R11, R12, R23, and R26, belong to the sub-equipment wall tube which has the potential to cause tube leakage or rupture. Leaks or ruptures in the tube are monitored using sensors for pressure, temperature, and water consumption through the Computer Control Room (CCR). When there is an anomaly, a Work Order (WO) will be made to handle it. In Figure 5, Value Stream Maintenance Mapping (VSMM) is presented. It is known that the mean maintenance lead time (MMLT) is 72 hours 45 minutes or the equivalent of 3 days 45 minutes. There are 3 non-value-added activities, 12 necessary non-value-added (NNVA) activities, and 12 value-added activities. The total activity consists of 27 activities.

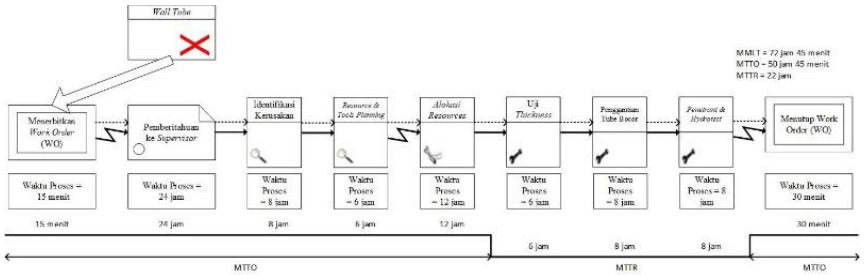


Figure 5. Value Stream Maintenance Mapping (VSMM) Wall Tube Boiler

4.4 Identification of 8 Maintenance Waste

Based on observations there are 4 wastes, then weighted with Analytical Hierarchy Process (AHP) to determine critical waste based on expert views. By combining pairwise comparisons from the Unit Manager, Engineering Supervisor, and IT Computer Control Room (CCR) Supervisor, the weights are obtained as shown in Table 8. The inconsistency of the questionnaire is 12%, but it is still accepted because it is within the 10%-20% limit (Saaty & Ozdemir, 2003). Based on the 80:20 principle, identified critical waste are poor maintenance with a weight of 41.2% and unproductive maintenance with a weight of 30.1% listed in Table 9.

Table 8. Recap of AHP Result

No	Maintenance Waste	Priority	Cumm	Rank	(+)	(-)
1	Poor maintenance	41,2%	41,2%	1	25,7%	25,7%
2	Unproductive maintenance	30,1%	71,2%	2	8,2%	8,2%
3	Waiting for maintenance	21,2%	92,4%	3	8,7%	8,7%
4	Under-utilization of resources	7,5%	100%	4	3,6%	3,6%
Inconsistency			0,12			

Table 9. Identification of Critical Waste's Causes

No	Waste Category	Waste Mode	Effects	Cause
1	Poor maintenance	Frequent *breaks down* on the *boiler*	Forced outage increases	Age of boiler
				The quality of tube coating is easy to peel off
				Less attention to a boiler
2	Unproductive maintenance	Repeated damage to the same component	Rework increases downtime	Recurrent damage of components boiler, especially wall tubes
				Overheating due to combustion and air usage is not optimal

4.5 Calculation of Performance Indicators (PI) Lundgren

In Table 10, are the results of the calculation of Performance Indicators (PI) selected based on the company's vision-mission and KPIs. There are 5 indicators (25%) that have reached the target, 7 indicators (35%) that have not met the target, and 8 indicators (40%) that have not had a target. The target value is obtained from the Service Level Agreement (SLA) and the contract that has been agreed upon between P3L as an asset operator and another company as an asset owner of PLTU Unit 3.

Table 10. Recap of PI Calculation Result

No	Performance Indicators	Result	Unit	Target	Status
1	Return of Maintenance Investment (ROMI)	8,22	%	>=7	Achieved
2	Ratio of spent training	4.000.000	IDR/Person		
3	Maintenance rework ratio	1/5	Rework		
4	Service Hours (SH)	5.275	Hour	>=7.008	Not achieved
5	Total Outage (Planned & unplanned)	3.485	Hour	<=1.752	Not achieved
6	Down time cost	1,036 T	IDR	<=521,1 M	Not achieved
7	Planned Outage Hours (POH)	1.315	Hour	<=1.272	Not achieved
8	Forced Outage Hours (FOH)	2.170	Hour	<=480	Not achieved
9	Average response time	219	Hour/Outage	<=212	Not achieved
10	Material management	85	%	>=75	Achieved
11	WO Closed Percentage	98,12	%	>=80	Achieved
12	Maintenance cost utilization	40	%		
13	Corrective maintenance cost	57,2	%		
14	Preventive maintenance cost	16,09	%		
15	Condition-based maintenance cost	25,07	%		
16	Predictive maintenance cost	1,64	%		
17	Environment damaging failure	1	Failure		
18	Equivalent Availability Factor (EAF)	59,26	%	>=75	Not achieved
19	Zero Accident	0	Incident	0	Achieved
20	Employee turn over rate	2,15	%	<=10	Achieved

4.6 Calculation of Return of Maintenance Investment (ROMI) Improvement

It is known that the 5th attribute, namely "The results of the work according to the contract" requires improvement. The asset owner feels that the results of the work are not under the contract because there are performances that are not achieved, namely EAF and EFOR. The forced outage exceeds the limit due to damage to the wall tube. This is validated by the results of the asset prioritization matrix which shows that the maintenance of the wall tube needs to be reviewed. Damage due to short-term overheating (R11), long-term overheating (R12), and coal particle corrosion (R23) can be controlled by external factors such as fuel quality control (coal and flue gas) and the operation of soot blowers. Although the control of external factors has been carried out properly (low occurrence and detection), it turns out that damage still often occurs due to internal factors or the design of the wall tube (R26). Therefore, it is proposed to replace the wall tube components. The costs required to replace the boiler wall tube with better quality are listed in Table 11.

Table11. Budget for Replacement of Wall Tube Boiler Components

No	Description	Number	Unit	Investment Value
1	Parsial Metal Waterwall Furnace Unit 1, Luasan 400 m2	1	Lot	IDR 25.000.000.000
2	Parsial Metal Waterwall Furnace Unit 2, Luasan 400 m2	1	Lot	IDR 25.000.000.000
3	Reverse Engineering Vortex cyclone A dan B Boiler Unit #1	1	Lot	IDR 3.800.000.000
4	Pipe line CWP Unit 1 (Inlet Condenser)	1	Lot	IDR 1.000.000.000
5	Pipe line CWP Unit 2 (Inlet Condenser)	1	Lot	IDR 1.000.000.000
Total				IDR 55.800.000.000

Table 12. Details of Fulfillment of Investment Costs

No	Description	Amount	
1	Budget allocation for investment	IDR	36.680.000.000
2	Switching maintenance budget	IDR	306.905.262
3	Remaining budget	IDR	18.813.094.738
Total		IDR	55.800.000.000

In Table 12, the fulfillment of investment costs comes from 3 sources. There is a switch in the maintenance budget from 3 risks are over maintenance. Each risk will only have a budget of IDR 97,195,931. After replacing the boiler wall tube, the rate of maintenance investment (ROMI) is calculated using Equation 4.

$$\text{ROMI (\%)} = \frac{Total\ revenue - investment}{Investment} x100\% \quad (4)$$

$$= \frac{(net\ revenue + (penalty) - investment}{Investment} x100\%$$

$$= \frac{(66.383.274.449 - 0) - 55.800.000.000}{55.800.000.000} x100\%$$

$$= 19{,}61\%$$

5. CONCLUSIONS

According to SERVQUAL, the outcomes of the work that are not in compliance with the contract are the traits that require change on a priority basis. Due to recurrent deterioration to the boiler wall tube caused by the standard/minimalist quality of design and materials, EFOR and EAF have not been reached. Consequently, it is suggested to swap out the boiler for one of higher grade that costs IDR 55.800.000.000. The transfer of maintenance from risks that are thought to be above maintenance, specifically the risks of R11, R12, and R23, is one source of fulfillment of investment expenses. The result obtained after computing the repair ROMI is higher than the preexisting condition, from 8,2% to 19.61%. This occurs because the improved boiler can enhance EAF and EFOR performance, preventing PPMC from being charged a 30% penalty for O&M services.

REFERENCES

Ananth, A., Ramesh, R., & Prabaharan, B. (2010). *Service quality gap analysis in private sector bank-a customer perspective*. *29505*, 245–252.

Biedermann, H., & Kinz, A. (2016). *Lean smart maintenance – Implementation in the process industry Lean Smart Maintenance – Efficient And Effective Asset*. *September 2019*.

Bokrantz, J., Skoogh, A., Berlin, C. and Stahre, J. (2017). Maintenance in digitalized manufacturing: Delphi-based scenarios for 2030. International Journal of Production Economics, (191), 154-169. https://doi.org/10.1016/j.ijpe.2019.107547

Lundgren C., Bonkrantz, J., Skoogh, A. (2020). Performance indicators for measuring the effects of Smart Maintenance. International Journal of Productivity and Performance Management, 70(6), 1291-1316. https://doi.org/10.1108/IJPPM-03-2019-0129

Passath, T., & Mertens, K. (2019). Decision Making in Lean Smart Maintenance: Criticality Analysis as a Support Tool. *IFAC-PapersOnLine*, *52*(10), 364–369. https://doi.org/10.1016/j.ifacol.2019.10.058

Saaty, T.L. & Ozdemir, M.S. (2003). Why the Magic Number Seven Plus or Minus Two. *Mathematical and Computer Modelling*, 38, 233-244. https://doi.org/10.1016/S0895-7177(03)90083-5

Zeithaml, V. A., & Berry, L. L. (1988). *SERVQUAL : A multiple- Item Scale for measuring consumer perceptions of service quality*. *September 2014*.

RISK MANAGEMENT ON THE CONSTRUCTION PROJECT OF THE 150 KV BANGKALAN HIGH VOLTAGE TRANSMISSION NETWORK

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ABSTRACT

Electricity project implemented by PT. PLN (Persero) UIP JBTB is a construction project of the High Voltage Transmission Network and High Voltage Cable Channel 150 kV Bangkalan. The construction will certainly stretch across various fields that have varying degrees of risk. In addition, the construction project of the 150 kV Bangkalan High Voltage Transmission Network is a very complex project so that each stage has different obstacles so that it has the potential to have high risks in its implementation. This raises a variety of risks that need to be identified, analyzed, responded to and monitored for implementation so that the project runs according to the planned targets. This research was conducted to identify the risks that arise in the High Voltage Transmission Network 150 kV Bangkalan development project and formulate the most effective response for each extreme, very high and high risk category of the project. The risk management will be based on SNI 8615:2018 Risk Management – Principles and Guidelines. Where the data collection method uses primary data in the form of FGD results and interviews with research respondents. And at the risk analysis stage of the High Voltage Transmission Network Bangkalan project qualitative methods are carried out. Risks that have extreme, very high, and high categories are risks that cannot be tolerated and a quantitative analysis will be carried out using the Expected Monetary Value method as measured data. Furthermore, with the Decision Tree Analysis diagram, several alternative risk response branches will be obtained which will then be analyzed using the multiplication of the response success value with the cost impact value in order to obtain the most effective response option.

Keywords: Decision Tree Analysis, Expected Monetary Value, High Voltage Transmission Network, Risk Response

1. INTRODUCTION

PT. PLN (Persero) as a State-Owned Enterprise in the electricity sector carries out a mandate from the Government to maintain the continuity of development and efficient operation of the electricity sector as a stimulus for economic growth. One of the units of PT. PLN (Persero) which plays a role in the construction of electricity installation projects in East Java and Bali is PT. PLN (Persero) UIP JBTB (Unit Induk Pembangunan Jawa Bagian Timur dan Bali). One of the electricity projects implemented by PT. PLN (Persero) UIP JBTB is a transmission network development project for High Voltage Air Line and High Voltage Cable Channel. The High Voltage Transmission Network 150 kV Bangkalan is one of the electricity infrastructure developments that requires risk analysis in project control. The application of risk analysis is used

to formulate an appropriate and appropriate risk control model, by applying it to the Transmission Network construction project, so that the project can be completed with the planned target (Trisanto & Wiguna, 2012). The challenge in the construction of the High Voltage Transmission Network 150 kV Bangkalan is the electricity demand on Madura Island which needs to be supplied from Surabaya through the High Voltage Cable Channel 150 kV Suramadu circuits 1 and 2 with a maximum capacity of 284 MW where the peak load has reached 273 MW which has served 926,707 customers, where 71% of that amount are subsidized customers. If there is a disturbance or maintenance on one of the circuits, there will be blackouts in parts of Madura Island. In order to improve the reliability of electricity supply on Madura Island and to avoid blackouts, PLN has built a 150 kV Kedinding – Tx Bangkalan High Voltage Cable Channel circuit 3 and 4 and built a 150 kV Bangkalan Incomer High Voltage Air Line which is a National Strategic Project (PSN), as stated in the General Plan of Electric Power Providers. (RUPTL) PLN 2021-2030 which has been ratified through the Decree of the Minister of Energy and Mineral Resources of the Republic of Indonesia Number 188.K/HK.02/MEM.L/2021 concerning the Ratification of the Business Plan for the Provision of Electric Power (RUPTL) 2021-2030 with an operating target year 2023.

150 kV High Voltage Bangkalan Transmission Network which are constructed will certainly stretch through various kinds of terrain such as settlements, straits, rice fields, roads and so on, each of which has various risks in its construction. Because the research location is on a construction project that crosses the Suramadu Bridge, the construction process will also have a high risk from both the management side of the Suramadu Bridge and road users on the Suramadu Bridge. This is in accordance with research findings by Indraswari, Norken & Suthayana (2018) which states that project development has various potential risks from various aspects that must be anticipated. Risk control in the 150 kV Bangkalan High Voltage Transmission Network project is an integral part of management's responsibility, in ensuring the achievement of project development goals and organizational goals (Trisanto & Wiguna, 2012). In the construction of the 150 kV Bangkalan High Voltage Transmission Network project, it is also necessary to know the risks that arise due to organizational & management factors related to the reporting of work progress, the risks that arise due to financial & economic factors related to inflation resulting in an increase in material prices, unexpected costs in the form of extortion or donations imposed by the community around the project, risks that arise due to cultural & environmental factors related to conflicts between villages, land disputes, risks that arise due to design aspects, work location, physical conditions of work and risks that arise due to condition factors natural disasters related to weather conditions such as rain for a long time or natural disasters that can cause work to be hampered. All of these aspects become the main focus that influences each other how the cost impact of the 150 kV Bangkalan High Voltage Transmission Network project is interconnected and risks hampering project completion. Thus, it is very necessary to identify good risks to find out all the risks that must be faced at the project development stage (Trisanto & Wiguna, 2012). The implementation of project risk management is a very important thing owned by the company, because the risks that occur can be managed and minimized to achieve company goals (Maharani, 2018). By using risk management, it will be known the risks that may occur and have an impact on project work, these risks can finally be anticipated and eliminated for the next project. Making risk management will be based on SNI 8615:2018 ISO 31000:2018 regarding Risk Management – Principles and Guidelines. SNI 8615:2018 ISO 31000:2018 describes the components of a risk management framework that includes important steps in the implementation and ongoing support of the risk management process (AIRMIC, 2010). So that by using SNI 8615:2018 ISO 31000:2018 as an umbrella to make risk management this will make it easier to manufacture and work. In addition, ISO 31000 is an international standard that has been recognized by the world (Dumara, 2017). Based on the potential risk events that exist, of course PT PLN must also prepare

response steps that must be taken so that these potential risks do not develop into an event that actually occurs. This anticipation is a form of response to the potential risks that occur in the construction of the 150 kV Bangkalan High Voltage Transmission Network. With this risk response, the control of a risk event will be better without any events that harm all related parties. Determining the response to potential risks in a project is an important thing that should not be overlooked. According to Sukaarta, Sompie, & Tarore (2012), there are four types of responses to risks that may occur during project implementation, namely avoiding risk, transferring risk, mitigation/reducing risk, and accepting risk. Based on the description of the background above, it is very important to conduct research on "Risk Management in the Construction of the 150 kV Bangkalan High Voltage Transmission Network Project". Various risks that may arise in the project will be reviewed from the point of view of the project owner in terms of organizational and management aspects, identified using a literature study that is strengthened by the results of Focus Group Discussions with expert judgment and related parties, which is then analyzed qualitatively with a risk matrix and quantitatively with the Expected Monetary Value & Decision Tree Analysis method until the most effective response is obtained to address each high, very high and extreme risk category that may arise in the construction project of the transmission network 150 kV Bangkalan by PT. PLN (Persero).

2. LITERATURE REVIEW

Every project can face specific risks that have never been experienced before. If one of the unpredictable events will occur, then there is always a risk that will affect the project objectives. The step-in risk management is to find solutions to deal with risky situations. According to Hilson & Hullet (2004) the problems from the projects that have been experienced do not necessarily provide solutions to overcome certain types of risks. The project team will consider the project objectives to be achieved including the project completion budget/cost, all of which are interrelated and risk impeding project completion. Risk management is the process of reducing an entity's risk to an acceptable level, using measurement, management and monitoring that are in line with strategic objectives (Gilbert, 2007). Meanwhile, according to ISO 31000:2018, risk management is a coordinated effort or activity carried out to direct and control an organization/company/project activity against the possible risks that exist (ISO 31000, 2018). ISO 31000:2018 which was adopted into SNI 8615 has been developed by several experts from all over the world with different fields and disciplines. This standard aims to provide guidelines for companies to be able to manage different types of risks from various industries with different organizational sizes, types, complexity, structures, activities and locations. (Dumara, 2017). ISO 31000 provides an enhanced list and description of the five attributes of the framework. The risk management process in this standard is described in Figure 1



Figure 1. Risk Management Process

From Figure 1 ISO 31000:2018 Risk Management Process it can be explained that the risk management process starts from the initial stage, namely determining the scope, context, and criteria, where risk management can be applied to various purposes and activities, both projects, companies and industries. Therefore, the first step in risk management is to determine the scope, context, and criteria for the implementation of risk management to be carried out, so that the risk management process is right on target. This initial determination in the ISO 31000:2018 Risk Management Process covers the strategic scope, risk management context and risk criteria and management structure. In accordance with ISO 31000:2018, the next step after determining the scope, context, and criteria is to carry out a risk assessment including risk identification, risk analysis, and risk evaluation

After conducting a risk assessment, risk treatment is carried out until finally it is applied to recording and reporting, monitoring and reviewing as well as communication and consultation. According to ISO 31000:2018, there are 5 main procedures for risk management : **Establish the Context** : Determining context means determining internal and external boundaries or parameters that will be considered and discussed in risk management. Determine the scope of work and risk criteria for the next process. The defined context should include all relevant and important internal and external parameters for the organization. The external context includes the social, political, economic, cultural environment both nationally and regionally. While the internal context includes organizational structure, organizational goals and policies. **Identify Risks :** Risk identification is one of the most important steps in project risk management. There are several ways (tools & techniques) that can be done for risk identification according to ISO 31000, including Document Review, Information Gathering Techniques, Checklist Analysis, Asumption Analysis, SWOT Analysis, and Expert Judgment. **Risk Analysis** : Risk analysis is a process in risk assessment to determine the Risk Level, which is carried out by measuring the level of possibility of events and their impacts. Qualitative Risk Analysis Risk analysis using qualitative techniques consists of several way that is: a. Possible risks and impacts, b. Probability and impact matrix, c. Risk data quality assessment d. Risk categorization Current Risk Level is measured to determine the effect of current risks by considering existing controls and their effectiveness. According to The Standards Australia/New Zealand Standard (1999), each risk is assessed qualitatively in five categories. The assessment of the respective likelihood and consequences is presented in Table 1 and Table 2.

Table 1. Level of Likelihood

Level	Descriptor	Description
A	Almost certain	Is expected to occur in most circumstances
B	Likely	Will probably occur in most circumstances
C	Possible	Might occur at some time
D	Unlikely	Could occur at some time
E	Rare	May occur only in exceptional circumstances

Table 2. Level of Impact

Level	Descriptor	Example detail description
1	Insignificant	No injuries, low financial loss
2	Minor	First aid treatment, on-site release immediately contained, medium financial loss
3	Moderate	Medical treatment required, on-site release contained with outside assistance, high financial loss
4	Major	Extensive injuries, loss of production capability, off-site release with no detrimental effects, major financial loss
5	Catastrophic	Death, toxic release off-site with detrimental effect, huge financial loss

Data from the Table of Impact Levels and Likelihood Levels collected from the questionnaire were analyzed using the Risk Matrix which is shown in Table 3.

Table 3. Matrix of Risk Level of Likelihood x Level of Impact

LEVEL OF LIKELIHOOD							
	Almost Certain	E	E.1	E.2	E.3	E.4	E.5
	Likely	D	D.1	D.2	D.3	D.4	D.5
	Possible	C	C.1	C.2	C.3	C.4	C.5
	Unlikely	B	B.1	B.2	B.3	B.4	B.5
	Rare	A	A.1	A.2	A.3	A.4	A.5
			1	2	3	4	5
			Insignificant	Minor	Moderate	Major	Catastrophic
	LEVEL OF IMPACT						

Information :

Extreme Risk	E.5 D.5	Priority 1
Very High Risk	E.4 D.4 C.5 B.5	Priority 2
High Risk	E.3 D.3 C.3 C.4 B.4 A.4 A.5	Priority 3
Moderate Risk	B.3 A.3 E.2 D.2 C.2 E.1	Priority 4
Low Risk	B.2 A.2 D.1 C.1 B.1 A.1	Priority 5

From the Qualitative Analysis using the Risk Matrix, which is a comparison between the level of likelihood and the level of impact, there are five different colors in the matrix in Table 3 where Extreme Risk is marked in red in boxes E.5 and D.5. For Very High Risk, it is marked in orange in boxes E.4, D.4, C.5, and B.5. For High Risk, it is marked in yellow in boxes E.3, D.3, C.3, C.4, B.4, A.4, and A.5. Moderate Risk is marked in light blue in boxes B.3, A.3, E.2, D.2, C.2, and E.1. And for Low Risk, it is marked with a light green color, namely in boxes B.2, A.2, D.1, C.1, B.1, and A.1. Risk grouping based on extreme, very high, high, moderate and low categories becomes the basis for setting criteria for risk appetite limits and risk tolerance as well as making decisions for implementing actions. Preparation of criteria for risk appetite/risk acceptability and criteria for risk tolerance/risk tolerability based on the Regulation of the Board of Directors of PT PLN (Persero) Number: 0071.P/DIR/2021 concerning General Guidelines for Integrated Risk Management of PT PLN (Persero) where the low and moderate risk categories are risks that are still acceptable or tolerable based on the risk appetite of the unit, while for the high, very high and extreme risk categories are unacceptable or unacceptable risks. Quantitative Risk Analysis is to calculate the combined effect of risk on project objectives, using tools such as Expected Monetary Value (EMV) and Decision Tree Analysis (DTA). Expected Monetary Value is the most frequently used criterion for analyzing decision trees. One of the initial steps of this analysis is to draw a decision tree and establish the financial consequences of all the outcomes of a particular problem. Expected monetary value (EMV) is the value of a variable that has several different possible natural conditions, each with its own probability. When probabilities are known, the maximum and minimum values represent the best case – worst case planning scenario. This value

represents the expected value or the average rate of return on capital if this decision can be repeated many times (Heizer & Render, 2005). The EMV of an alternative is the sum of all the alternatives' benefits, each of which is assigned a probability of occurrence.

$NH_i = \sum_{j=1}^{n} p_j \times h_{ij}$ for $i = 1, 2, \ldots, n$ (2.1)

$$\sum_{j=1}^{n} p_j = 100\%$$

Where

NH_i = Expected value of decision branch -i.

p_j = Probability of occurrence of the state -j.

h_{ij} = The value of the decision if the i decision alternative is taken and the j situation occurs.

Decision Support / Decision Tree Analysis using risk response aims to reduce risk to a level that is acceptable to all parties. In a risk assessment, it involves many parties where there will be alternative risk responses that have advantages and disadvantages that will cause contradictions between the parties involved. The decision tree method or decision tree analysis is a visual model to simplify the rational decision-making process (Siswanto, 2007). Analyzing a problem using a decision tree includes five steps: 1. Define the problem. 2. Draw a decision tree. 3. Determine opportunities for natural conditions. 4. Estimating the payoff for each possible combination of alternative decisions and natural conditions. 5. Solve the problem by calculating the EMV for each point of the natural condition.

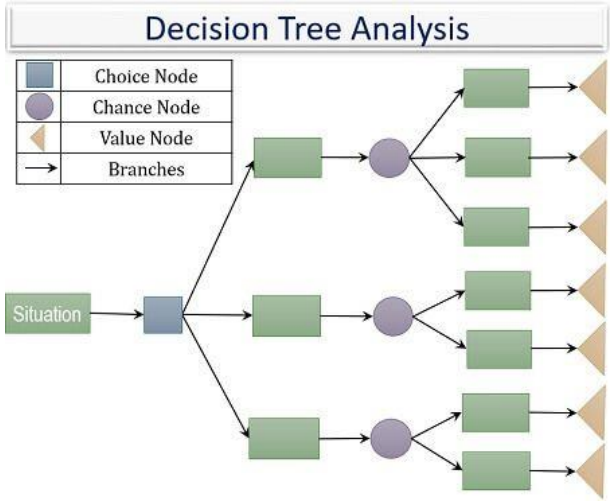


Figure 2. Decision Tree Analysis Diagram

Risk Evaluation : The purpose of risk evaluation is to assist the decision-making process based on the results of the analysis. The risk evaluation process will determine which risks require treatment and how to prioritize them. This can be done by grouping or classifying the probability and impact values into a risk matrix. After knowing the existing consequences and likelihood values, it can be plotted on a risk matrix to find out how high the risk is. The result of the risk evaluation is risk rating data that requires further treatment on the basis of the remaining risk and the effectiveness of the existing risk response. **Risk Response** : The purpose of risk response is to determine what can be done to reduce the overall project risk by reducing the probability and impact of threats and increasing the likelihood and impact of opportunities (Mulcahy, 2010).

3. METHODS

This research methodology describes the steps that will be carried out in the research, including the mechanism of data collection and the types of methods used for data analysis

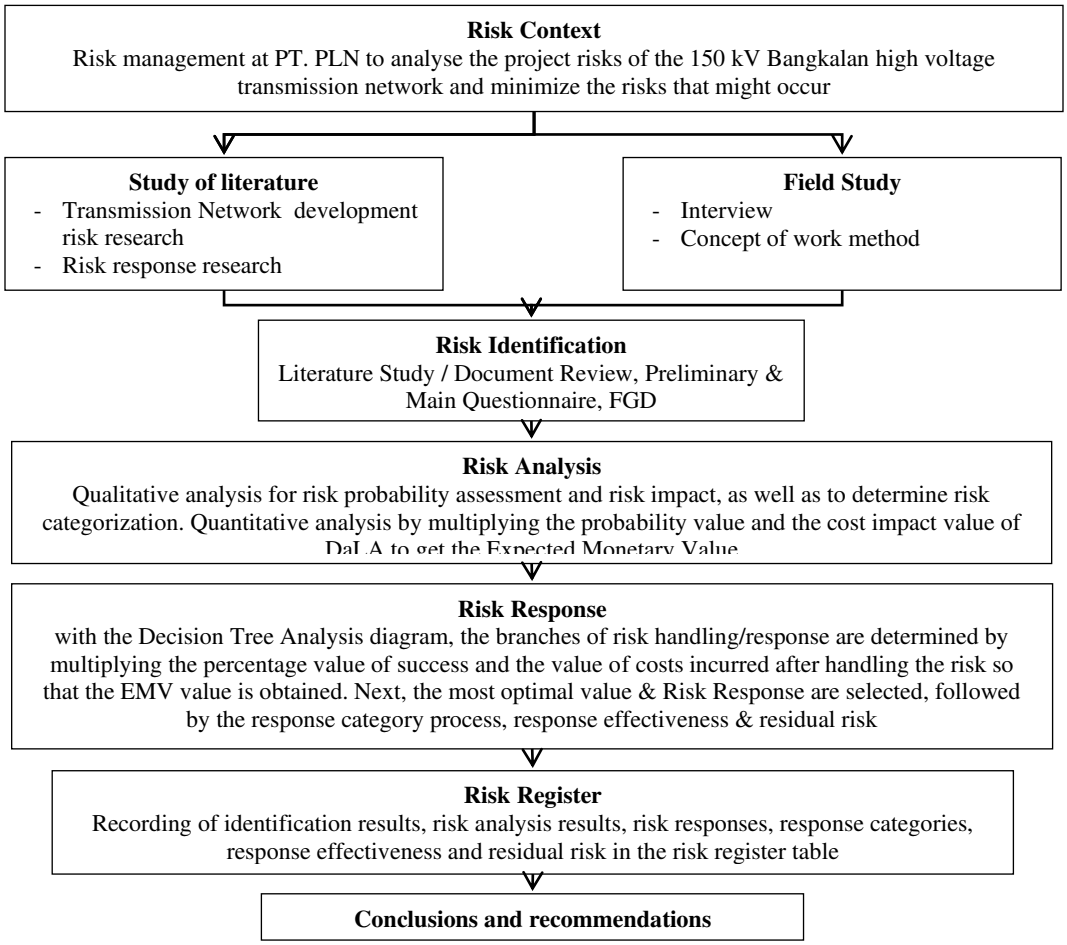


Figure 3. Research Flow

The research "Risk Management in the Construction of the 150 kV Bangkalan High Voltage Transmission Network Project" is a type of case study research which is descriptive qualitative research. Case study research is intended to study the background of the problem, the situation and position of an event, as well as the interaction of certain objects that are given as they are.

The variables in this study were obtained from literature studies and field studies with expert judgment interviews of construction involved in the construction of the Transmission Network project seen also from the perspective of the project owner, namely PT PLN (Persero). The variable is a list of risk identification that may occur during the construction of the 150 kV High Voltage Transmission Network in Bangkalan. Especially the risk identification that will be discussed are the stages during the construction of the 150 kV Bangkalan High Voltage Transmission Network project. According to Giri Trisanto & Wiguna (2012), the determination of risk sources during the implementation of relevant projects is based on the categories of Organizational & Managerial, Finance & Economics, Culture & Environment, Job Design, Work Location, Physical Work, and Natural Conditions. The research variables in order to identify occupational risks in each category and job risk event.

Table 4. Research Variables to Identify Risks in the 150 kV Bangkalan Transmission Network Project

No.	Risk Identification
A	**Organizational, Managerial and Human Resources Aspects**
	Inaccurate reporting of work progress for supervision
	Project execution time is not in accordance with the project schedule
	Lack/no competence of field implementers (contractors)
	Lack/no competence of field supervisors (PT. PLN)
	At least holding coordination meetings in the field

No.	Risk Identification
	Weak service provider administration and documentation system
	Low evaluation and decision-making system
B	**Financial and Economic Aspects**
	Error in calculating RAB (unit price and unit price of work)
	Project funding was hampered due to late advance from PT. PLN
	Unexpected costs in the form of extortion or donations imposed by the community around the project
	Changes in the country's economic conditions and government policies on finance
C	**Cultural and Environmental Aspects**
	There are issues by NGOs to local communities regarding the dangers of transmission lines
	The payment of compensation for land/plants passed by the transmission line has not yet been completed
	Temporary cessation of work due to national holidays, traditional ceremonies, religious ceremonies
	Work stops orders by local government authorities
	Conflicts between regions traversed by transmission lines
	Permits from local government authorities to carry out work have not been issued/constrained
	The existence of irresponsible elements who interfere with project implementation (extortion, etc.)
	Slow land acquisition and compensation process
	There are residents' resistance to land acquisition
	Land acquisition process in conflict with other agencies (PT KAI, PUPR, and local government)
	Community protests on development that does not involve citizens
D	**Design Aspects and Work Documents**
	Working drawings (shop drawings) have not been approved by PT. PLN as the owner of the job
	Tower design changes
	Design error
	The technical specifications required by PT. PLN does not match the conditions in the field
	The data used in the feasibility study is less accurate, so it has the potential to cause estimation errors
	Improper planning that has the potential to pose a risk of changes to the plans that have been made
	Incomplete BOQ details
E	**Aspects of Job Location**
	Unavailability of access for materials, equipment and work to the site
	Unavailability of resources for civil works and working water on site
	Unavailability of power source on site to perform certain work
	Lack of communication tools for coordination and supervision
	The condition of the soil structure at each location requires different methods and times of foundation work
	The low productivity of local labor is not as expected
	Work accidents for work at height
	Security conditions at the project site that may pose a risk of loss of project materials or logistics
	The occurrence of traffic jams around the project site due to the construction of the project
	Difficulty in sliding materials (locations that are difficult to reach and far from major roads)
F	**Physical Aspects of Work**
	Damage to equipment during use at locations that take a long time to repair
	Incomplete material in the field for tower structure and stringing works
	Theft/loss of tower structure materials
	Inadequate technical personnel for certain jobs that require expertise
	Material discrepancy in the field with the specifications required by PT PLN
	There is a defect in the work so that it does not match the specifications and technical requirements
	Uncertainty in the availability of materials needed for construction creates the risk of increasing costs
	Errors in applying standard construction methods to do a job
	Error applying fieldwork drawing
	Waste of material usage on site
	Errors in applying standard construction methods to do a job
	Lack of equipment to support work in the field
	The need for adequate technology for very complex jobs
G	**Aspects of Natural Conditions**
	Weather conditions such as rain, wind, and so on for a long-time cause work to be hampered
	The existence of natural disasters such as earthquakes, landslides, floods, volcanic eruptions cause work to stop

The project risks that have been identified are then analyzed qualitatively, namely based on data obtained from FGDs with research respondents to obtain an assessment of risk in order to obtain information needed for further analysis. Risk identification is analyzed by qualitative method by plotting the level of likelihood against the level of impact in the Risk Matrix table, where the

identification / variable is determined based on the level of likelihood and level of impact. The 150 kV Bangkalan High Voltage Transmission Network Project is in accordance with Table 5 which is used as the basis for assessing the possibility of risk and filling out the impact scale according to Table 6.

Table 5. Level of Likelihood in the 150 kV Bangkalan High Voltage Transmission Network Project

Risk Parameter / Level of Likelihood		Probability	Qualitative Description	Previous Incident
E	**Almost Certain**	> 80% - 100%	Almost certainly will happen	Happened more than once in the last 6 months
D	**Likely**	> 60% - 80%	Most likely will happen	Happened once in the last 6 months
C	**Possible**	> 40% - 60%	The probability is the same between it will happen and not happen	Happened once in the last 1 year
B	**Unlikely**	> 20% - 40%	It's less likely to happen	Did not happen within the last 1 year
A	**Rare**	0% - 20%	Almost certainly won't happen	Never happened in a span of more than 1 year

Table 6. Level of Impact in the 150 kV Bangkalan High Voltage Transmission Network Project

Factor	Impact Scale				
	Insignificant	**Minor**	**Moderate**	**Major**	**Catastrophic**
Cost	Almost no increase in project costs (Fee increase 0.1%)	The increase in project costs is not significant (0.1% Cost increase 0.5%)	The increase in project costs is quite significant (0.5% < Cost increase 1%)	Significant increase in project costs (1% < Cost increase 2%)	The increase in project costs is very significant (2% < Cost increase)
Scale	1	2	3	4	5

From the Qualitative Analysis using the Risk Matrix, namely the comparison between the level of likelihood and the level of impact, there are five different colors in the matrix in Table 3. The qualitative analysis process is shown in Table 7.

Table 7. Risk Categories in the Comparison of Likelihood Levels x Impact Levels

No.	Risk Identification	Likelihood Level	Impact Level	Category Box	Information
…	Risk variables	Filling the level of possible risk based on the results of the FGD.	Filling in the level of risk impact based on the results of the FGD.	Risk categories based on risk matrix plotting	Extreme Risk Very High Risk High Risk Moderate Risk Low Risk

Risks with Extreme, Very High, and High levels are types of unacceptable risk (J.Susilo & Kaho, 2018) in the 150 kV Bangkalan High Voltage Transmission Network project and must be responded to. These risks must be analyzed further in order to obtain solutions in the form of appropriate responses to handle extreme, very high, and high risks. Quantitative analysis was carried out to obtain measurable data to determine the impact on costs using Expected Monetary Value (EMV) and Decision Tree Analysis. The use of these two instruments in risk analysis has been carried out by Albani (2020) where EMV is used to determine the costs that must be incurred for each response alternative, while Decision Tree Analysis is used to choose the best response among several alternative responses (Albani, 2020). The data taken is the percentage of the effect of the response effort and how much the response effort costs. The decision-making process with decision tree analysis and EMV calculation diagrams is shown in Figure 4

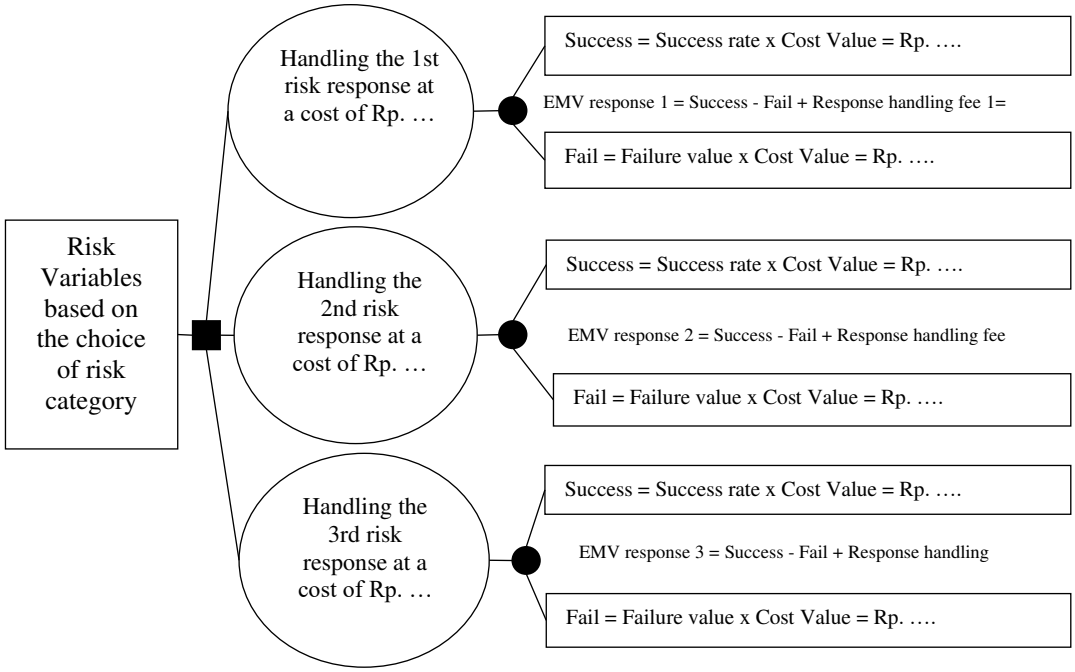


Figure 4. Calculation Diagram with Decision Tree Analysis and EMV

Based on the results of the Decision Tree Analysis, the response that can provide the greatest benefit from the alternative branch is the response that has the lowest EMV value after the response compared to other alternatives and the previous EMV. The next step after selecting response alternatives is to categorize the responses. The risk response of each decision choice will be categorized into mitigation/reducing risk, transferring risk, and accepting risk. This act of accepting risk is usually applied to risks with a low and moderate level of risk for the company so that if the residual risk is handled, it will cause costs that are not proportional to the company's profits. After the risk response, response category, and response effectiveness test have been carried out, the residual risk calculation is then carried out which is used to determine the residual risk value after the response. The residual risk from the risk response results based on the DTA diagram and EMV calculation will be reviewed based on the value of the cost impact that must be included in the moderate and low-level risk categories in accordance with the basis for determining risk appetite limits and risk tolerance. If at the residual risk stage there is still risk with extreme, very high, or high levels, then the risk response process needs to be carried out further until the risk target is achieved in accordance with the risk tolerance.

After the risks are identified, analyzed, responded to and the residual risk results are obtained, the entire risk management process will be recorded in the Risk Register of Risk Management in the Construction of the 150 kV Bangkalan High Voltage Transmission Network Project. Risk Register is a document or database containing a list of identified risks along with the results of their analysis and handling related to activities.

4. RESULTS

From the results of risk identification, we assess the level of likelihood and level of impact with FGDs. After that, the 10 highest risk categories were obtained and can see in Table 8.

Table 8. Risk Variables with High, Very High and Extreme Risk Categories

No.	Risk Identification	Likelihood Level	Impact Level	Category Box	Information
1	Delay in the bridge manager's approval to start the work	D	4	D.4	Very High Risk
2	The contractor's performance is less than optimal causing late project completion	C	3	C.3	High Risk

No.	Risk Identification	Likelihood Level	Impact Level	Category Box	Information
3	Project handover delay	C	3	C.3	High Risk
4	The payment of compensation for land/plants passed by the transmission line (ROW) has not yet been completed	D	4	D.4	Very High Risk
5	Changes in ownership of land, buildings and plants crossed by the ROW	C	3	C.3	High Risk
6	The project implementation process disrupts traffic flow	C	3	C.3	High Risk
7	The implementation of the project causes a security disturbance in the condition of the Suramadu bridge	C	4	C.4	High Risk
8	There was a fire / sparks on the cables and bridges due to construction errors	B	5	B.5	Very High Risk
9	The reliability of the 150 kV Bangkalan Transmission Network electricity system is disrupted	B	5	B.5	Very High Risk
10	Damage to buildings around the construction work area	A	4	A.4	High Risk

In the Extreme Risk category there are no risk variables, while 4 risks are in the Very High-Risk category, and 6 risks are in the High Risk category. Furthermore, these 10 risks need to be followed up with Quantitative Analysis using the Expected Monetary Value (EMV) and Decision Tree Analysis (DTA) methods.

Table 9. EMV Values for High, Very High and Extreme Risk Categories

No.	High and Very High-Risk Variables	Probability Value	Impact Value (Rp)	EMV = Probability Value x Impact Value
1	Delay in the bridge manager's approval to start the work	0,8	2.478.000.000,00	1.982.400.000,00
2	The contractor's performance is less than optimal causing late project completion	0,6	3.477.313.365,78	2.086.388.019,47
3	Project handover delay	0,6	2.781.850.692,62	1.669.110.415,57
4	The payment of compensation for land/plants passed by the transmission line (ROW) has not yet been completed	0,8	2.262.386.981,00	1.809.909.584,80
5	Changes in ownership of land, buildings and plants crossed by the ROW	0,6	530.448.000,00	318.268.800,00
6	The project implementation process disrupts traffic flow	0,6	250.629.941.45	150.377.964,87
7	The implementation of the project causes a security disturbance in the condition of the Suramadu bridge	0,6	375.944.912.18	225.566.947,31
8	There was a fire / sparks on the cables and bridges due to construction errors	0,4	1.563.879.000,00	625.551.600,00
9	The reliability of the 150 kV Bangkalan Transmission Network electricity system is disrupted	0,4	1.563.879.000,00	625.551.600,00
10	Damage to buildings around the construction work area	0,2	145.652.092.68	29.130.418,54

With the Decision Tree Analysis diagram, the branches of risk handling/response are determined by multiplying the percentage value of success and the value of costs incurred after handling the risk so that the EMV value is obtained. In Table 10, we can see the risk response, most optimal value calculates with EMV using DTA and selected response and the residual risk.

Table 10. Risk Response for High, Very High and Extreme Risk Categories

No.	High and Very High-Risk Variables	Risk Response	EMV Calculation with DTA Diagram	Selected response	Residual Risk
1	Delay in the bridge manager's approval to start the work	1. Coordinate with Bridge managers regarding the manufacture of Detail Engineering Designs and cooperate with independent consultants for DED approval and re-design in accordance with Bridge Manager specifications and requirements	1.098.187.500	1	Moderate Risk
		2. Improvement design of existing cables with monitoring, protection, security, operation and maintenance systems as well as fire prevention systems.	1.939.522.500		
2	The contractor's performance is less than optimal causing late project completion	1. The process of providing goods/services is selected through an auction process that is included in the List of Selected Providers, contractors who carry out construction development are not included in the blacklist and emphasis is placed on the substance of the agreement which contains rights & obligations between the two parties where there is an administrative sanction clause (fines) if the contractor does not complete the project on time	517.277.603,90	1	Moderate Risk
		2. Accelerate payment of work progress to maintain contractor cashflow, monitor contractor work and performance on a regular basis and contractors with less-	1.301.832.811,68		

No.	High and Very High-Risk Variables	Risk Response	EMV Calculation with DTA Diagram	Selected response	Residual Risk
		than-optimal performance will be given a warning letter, fined and put on the blacklist			
		3. Evaluating 5M (Man, Material, Machine, Method, Money) in regular meetings, instructing to add competent workforce, adding and using adequate work materials/tools.	864.555.207,79		
3	Project handover delay	1. Accelerate the completion of pending construction work items, speed up the land certification process and monitor the completion of requirements for Project Handover	867.644.166,22	1	Moderate Risk
		2. Conduct a coordination meeting with the Project Handover Team, namely the development unit and the operational unit	1.101.466.249,33		
4	The payment of compensation for land/plants passed by the transmission line (ROW) has not yet been completed	1. Monitoring the progress of land acquisition and compensation for ROW and looking for the root cause of the non-payment of payments. After knowing the problem, then an approach is carried out with the residents and relevant stakeholders through a further socialization process by involving experts from public consultants, TP4D, local governments, religious leaders/community leaders and assistance with the Office of Public Appraisal Services in the context of assessing compensation/compensation, as well as providing compensation. Corporate Social Responsibility (CSR) assistance in carrying out social and environmental responsibilities around project development.	1.123.963.833,56	1	Moderate Risk
		2. Land compensation and ROW compensation are entrusted to the district court / consigned	1.547.927.667,84		
5	Changes in ownership of land, buildings and plants crossed by the ROW	1. Coordinate with the village government, and local residents as well as landowners to find out the boundaries & actual owners of land, buildings, and perennials crossed by the ROW route, re-check surveys accurately involving residents and accompanied by village officials and complete administrative documents completely and thoroughly	220.961.280	2	Low Risk
		2. The results of the inventory survey are socialized to all residents related to the project, residents who own land, buildings, and perennials, witnessed by stakeholders (village government, KJPP) and signed for mutual agreement in the Minutes of Submission of Inventory Results so that there is no change of ownership back in the future	197.307.520		
		3. If there are doubts regarding the ownership of land, buildings, and perennials related to land compensation and ROW compensation, they are entrusted to the district court / consigned	163.653.760		
6	The project implementation process disrupts traffic flow	1. Develop SOPs for implementing the most effective work and causing as little traffic disruption as possible.	135.264.575,41	2	Low Risk
		2. Coordinate with the Traffic Police and other related parties for the preparation of traffic engineering arrangement scenarios during the work period	130.151.185,95		
7	The implementation of the project causes a security disturbance in the condition of the Suramadu bridge	1. Ensure the implementation of the utility deployment in accordance with the agreed SOP and ensure that the work implementation meets bridge construction standards and K3, traffic regulation and road user safety	95.113.389,46	1	Low Risk
		2. Supervise and report on the implementation of work periodically to the Bridge Manager, create a Joint Operation Committee between PLN and the Bridge Manager to ensure coordination and approval in each process.	205.340.168,39		
		3. Conducting mediation with the Bridge Manager regarding the problem of compensation for damage due to project implementation	190.226.778,92		
8	There was a fire / sparks on the cables and bridges due to construction errors	1. Using XLPE insulated cable (Heat Resistant up to 90ºC) and vibration resistant Corrugated Alloy Sheath type with Partial Discharge Monitoring implementation, cable external protection with Cable Coating, electrical system protection using main and back up pattern protection, installation of fire extinguishers portable, hydrant installation, providing a PLN office near the Suramadu Bridge as a Control Room and Fire Fighting Unit, providing CCTV at the Main Bridge as well as conducting periodic inspections and maintenance of cable conditions, including surprise (CCTV, load current, temperature, visual), 3 months (thermovision), 6 months (maintenance in the manhole), 1 year (simulation of emergency conditions with stakeholders), providing trained human resources for monitoring the Health of the cable and human resources for the Fire Emergency Rapid Response Team (TRC)	95.113.389,46	1	Moderate Risk
		2. Performing Risk Transfer by insuring cable assets and file a cable insurance claim in case of interference.	2.130.441.280		
		3. Making SOPs (including Basic Communication and organizations related to handling in the event of a fire, periodic joint inspections between PLN and BBPJN and implementing the company's K2 and K3 programs strictly	425.330.960,00		
9	The reliability of the 150 kV Bangkalan Transmission	1. Performing FAT to ensure cable quality meets standards by involving bridge managers, Using XLPE insulated cables (Heat Resistant to 90ºC) and vibration-resistant Corrugated Alloy Sheath armor types, and installing CCTV cameras and conducting routine surveillance	95.113.389,46	1	Low Risk

No.	High and Very High-Risk Variables	Risk Response	EMV Calculation with DTA Diagram	Selected response	Residual Risk
	Network system is disrupted	2. Cooperating and MOU with bridge managers and parties related to the placement of cables on the bridge to jointly take responsibility for the maintenance of utilities on the Suramadu Bridge, cooperate with the local police in supervising bridge safety and make effective maintenance SOPs with bridge managers with continue to pay attention to the safety and security aspects of electricity and bridges	425.330.960,00		
10	Damage to buildings around the construction work area	1. Conducting Job Safety Analysis and carrying out development socialization to local residents whose work implementation is still based on K3 aspects to avoid damage due to project development	190.226.778,92	1	Low Risk
		2. Provide compensation or repairs due to damage to the project work area that is included in the contract clause and provide Corporate Social Responsibility (CSR) assistance in carrying out social and environmental responsibilities around project development.	220.961.280		

5. CONCLUSIONS

The application of risk identification in the 150 kV Bangkalan Transmission Network Project is very important to identify the risks that may occur. After knowing the list of risks that occur, an assessment of the probability and impact on each risk can be carried out using qualitative analysis to obtain the risk value that needs further analysis. Risk analysis that has an impact on project losses will be measured using quantitative analysis, especially in the high-risk, very high risk and extreme category. From several alternative responses, the decision tree can make it easier to make the right decision by comparing the probability of success or failure of the response and a large reduction in the risk value, so the response can be recommended for application. So that the application of risk management is highly recommended in the construction in the 150 kV Bangkalan High Voltage Transmission Network Project to minimize losses in development projects that will take place.

REFERENCES

AIRMIC. (2010). *A Structured Approach to Enterprise Risk Management (ERM) and The Requirements of ISO 31000*.

Gilbert, J. B. (2007). *Enterprise Risk Management: The New Imperative*. Houston: Lexicon System, LLC.

Heizer, J., & Render, B. (2005). *Manajemen Operasi (edisi ketujuh)*. Jakarta: Salemba Empat.

Hilson, D. A., & Hullet, D. T. (2004). *Assessing Risk Probability : Alternative Approaches. PMI Global Congress Proceedings – Prague*. Czech Republic, 1–7.

J.Susilo, L., & Kaho, V. R. (2018). *Manajemen Risiko: Panduan Untuk Risk Leaders Dan Risk Practitioners*. Jakarta: Grasindo.

Kania, B., Kurniawan, A., & Yahya, R. G. (2020). *Kajian Keterlambatan Proyek Engineering Procurement Construction Commisioning Jaringan Transmisi 150 kV Studi Kasus PLTP Karaha - GI Garut*. Jurnal TIARSIE Vol 17 No. 1.

Keshk, A. M., Maarouf, I., & Annany, Y. (2018). *Special Studies In Management Of Construction Project Risks, Risk Concept, Plan Building, Risk Quantitative And Qualitative Analysis, Risk Response Strategies*. Alexandria Engineering Journal, 1–9.

Muhammad, F. A. (2021). *Analisis Risiko dan Rencana Respon Pada Proyek Pembangunan Conveyor System Di Area Lepas Pantai*. Surabaya: Institut Teknologi Sepuluh Nopember

Mulcahy, R. (2010). *Risk Management, Trick of the Trade for Project Managers*. Chicago: RMC Publications Inc.

Novrizal, E. (2011). *Pemodelan Metode Matriks Kardinal (Fungsi Nilai) dalam Analisis Risiko Pembangunan Jaringan Transmisi Tenaga Listrik*. Bandung: Institut Teknologi Bandung.

Siswanto. (2007). *Operations Research*. Jakarta: Erlangga.

Strandard, A. (1999). *Standards Australia Risk Management AS/NZS 4360:1999*.

Trisanto, G. (2012). *Analisis Risiko Pekerjaan Proyek Pembangunan Jaringan Transmisi SUTT (Saluran Udara Tegangan Tinggi)*. Surabaya: Institut Teknologi Sepuluh Nopember.

US Military Standard MIL-STD-1629A. (1980). *Military Standard Procedures for Performing a Failure Mode, Effects and Criticality Analysis*.

Wantouw, F. & Mandagi R. J. M. (2014). *Manajemen Risiko Proyek Pembangunan Saluran Udara Tegangan Tinggi (SUTT) 150 kV Lopana-Tel*ng. Jurnal Ilmiah Media Engineering Vol. 4 No 4 ISSN : 2087-9334.

COACHING MODEL AS A TEAM MANAGEMENT BUILDING STRATEGY TO INCREASE STARTUP SUCCESS: A LITERATURE REVIEW

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ABSTRACT

In recent years, startup companies in Indonesia have grown rapidly, but many have failed. The success of a business requires good management and a team. One approach to building this is coaching which has been shown to have an impact on a variety of individual and organizational outcomes, such as individual skills and behavior, team performance, and productivity. This study aims to collect literature related to increasing startup success by building team management through a coaching approach. The literature review method was carried out by collecting and generalizing 20 journals regarding coaching methods with different coaching models. The results show that there are 5 important stages in the coaching model, Objective, which is to provide the basis for good teamwork by establishing the team's core mission and framing its goals, Identify, which is to identify roles that can be explained by authorities, responsibilities, and tasks and need to be aligned to support the goals set, Planning and Affirm is building plans and collecting alternatives that can be considered as solutions and determining the standard of interaction within the team, Action with awareness and motivation for changes that will be made to achieve goals and Monitoring & Review to improve coachee and business performance continuously (continuous improvement).

Keywords: literature review, startup companies, coaching model

1. INTRODUCTION

An entrepreneur has full autonomy to run a business in the form of a hobby or something he likes with the aim of getting maximum profit. This is the reason many individuals start to become an entrepreneur by establishing a startup. According to the European Association of Business Angels (EBAN), there are about 50 million new projects launched every year, or 137,000 per day. However, statistics in the literature of The 5th International Conference on Management of Technology, Innovation, and Project, 2022 show that around 90% of startups fail (Bednár and Tarišková, 2017). Triebel, et al (2018) stated that as many as 23% of startups failed due to "not the right team" based on the results of a survey conducted by the United States Company, CB Insights on 101 failed startups. This statement is supported by the research of Öndas (2021) which

confirms that startup failure is closely related to management problems, namely the lack of a competent team. Prohorovs, Bistrova & Ten (2018) emphasize that the success rate of startups tends to be higher if the startup is managed by entrepreneurs who can build teams and have high-level management skills.

This study aims to increase the success of startups by building team management through a coaching approach. Coaching has had an impact on a variety of individual and organizational outcomes, such as individual skills and behavior, team performance, and productivity (Meuse, Dai & Lee, 2009). Wiginton (2018) also states that team involvement shows statistically significant results from the coaching approach. The purpose of this research is to develop a coaching method for building good team management as a determinant of startup success and to help decision-makers to consider developing new methods to improve the professional attitude of startup founders. If the method is successfully applied, it is hoped that startups can present innovations and successfully develop according to their targets and benchmarks for success.

2. LITERATURE REVIEW

A startup is a human institution designed to create a new product or service under conditions of extreme uncertainty. A startup is a temporary organization designed to seek a repeatable and scalable business model. In this definition, a startup can be a new business or division, or business unit in an existing company. A startup is a company with product characteristics in the form of technology, an environment with a high level of uncertainty, massive growth, and the mode of operation is searching (Brikman, 2015).

Startup success can be measured by an achievement that identifies the results of startup business development. This success certainly cannot be generalized to everyone because it is adjusted to the success benchmarks that have been set by the individuals and companies concerned, as well as the performance of business actors related to ability, effort, and level of difficulty (Cahyono, 2005). Hamdani (2012) states that in general, the benchmark for successful business success focuses on actors who have competence, namely startup founders with knowledge, skills, and individual qualities which include attitudes, motivations, values, and behaviors needed to carry out work. or activities. On the other hand, Prohorovs, Bistrova & Ten (2018) emphasize that the success rate of startups tends to be higher if the startup is managed by entrepreneurs who can build teams and have high-level management skills.

Team management is the main function of any organization. Team Management plays an important role in increasing the productivity, profitability, and service quality of any organization. Team management is the ability of individuals or organizations to manage and coordinate a group of individuals to perform certain tasks (Mehek, 2020). The team's management strategy enhances the ability and capacity to perform better and improve overall project performance. effective development methodologies go hand in hand with increasing team productivity and organizational performance (Jayarathn & Weerakkody, 2016; Njue & Chandi, 2019).

Bang & Midelfart (2017) identified several variables that appear to be critical to the effectiveness of team management based on a review of international research on management and team decision-making. Variables are organized into 4 different categories:

1) Input factors are relatively stable characteristics of the management team and team environment. These variables can be seen as basic conditions for effective teamwork.
2) A process that refers to how the management team works. Processes include task-related processes such as how members work together on team tasks and interpersonal processes such as what happens on a psychological level when members work together.

3) Emergencies are "team natures which are usually dynamic and vary as a function of team context, inputs, processes, and outcomes" (Marks, Mathieu, & Zaccaro, 2001). They describe the cognitive, motivational, and affective states that emerge in teams and can be considered indicators of team viability (de Wit, Greer, & Jehn, 2012; Hackman, 2002).
4) Output factors that describe two different types of outcomes of achievement by the management team, task performance, and individual welfare and growth.

In addition, Tabassi, Abdullah & Bryde (2019) found that conflict management contributes to team effectiveness. Two conflict management styles of team leaders, namely the cooperative and avoiding styles, have a significant positive influence on team coordination. In addition, the two conflict management models have a direct impact on team performance.

Coaching is the consistency of the process of observation, providing feedback, counseling, taking corrective steps, and collaboratively developing certain plans. In coaching, it is necessary to make individual and continuous adjustments that focus on the issues at hand and changes that are relevant to the individual's problems (Mosca, Fazzari & Buzza, 2010). Peterson and Miller (2005) note that coaching is guided by two overarching principles, namely a coach who can be invited to work together where this is due to the differences of each person so it is not justified if everyone follows the same routine process and aims to become a great coach. If done properly, coaching can be an effective way to improve business results. Research shows that coaching which includes goal setting, problem-solving, practice, feedback, supervisory involvement, evaluation of final results, and public presentations will increase productivity fourfold compared to training alone (Olivero, Bane, & Kopelman 1997).

There are several critical success factors of coaching which are separated into two important dimensions. The first dimension is the actors in the coaching process, in this case, the coach and the coachee. A good coach-coachee relationship is critical to successful coaching. The second dimension is the time dimension from before and during coaching. The duration of coaching is mostly not problematic because it has an indirect impact on the success of coaching. There is no perfect duration for coaching. Some problems can be solved in a very short time whereas others should lead to a larger number of training sessions. Therefore, the number of coaching sessions should be flexible to allow for optimal coaching effect. In this case, the coaching program will be successful if the coach and business founder can comply with all the rules and meet the criteria. This success must be measurable in certain outcome variables, such as income, number of employees, turnover, and satisfaction (Loersch, 2014).

The coaching program that has been implemented for various purposes has its role that has an impact on the performance of an individual or an organization's business. Coaching is often used as a tool that has the potential to build human resources and the organization itself. This is because the role of coaching can lead individuals to better performance which has a positive impact on the welfare of the company. Utrilla, Lorenzo & Torraleja (2015) describe a conceptual model for the study of coaching as follows:

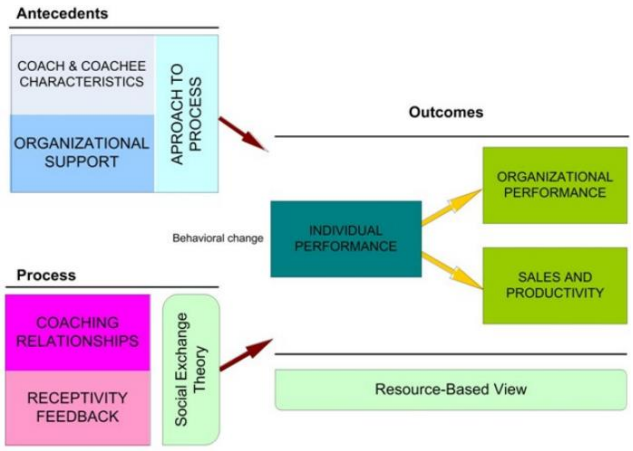


Figure 1. The Theoretical Framework For The Study Of Coaching.
(Source: Utrilla, Lorenzo & Torraleja, 2015).

The framework translates that coaching is a useful tool for professional development in organizations. When the coaching process is carried out according to the proposed criteria, both coach and coachee will have a significant impact, especially for coachees who show increased individual performance. The coaching process provides individuals with some attributes that are converted into valuable capital for the company. As a result, competitors will be difficult to imitate, thus making the resulting competitive advantage more sustainable. Improved individual coachee performance obtained from the coaching process will be translated into better performance in their daily work in the company, which will positively affect the performance and productivity growth of the organization (Utrilla, Lorenzo & Torraleja, 2015). This can be caused by several factors, first, namely, the duration of the process which is more focused on the short term, so that its implementation is cheaper for the company than the long term oriented. However, if implemented in the long term, it will have a direct causal effect on company performance, such as employee performance and company growth. The second factor is that coaching directly and immediately affects professional performance so that it can benefit the business quickly (Utrilla & Torraleja, 2013).

Another study on coaching in startups conducted by Setyawati (2016), clarified that a coach channeled a positive influence by giving time, special attention, advice, training to start a business, and directing to focus on business goals so that they could advance the business. In addition, coaching influences the business startup stage because coaches provide motivation, knowledge, and skills to manage a business, and how to behave in business. The success of a startup business can be measured by the efforts that have been made by young entrepreneurs in running their business, such as always being careful, carrying out business activity documentation properly, having a concern for wanting to work well, increasing productivity, and making big changes in their business.

3. METHODS

The literature review method has been carried out by collecting as many as 20 journals regarding coaching methods with varied objectives where each journal has a different coaching model. This shows that there are no standards regarding the coaching framework and guarantees that a certain model will increase the success of coaching there are so many models that are implemented according to the needs of the coachee.

This study uses a coaching method that is under the research objective, namely building a good management team that will produce a competent and professional team. The literature review is carried out by generalizing the coaching method used. The main point is not only to mention the effect or contribution of coaching on individual and organizational performance but also to explain the program and coaching model used.

4. RESULTS

Based on the results of a literature review conducted by collecting 20 journals, Table 1 below is a review of each of these journals:

Table 1. Literature Review on Coaching Method

No	Author(s)	Objective	Coaching Programs / Methods
1	Heinrich et al., 2021	Organize and implement high-impact educational practices.	GORP Framework (Gravity, Ownership, Relationship, and Place)
2	Guedes, 2021	Development of skills, knowledge, and disposition of teachers to build capacity as educators.	GROW (Goal, Reality, Options, Will) Coaching Model
3	Richter et al., 2021	Facilitating professional growth	Positive psychological coaching (PPC) Phase 1 (Creating the Relationship) Phase 2 (Strengths Profiling and Feedback) Phase 3 (Developing an Ideal Vision) Phase 4 (Realistic Goal Setting, Strategizing, and Execution) Phase 5 (Concluding Relationships and Re-contracting)
4	Thipatdee, 2019	Developed the student teachers' performance and behaviors	GROW (Goal, Reality, Obstacles, Options, Way Forward) Coaching Model
5	Knight, 2019	Support teachers learn new strategies in the context of their day-to-day work and help students attain higher achievement and greater well-being	ILI Model : a) Identify b) Learn c) Improve
6	Gray, 2018	More effectively prepare, support, and sustain new school leaders in the field and profession	Leadership preparation, Leadership-focused coaching, Mentoring, and Experiential Learning
7	Burke, 2018	Practice positive psychology coaching, and inform the policy and curriculum of programs teaching positive psychology coaching in third-level education.	Positive Psychology Coaching consists of six elements: 1. Knowledge, 2. Strength-based models, 3. Positive diagnosis, 4. Optimal-functioning goals, 5. Positive psychology interventions, 6. Positive measures
8	Balci, 2017	Coaching process of developing leadership potential in the universities	Model GROW, Monitoring, Evaluation
9	Yapardi & Milawaty, 2016	Leadership education and training	GROW Model
10	Deiorio et al., 2016	Academic coaching in medical	These constructs focus on

		education.	1) establishing relationship principles, 2) conducting learner assessments, 3) developing and implementing an action plan, and 4) assessing results and revising plans accordingly
11	Miller, 2016	Develop students holistically by measuring both cognitive and non-cognitive factors of student success	PROSPER program. Tools used to determine the effective outcomes, like self-efficacy, Data on student performance GPA, Academic Probation, Attendance, LRC.
12	Brown, 2016	Professional development	a) Planning b) Collaborations c) Modeling d) Observations e) Consultations
13	Newman, 2015	Student and graduate nascent entrepreneurs at the University of Central Lancashire (UCLan).	Introductory Enterprise Coaching/Mentoring Session Incorporating OSKAR. 1. Introduction and Rapport 2. Establish Outcome 3. Scaling 4. Know-How 5. Affirm 6. Action Coaching in the Entrepreneurial Iterative Learning Process at UCLan : Awareness => Mindset & Capability => Venture Creation => Venture Building
14	Garbacz et al., 2015	Learn critical instructional and behavior management skills	EBIs focused on ways to train teachers in intervention tactics, and procedures to support teacher implementation - Goal Setting - Skill Building (Modeling With Practice, Behavioral Rehearsal, Live Prompting) - Support for Implementation (Verbal Performance Feedback, Graphic and/or Written Performance Feedback, Reinforcement)
15	Cervera, 2014	Introduced the concept of coaching and two successful models for its implementation:	The FUEL model consists of four elements: (a) context of the conversation, (b) the current state of the coachee, (c) desired state, and (d) action plan to achieve the desired state
16	Mosca, Fazzari & Buzza, 2010	Train sales employees (salesmen)	a. Clarifying expected performance b. Evaluating sales performance c. Planning for sales performance
17	Cote & Gilbert, 2009	Coaching, teaching, positive psychology, and athletes' development	Participation Coach for Adolescents and Adults: Provide, Afford, Teach and Asses, Teach Performance Coach for Young

			Adolescents: Organize, Teach, Offer, Teach and Assess, Present Positive Growth Performance Coach for Older Adolescents and Adults: Set Up Training, Allow Rest, Prepare, Teach and Assess, Provide
18	Palmer, 2008	Focus on solution-seeking and implementation and avoid problem-talk.	Steps: Problem Identification, Realistic (Relevant Goal Developed, e.g SMART Goals), Alternative solutions generated, Consideration of sequences, Target most feasible solutions, Implementation of Chosen solutions, Evaluation
19	Joo, 2005	Learning, development, behavioral change, performance, leadership, career success, and organizational commitment.	- Antecedents (Coach Characteristics, Coachee Characteristics, Organizational or Client Support) - Process (Coaching Approach and Relationship, Feedback Receptivity) - Proximal Outcomes (Self Awareness, Behavioral Change, Learning) - Distal Outcomes (Individual Success – Organizational Success)
20	Neenan & Palmer, 2001	Focus on problem-solving in a structured and systematic way.	1. Problem identification 2. Goal selection 3. Generation of alternatives 4. Consideration of consequences 5. Decision making 6. Implementation 7. Evaluation

The outline of the entire coaching method applied to the entire journal is that goal setting at the beginning of the activity is crucial. This is because the goals or objectives will be used as targets for the success of coaching, as well as being the basis for the direction of the coaching program. It is also important to carry out a comprehensive current condition from the coachee to better understand the extent of the steps that have been taken, what problems are being faced, as well as what possible actions to be taken as a solution to the problem. Next is planning or planning what kind of action can be carried out to achieve the goal. The planning can describe several alternatives that consider the potential advantages, weaknesses, and risks of each alternative. One alternative can be chosen to be built into an optimal scenario to achieve the goal. From this scenario, it is continued to the implementation stage by the coachee who is monitored by the coach to help direct and control the application of the selected scenario. The last step is a review or evaluation or assessment to assess and see to what extent these steps can achieve the predetermined goals and do not rule out the possibility that there is a revision or readjustment of the selected scenario to make it more relevant to the current conditions. Based on these points, the following is a coaching model that is under the research objective, namely building team management which is visualized in Figure 2:

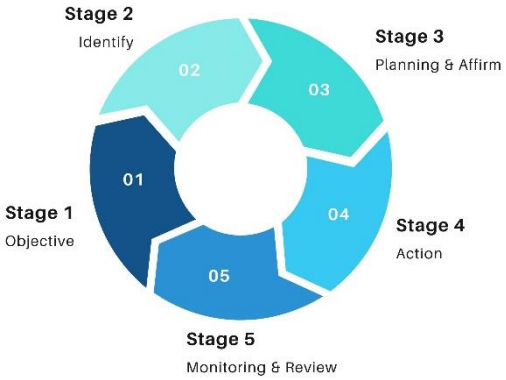


Figure 2. Coaching Model for Team Management

1. Objective

Provides the basis for good teamwork by establishing the team's core mission and framing its goals. A coach provides direction to the team, enabling them to understand where they are now, determine where they want to go, and unite each effort to get there. Shared goals are what makes a team a team. Without clear, shared, and agreed goals, any team development will have limited impact. Team members must understand, accept, share, and commit to a common goal. These valid goals must be Specific, Measurable, Achievable, Relevant, and Time-bound (Raue et al, 2013).

2. Identify

This phase is intended to allow the coachee to develop an emotional connection with the changes that will occur by describing his situation (Janse, 2001). The coach helps the team to identify what are the biggest drawbacks of the team. In addition to the team, identification needs to be deepened on each individual, especially their strengths and weaknesses. With this identification, the team will know themselves better and realize which side needs to be improved and improved. Furthermore, identification can also determine the role of each member. Roles can be defined by authorities, responsibilities, and duties and need to be aligned to support the stated goals.

Functional roles are defined by the tasks that need to be performed and require different types of skills, knowledge, experience, and so on (Biddle, 1986). In line with the important factors in startup success, namely experience and knowledge, which have been proven to play an active role in maintaining startup success (Sahaf & Tahoo, 2021). The team must understand, agree, and be satisfied with the roles and responsibilities individually and collectively. This is the basis of a clear process for addressing, clarifying, and resolving issues. A clear role definition takes into account the interdependence of authority, responsibility, and duty to deliver and achieve team role goals and objectives, aligned with individual goals (Raue et al, 2013). A clear perception of the role has a positive effect on career commitment, organizational commitment, and employee performance in the workplace (Kalkavan & Katrinli, 2014).

3. Planning and Affirm

In the planning stage, the coach helps the team build a plan and gather alternatives that can be considered as solutions. If an unrealistic alternative exists, it can be modified to suit the problem at hand. Brainstorming can be used to find the ideal solution where the coach can help to explore potential, open insights, discuss, and make choices with coaches. In addition to alternative solutions, it is necessary to determine the standard of interaction within the team.

Setting smart standards for action, decision making, conflict management, problem-solving, communication procedures, resource allocation, and so on will effectively support team goals by defining interactions within the team. By doing so, a team can gain significant insight into how the work gets done, as process flows will be identified. People will be in a position to work together efficiently by responding quickly to constraints in a team (Raue et al, 2013).

4. Action

   At this stage, the coachee has gained awareness and motivation to take responsibility for the changes that will be made to achieve the goal (Asmoko, 2015). Coachees must show their ways to change and consider the impact of those changes. Janse (2021) suggests doing this in a 5W+1H question-based approach.

5. Monitoring & Review

   To ensure the coachee achieves the ultimate goal, the coach needs to pay attention to motivating the coachee, because in most cases that is the key to success (Kunos, 2017). During the intervention and evaluation sessions, it is important to reflect on what has been decided and what should have happened. This can be done effectively with dedication. Whenever a change has been made, it is a good idea to revisit that action (Janse, 2021). The purpose of the evaluation is to improve the performance of the coachee and the business continuously (continuous improvement).

6. CONCLUSIONS

This study aims to develop a coaching framework that is used to build good team management for startup founders so that they can increase startup success through a coaching approach. The coaching model carried out consists of 5 stages, namely Objective which is to provide the basis for good teamwork by setting the team's core mission and framing its goals, Identifying which is to identify roles that can be explained by authorities, responsibilities, and tasks and need to be aligned to support the goals set, Planning and, namely building plans and collecting alternatives that can be considered as solutions and determining the standard of interaction within the team, Action with awareness and motivation for changes that will be made to achieve goals and Monitoring & Review to improve coachee and business performance continuously (continuous improvement).

The consolidation and generalization process in this paper is used to narrow the broad realm of coaching as well as the first step in developing a coaching model to build good team management. The next step can be to validate the model that has been determined against the views of experienced practitioners. In addition, it is also necessary to determine the variables that affect the indicators of success.

Further research can test the model by combining qualitative and quantitative methods to see how effective the model is, and can add indicators of success or team management performance. More broadly, it can add to the impact of team development on the success and progress of a startup.

REFERENCES

Bang, H., Midelfart, T.N. (2017). What characterizes effective management teams? A research-based approach. *Consulting Psychology Journal: Practice and Research*, 69 (4), 334 – 359.

Balci, Y. (2017). Coaching As A Modern Method Of Development Of Leadership Potential In University. *International Scientific Journal of Universities and Leadership*, 1 (4), 1 – 11.

Bednár, R., Tarišková, N. (2017). Indicators of startup Failure. *International Scientific Conference: Industry 4.0* 2, 276 - 279.

Biddle, B.J. (1986). Recent Developments in Role Theory. *Annual Review of Sociology*, 12 (1), 67 – 92.

Brikman, Y. (2015). *Hello, Startup: A Programmer's Guide to Building Products, Technologies, and Teams*, 1st Edition, O'Reilly Media, California.

Burke, J. (2018). Conceptual framework for a positive psychology coaching practice. *The Coaching Psychologist*, 14 (1), 16 – 25.

Brown, C.S. (2016). A Conceptual Framework for Coaching that Supports Teacher Development. *Journal of Education & Social Policy*, 3 (4), 14 - 25.

Cervera, C.M. (2014). *Successful coaching models: The FUEL and the Mindful Coach frameworks in context*. Retrieved From: https://www.academia.edu/35520211/Successful_coaching_models_The_FUEL_and_the_Mindful_Coach_frameworks_in_context

Côté, J., Gilbert, W.D. (2009). An Integrative Definition of Coaching Effectiveness and Expertise. *International Journal of Sports Science & Coaching, 4*, 307 - 323.

De Meuse, K.P., Dai, G., Lee, R. (2009). Evaluating the effectiveness of executive coaching: Beyond ROI?. *Coaching: An International Journal of Theory Research and Practice*, 2 (2), 117 - 134.

De Wit, F.R., Greer, L.L., & Jehn, K.A. (2012). The paradox of intragroup conflict: Ameta-analysis. *Journal of Applied Psychology*, 97 (2), 360 - 390.

Deiorio, N.M., Carney, P.A., Kahl, L.E., Bonura, E.M., & Juve, A.M. (2016). Coaching: a new model for academic and career achievement. *Medical education online 21*, 1 - 4.

Garbacz, S., Lannie, A., Jeffrey-Pearsall, J., Truckenmiller, A. (2015). Strategies for Effective Classroom Coaching. *Preventing School Failure: Alternative Education for Children and Youth*, 59 (4), 263 - 273.

Gray, J.A. (2018). Leadership Coaching and Mentoring: A Research-Based Model for School Partnerships. *International Journal of Education Policy and Leadership*, *13* (12), 1 – 17.

Guedes, B.A. (2021). What effect does the coaching model of professional development have on the building of teacher capacity?. *Doctoral Dissertation, The University of Melbourne*. Retrieved From: jupiter.its.unimelb.edu.au:11343/260492.

Hamdani, M. (2012). *Buku Ajar Entrepreneurship untuk Mahasiswa: Sebuah Solusi untuk Siap Mandiri*, Trans Info Media, Jakarta.

Hackman, J.R. (2002). *Leading teams: Setting the stage for great performances*, Harvard Business School Press, Boston.

Heinrich, W.F., Louson, E., Blommel, C., Green, A.R. (2021). Who Coaches the Coaches? The Development of a Coaching Model for Experiential Learning. *Innov High Educ* 46, 357 – 375.

Jayarathna, D.Y., Weerakkody, W.A. (2016). Impact of Decision Making, Reward Management on Job Performance: Mediation of Job Satisfaction: A Case of a Private Banks in Sri Lanka. *European Journal of Business and Management,* 8 (32), 65 – 73.

Janse, B. (2021). *CLEAR Coaching Model by Peter Hawkins*. Retrieved from https://www.toolshero.com/management/clear-coaching-model/.

Joo, B. K. (2005). Executive Coaching: A Conceptual Framework From an Integrative Review of Practice and Research. *Human Resource Development Review*, 4 (4), 462 – 488.

Kalkavan, S., Katrinli, A. (2014). The Effects Of Managerial Coaching Behaviors On The Employees' Perception Of Job Satisfaction, Organisational Commitment, And Job Performance: Case Study On Insurance Industry In Turkey. *Procedia - Social And Behavioral Sciences*, 150 (150), 1137 – 1147.

Knight, J. (2019). Instructional Coaching for Implementing Visible Learning: A Model for Translating Research into Practice. *Education Sciences*, *9* (2), 101.

Kunos, I. (2017). Role Of Coaching Models. *International Journal of Research in Business Studies and Management*, 4 (9), 41 - 46.

Marks, M.A., Mathieu, J.E., Zaccaro, S.J. (2001). A temporally based framework andtaxonomy of team processes. *Academy of Management Review*, 26 (3), 356 - 376.

Mehek, A. (2020). Team Management: Effective Tool. *International Research Journal of Modernization in Engineering Technology and Science,* 2 (6), 1376 – 1379.

Miller, A.P. (2016). *An Academic Coaching Model for First-Year Student Success*. Concordia University Wisconsin. Retrieved From: https://www.researchgate.net/publication/316526557_An_Academic_Coaching_Model_for_First-Year_Student_Success.

Mosca, J.B., Fazzari, A.J., & Buzza, J. (2010). Coaching To Win: A Systematic Approach To Achieving Productivity Through Coaching. *Journal of Business & Economics Research,* 8 (5) , 115 – 130.

Neenan, M., Palmer, S. (2001). Cognitive Behavioral Coaching. *Stress News, 13* (3), 14 - 18.

Newman, J.A. (2015). An Integrated Coaching Model for the Student and Graduate Entrepreneurial Learning Environment. *UCLan Journal of Pedagogic Research*, 6 (1), Retrieved from: https://pops.uclan.ac.uk/index.php/ujpr/article/download/331/135.

Njue, N.G., Chandi, J.R. (2019). Influence of Team Management Practices on Performance of community-Based Projects in Embu County, Kenya. *European Scientific Journal ESJ*, 15 (10), 293 – 313.

Olivero, G., Bane, D., Kopelman, R.E. (1997). Executive coaching as a transfer of training tool: Effects on productivity in a public agency. *Public Personnel Management,* 26 (4), 461 - 470.

Öndas, V. (2021). A Study on High-tech Startup Failure: Antecedents, Outcome and Context. *Master's Thesis, JAMK University of Applied Sciences,* DOI:10.13140/RG.2.2.25524.37765.

Palmer, S. (2008). The PRACTICE model of coaching: towards a solution-focused approach. *Coaching Psychology Internasional*. 1 (1). 4 - 8.

Peterson, D.B., Millier, J. (2005). The alchemy of coaching: "You‟re good Jennifer, but you could be really good". *Consulting Psychology Journal*, 57 (1), 14 - 40.

Prohorovs, A., Bistrova, J., Ten, D. (2018). Startup success factors in the capital attraction stage: Founders' perspective. *Journal of East-West Business*, 25 (1), 26 – 51.

Raue, S., Tang, S.H., Weiland, C.W., Wenzlik, C. (2013). *The GRPI model – an approach for team development,* 2nd Edition, Systemic Excellence Group. Retrieved from : https://hsrc.himmelfarb.gwu.edu/.

Richter, S., Van Zyl, L. E., Lara, C., Stander, MW. (2021). Positive psychological coaching tools and techniques: a systematic review and classification. *Frontiers in Psychiatry* 12, 1 - 19.

Sahaf, M.A., Tahoo, L.A. (2021). Examining the Key Success Factors for Startups in the Kingdom of Bahrain. *International Journal of Business Ethics and Governance*, 4 (2), 9 - 49.

Setyawati, C.Y. (2016). Mentoring the Impact of Success of a Start-Up Business: A Case Study of a Start-Up Business in Indonesia. *DeReMa (Development Research of Management) Management Journal 11*, 290 - 310.

Tabassi, A.A., Abdullah, A., Bryde, D.J. (2019). Conflict management, team coordination, and performance within multicultural temporary projects: Evidence from the construction industry. *Project Management Journal*, 50 (1), 101 - 114.

Thipatdee, G. (2019). The development of coaching and mentoring skills through the GROW technique for student teachers. *Journal of Education and Learning*, 8 (5), 168 – 174.

Triebel, C., Schikora, C., Graske, R., Sopper, S. (2018). *Failure in startup companies: why failure is a part of founding*. https://doi.org/10.1007/978-3-319-72757-8_9.

Utrilla, P.N., Grande, F.A., Lorenzo, D. (2015). The effects of coaching in employees and organizational performance: the Spanish Case. *Intangible Capital 11*, 166 - 189.

Wiginton, J.G. (2018). *A Case Study: Broad Insights, A Survey of Business Coaching Impacts on Companies and Their Leaders*. Paris School of Business, Paris. Retrieved from https://broadinsights.com/.

Yapardi, N., Milawaty, M. (2016). Grow Model As An Alternatif Approach To Coaching Process In Leadership Training And Education Level IV At PKP2A II LAN. *Jurnal Transformasi Administrasi*, *6* (2), 1172 – 1187.

LEAN MAINTENANCE MANAGEMENT FOR THE SELECTION OF ALTERNATIVE EFFICIENCY MAINTENANCE ACTIVITIES IN STEEL SMELTING FACTORIES

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ABSTRACT

Maintenance is one of the important factors in an industry to ensure that equipment can run well and reliably. Efficiency in maintenance process must be considered so the downtime that occurs is not too excessive due to the waste that occurs during the process. This research was conducted at a Steel Smelting Factories which has high documentation of downtime. The Lean maintenance approach is used to analyze and reduce the waste generated in the maintenance process by identifying non-value-added activities using the Maintenance Value Stream Mapping. Root cause analysis using the 5 why's method also carried out to provide the recommendations to reduce waste. Based on the results of current maintenance value stream mapping, waste is obtained in the form of centralized maintenance, ineffective data management, poor inventory management, poor maintenance, under-utilization of resources, and waiting for maintenance resources. There are 3 alternative improvements, namely carrying out internal training related to standard maintenance standards and basic mechanical repairs to maintenance technicians, supervisors, and machine operators, making an IT e-Maintenance system, and making an inventory database of equipment and spare parts. The result obtained is a reduction in repair time by up to 25 – 30 minutes, especially in activities that are administrative

Keywords: Lean Maintenance, Maintenance Value Stream Mapping, Downtime, 5 Why's

1. INTRODUCTION

The smoothness of the production process is one of the factors in supporting the success of the manufacturing industry in producing quality products, punctuality of completion time, and efficient production costs. Industrial machinery is an important part of the successful business of the manufacturing industry so it requires special attention to achieve the smooth operation of an industry with maintenance. Alsyouf (2007) states that efficient maintenance policies can affect the productivity and profitability of manufacturing processes through their direct impact on the quality, efficiency, and effectiveness of operations. Nursanti, et al (2019) also stated that in their efforts to maintain machinery or equipment so that the sustainability of production is guaranteed, maintenance activities must also run effectively and efficiently by reducing waste to increase the efficiency of the process so that downtime does not run too long.

The Steel Smelting Plant is one of the 3 factories operating in the company's area and among the three factories, this factory is a vital area where the beginning of the process of the product will be carried out. The length of downtime that occurs in almost every machine when there is damage becomes a special problem because it affects the running production process. The factory has a maintenance policy along with documentation in the form of damage records, downtime, and repair or repair times under the auspices of the maintenance division and records

several factors that cause downtime along with the length of time and it is known that not only the repair process but also there are other things such as waiting for manpower and procurement of spare parts materials that are too long. This can also show that the maintenance process has not run efficiently. The longer the downtime, the more it can indicate the presence of waste that affects the production and maintenance processes so that it runs inefficiently.

To evaluate the efficiency of maintenance activities, there is an approach that can be done, namely with Lean maintenance. Lean maintenance is expected to be able to reduce waste caused by the maintenance process by identifying activities that are not value-added and creating a smooth flow of value throughout maintenance activities. Smith & Hawskin (2004) states that Lean maintenance can reduce desired resources through waste elimination in all maintenance processes and activities. Mostafa, Dumrak, & Soltan, (2015) also supports the same by clarifying that Lean maintenance can reduce unscheduled downtime through optimization of maintenance support activities such as problems related to machines, quality, and human resources related to maintenance activities.

2. LITERATURE REVIEW

Maintenance has become very important in production systems. The paradigm shift towards efficient asset lifecycle management has led to the incorporation of various techniques, philosophies, and technologies to achieve higher levels of system performance and sustainability. In recent years, efforts have been made to propose and improve maintenance strategies aimed at extending the useful life of each existing equipment, increasing its availability, and guaranteeing a higher level of reliability. According to Kaczmarek & Szafer (2016), poor care also affects consumer confidence. Frequent failures leading to unplanned downtime can hinder deliveries to customers and a bad reputation for the company. The application of lean methodologies can focus on manufacturing efficiency and the application of maintenance to ensure its success.

2.1 Lean Maintenance

In recent years, lean thinking has become popular in many different sectors, for example, food, manufacturing, and process industries. Womack & Jones (2007) states that Lean maintenance is an approach based on lean thinking that is applied in maintenance operations by reducing or eliminating activities that do not add value, such as inventory, overproduction, inspection, and transportation. According to Kaczmarek & Szafer (2016), poor care also affects consumer confidence. Frequent failures leading to unplanned downtime can hinder deliveries to customers and a bad reputation for the company. The application of lean methodologies can focus on manufacturing efficiency and the application of maintenance to ensure its success. Kolanjiappan (2015) argues that the purpose of Lean Maintenance is to minimize waste, or reduce activities that do not add value and customers are unwilling to pay for: waiting times, moves, excessive maintenance, excessive resource applications, and rework. Likewise, Duran, et al (2016) mentioned that the reduction of waste in maintenance means a better organization in the stock of parts, and the standardization of maintenance procedures The process of maintenance it is also possible to find seven main types of waste as follows:

1. Unproductive maintenance: excessive preventive maintenance and at non-optimal frequencies
2. Waiting for maintenance resources: waiting for tools, documentation, spare parts, and technicians.
3. Centralized maintenance: located far away from the work station, spare parts are not easily accessible, work orders are not available, all-cause transportation overload
4. Poor maintenance: rework, which affects maintenance costs and quality of service

5. Unnecessary motion: Wasted movements that occur in preventive maintenance activities such as monthly inspections on tools that do not have a change in status for a long time.
6. Poor inventory management: absence of spare parts inventory than needed
7. Under-utilization of resources: This waste occurs when maintenance technicians are carrying out non-value-added activities: searching for spare parts, equipment, documents

2.2 Maintenance Value Stream Mapping

Maintenance Value Stream Map (MVSM) is a method used to describe the flow of maintenance activities developed from VSM (Value Stream Mapping) to identify waste in maintenance activities. The MVSM method is distinguished based on the maps created, namely the current state map and the future state map. Based on the map that has been created, activities that do not have added value (non-value added) and have added value (value-added) can be known in the form of time in each process flow. MVSM serves to describe the company's actual maintenance activities so that an overview of activities that have added value is obtained, namely Mean Time to Repair (MTTR) and activities that do not have added value, namely Mean Time to Organize (MTTO) and Mean Time to Yield (MTTY). MTTO is the time it takes to coordinate the tasks in initiating maintenance repairs, MTTR is the time it takes to repair and maintain equipment whereas MTTY is the time it takes to produce a good part after maintenance.

3. METHODS

The first process that must be carried out in this study is to make a current state mapping of maintenance activities with existing conditions. This current state mapping will show details of the activity and time emitted in detail. After the current state mapping has been compiled, then the waste can be identified according to its category and further analyzed to find the root cause using the 5 why method. Brainstorming is carried out with all factory maintenance personnel from the supervisor level to staff to objectively see what are the causes of waste and what recommendations can and want to be given. The alternative improvements selected will then be estimated to see how much influence it has to minimize the waste that occurs. Future state mapping is then prepared by conditioning the improvements that have been planned and compared with previously existing conditions.

4. RESULTS

Monitoring is carried out in 2 aspects, namely maintenance activities in the form of preventive maintenance and corrective maintenance carried out at one of the production facilities. The results of these observations will be poured into the form of value stream mapping so that waste identification can be carried out from the ongoing maintenance process. Preventive maintenance activities are carried out on the sand reclamation machine where the machine functions in a shake-out process that aims to remove the cast results from the mold and ensure that no sand sticks to the surface of the cast result. Corrective maintenance activities are carried out on the blast hanger machine, which is during the process of replacing blade impeller components.

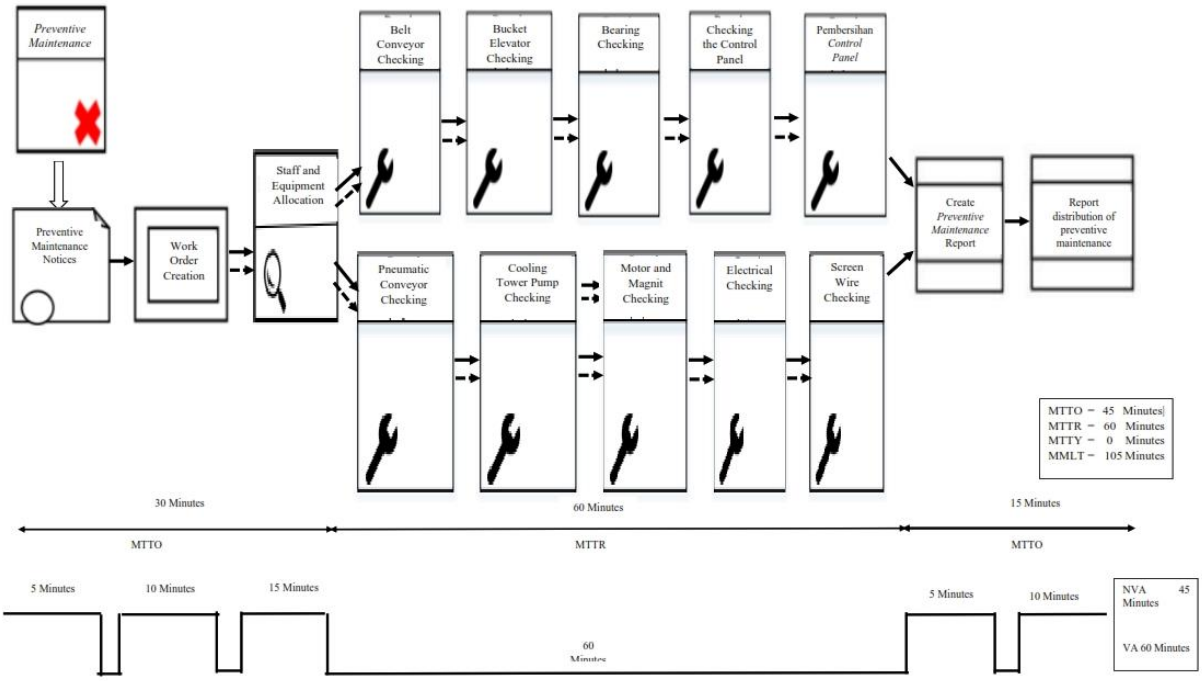


Figure 1. Current Value Stream Mapping Preventive Maintenance

Based on Figure 1, it can be seen that there are non-value added activities from Mean Time To Organize (MTTO) with an estimated time of 45 minutes from administrative and organizational activities such as reporting and waiting for the allocation of available resources and equipment. In addition, the activity included in the value added category is the Mean Time to Repair (MTTR) with an estimated time of 60 minutes.

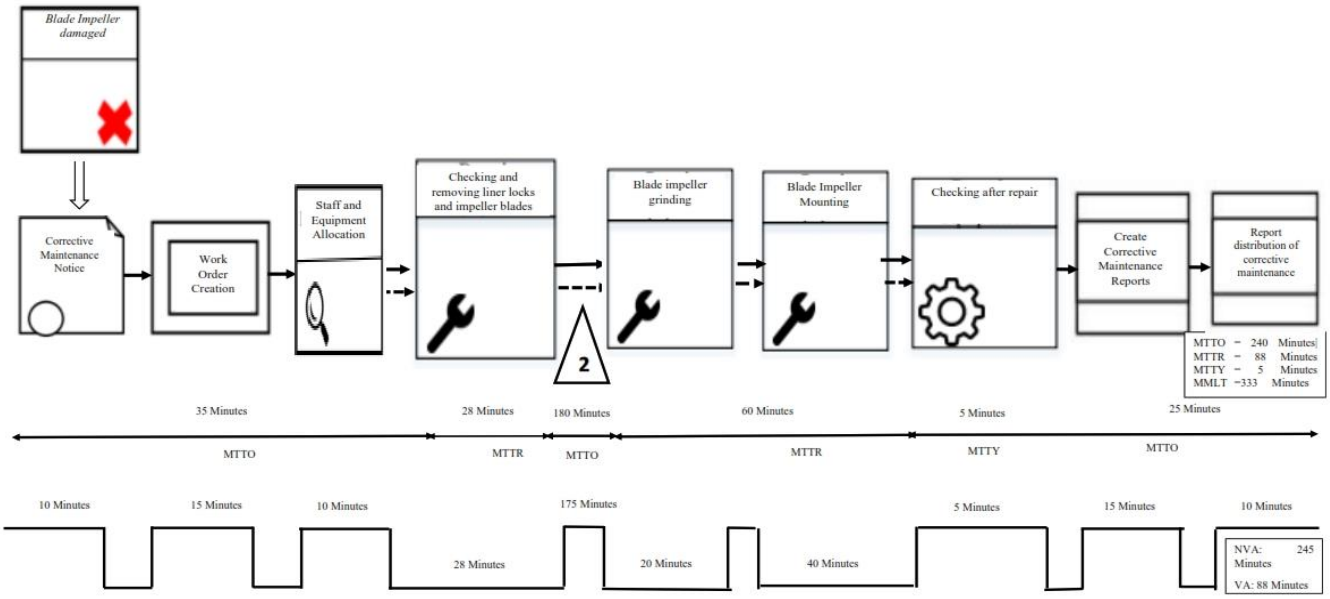


Figure 2. Current Value Stream Mapping Corrective Maintenance

Based on Figure 2, it can be seen that non-value added activities from Mean Time To Organize (MTTO) with an estimated time of 60 minutes from administrative and organizational activities such as reporting and waiting for resource allocation and 180 minutes of delays due to the unavailability of spare parts and other components needed so that it takes time to carry out the search and procurement process. There is Mean Time to Yield (MTTY) for 5 minutes due to the set up. Additionally, the repair or Mean Time to Repair (MTTR) runs for 88 minutes.

Waste identification is carried out on several types of waste from maintenance. Waste found in maintenance activities is centralized maintenance, ineffective data management, poor inventory management, poor maintenance, under-utilization of resources, and waiting for maintenance resources. To analyze the root cause of the problem in each waste, identification of Root Cause Analysis (RCA) was carried out using the 5 Why's a method. The root cause of the problem is compiled based on the results of observations directly to the Company and conducting interviews with supervisors and maintenance staff, especially at the Steel Smelting Plant.

Table 1. Root Cause from Waste Using 5 Why's Method

No	Maintenance Waste	Waste Description	Why 1	Why 2	Why 3	Why 4	Why 5
1	*Centralized maintenance*	Incomplete repair documentation	Documentation is still done manually	SPV time limitations to instantly document each fix	Limited time for SPV to document maintenance activities		
		There is a difference in understanding of the best way and order in the maintenance process	There is no specific standard for how repairs are made even though it has become a case that is often done	No specific training is planned so not all technicians understand the case of repairs to be made to each machine	There are no special programs created by the human capital department and there are no special standards made by the maintenance department for machine repairs, especially in the case of frequent repairs.		
2	*Ineffective Data Management*	Repair recaps and repair submissions are still done manually	There is no specially built integrated IT system yet so that reporting, job requests, and repair history can be done and known quickly and precisely	Limited costs in submitting vendors to create IT systems desired by the maintenance department			

No	Maintenance Waste	Waste Description	Why 1	Why 2	Why 3	Why 4	Why 5
3	*Poor Inventory Management*	No spare part components available in the warehouse	There is no special annual procurement of spare parts submitted by the maintenance department	Limited costs allocated by the Company so that the maintenance department prefers to buy when damage cases occur			
		Manufacture and adjustment of spare parts made by maintenance technicians themselves	The existence of a target of completing maintenance quickly by the production department and the process of finding the desired spare parts takes a long time	No spare part components available in the warehouse	Limited costs allocated by the Company so that the maintenance department prefers to buy when damage cases occur		
4	*Poor Maintenance*	Preventive maintenance activities that are not carried out on schedule	The number of request orders for repair work submitted by the production department	The maintenance department prioritizes the improvement to be carried out in advance rather than preventive maintenance that has been submitted and scheduled	Limited allocation of available maintenance personnel	There are internal problems of the Company so that efficiency is carried out on the needs of employees	
	Poor Maintenance	Technicians require several machine setups when finished performing maintenance	There is a difference in understanding of the best way and order in the maintenance process so that there are doubts when the repair process is completed	There are no specific standards regarding how repairs are carried out even though they have become frequent cases	There is no specific training planned so not all technicians understand the case of repairs that must be carried out on each machine	There are no special programs created by the human capital department and there are no special standards made by the maintenance department for machine repairs, especially in the case of frequent repairs.	
5	*Under-Utilization of Resource*	Repeated picking of spare parts or maintenance equipment	Technicians have not allocated maintenance equipment needs correctly	The maintenance equipment used is limited so there is waste in waiting for its availability	Equipment is often lost and not centralized so it takes time to search	There is no recording in and out of the use of maintenance inventory	

No	Maintenance Waste	Waste Description	Why 1	Why 2	Why 3	Why 4	Why 5
6	*Waiting for maintenance resources*	SPV takes time to find available technicians	Many orders for repair and maintenance work but the maintenance department has a limited number of technicians	There are internal problems of the Company so that it makes efficient to the workforce in the maintenance department			
		The spare parts procurement process takes a long time	The maintenance department does not have spare parts stock available so they must order from the procurement department in case of damage	The procedure of procurement process requires approval from many parties	Related to the availability of financing for the purchase of spare parts.		

Based on the table above, 10 sub-wastes were obtained where there were two having the same type of root cause so that a total of 6 root causes were obtained that must be given recommendations for improvement. Here are some alternative improvements proposed:

1. Alternative 1: Carry out Internal Training related to standard standards of maintenance and basic repair of machines to maintenance technicians, area supervisors, and machine operators.
2. Alternative 2: Creation of an e Maintenance integrated IT system
   The e Maintenance system is arranged in an integrated manner and accessible to all parts and production levels, both operators, mechanics, area supervisors, maintenance, PPC to factory managers. With open access, if there is damage to a machine, the operator can immediately input a damage report and the report is delivered immediately to other parties including maintenance. The maintenance department can also quickly allocate resources to respond to the damage.
3. Alternative 3: Creation of a special database of inventory of equipment and spare parts.
   The warehouse department creates data on the availability of spare parts and toolboxes. With a continued report on this availability, it can be a joint study material for increasing the number of spare parts and maintenance toolboxes and also the allocation of needs if there is damage can be immediately met quickly and precisely so that the time of maintenance activities can be shortened.

Based on the alternative recommendations prepared, the Factory agrees to implement all alternatives because the whole can be implemented and is urgently needed. Furthermore, future state mapping is made to see how the condition after improvement is made and compared with the previous existing state.

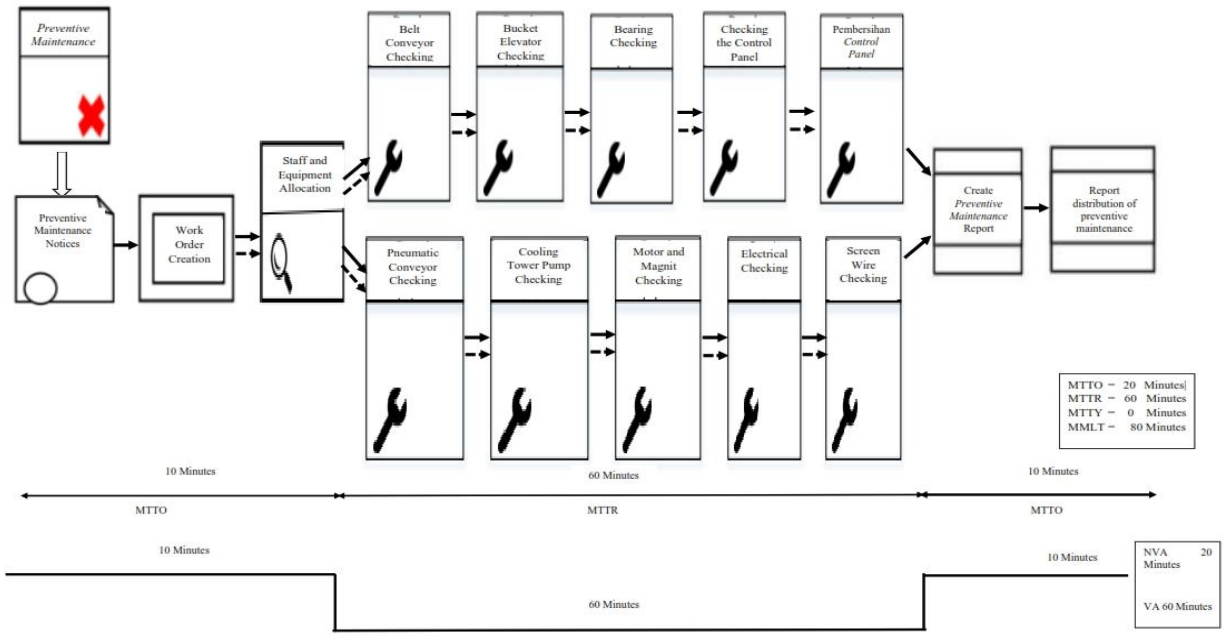


Figure 3. Future Value Stream Mapping Preventive Maintenance

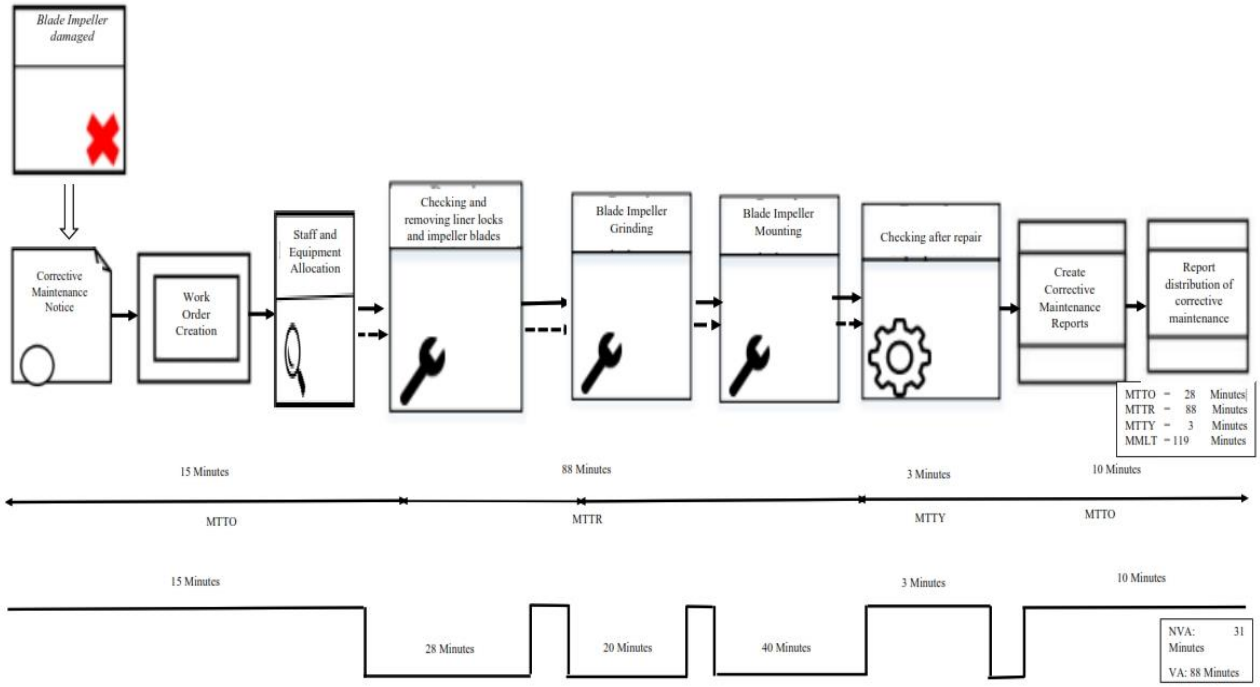


Figure 4. Future Value Stream Mapping Corrective Maintenance

In the concept of implementing Lean Maintenance which succeeds in reducing waste and time that is non-value added, it can affect the availability of equipment where the aspect that affects is the decreasing downtime. The faster the maintenance process runs, the faster the downtime and the greater the level of equipment availability. In the proposed improvement, the estimated time of non-value-added processes can be reduced to 25 - 30 minutes, especially in organized or administrative.

6. CONCLUSIONS

The efficiency of the maintenance process is an important thing to pay attention to because it will reduce time and costs when production stops. Lean maintenance is the right tool to use so that all waste that occurs in the maintenance process can be minimized. This research focuses on efficient processes regardless of how the maintenance strategy is drawn up by the Company to maintain the reliability of its machines. Based on the results of the waste found, 3 alternative recommendations have been prepared, there are holding internal training, creating an IT e Maintenance system, and also a list of spare parts inventory. The three alternatives are approved to be carried out by the Company where the benefits provided can be maximized. From the results of the improvements made, it can be estimated that it can reduce the time of non-value-added processes up to 25 - 30 minutes, especially in organized or administrative.

REFERENCES

Alsyouf, I. (2007). The Role of Maintenance in Improving Companies Productivity and Profitability. *International Journal of Production Economics*, 70-78.

Duran,O, Capaldo, A and Acevedo,P. A. D. (2017). Lean maintenance applied to improve maintenance efficiency in thermoelectric power plants. *Energies* 10, MDPI, Switzerland, 1–22.

Kaczmarek, M.J and Szafer, P. (2016). Maintenance Management Issues in the Process of Supplier Assessment. *IFAC Proceedings* 19, 9–20.

Kolanjiappan, S. (2015). Innovative Approach in Introducing Lean Manufacturing Tools in Maintenance of Aircraft," *Applied Mechanics Material*. 766–767,1190–1195.

Mostafa, S., Dumrak, J., & Soltan, H. (2015). Lean Maintenance Roadmap. *International Materials, Industrial, and Manufacturing Engineering Conference*, 434-444.

Nursanti, E., Avief, R. S., Sibut, & Kertaningtyas, M. (2019). *Maintenance Capacity Planning*. Malang: Dream Litera Buana.

Smith, & Hawskin. (2004). Lean Maintenance: reduce costs, improve quality and increase market share. *Elsevier*.

IMPROVING MANUFACTURING EXCELLENCE THROUGH LEAN SIX SIGMA (CASE STUDY IN PBR COMPANY)

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ABSTRACT

Manufacturing excellence (ME) is a measure of the ability to manufacture companies to react quickly to any changes in dynamically changing market conditions, namely by conditioning the company to achieve high and reliable efficiency targets. Many techniques have been used by manufacturing companies in implementing ME, one of which is lean six sigma to reduce production wastes and process variability. Lean six sigma becomes very important in achieving ME as a control starting from raw materials to finished products by eliminating waste and achieving zero waste in every manufacturing process. As the main orientation of the company that focuses on reducing product defect rates and based on the results of research on PBR Companies is 3 sigma level where PBR companies are still far from achieving the expected manufacturing excellence with a target of 1% smaller defect rate produced by 6 sigma levels. Therefore, strategic steps are needed to achieve manufacturing excellence, namely by improving the production process system through evaluation of work standards, using a new system with kanban and andon systems to implement lean principles in all work activities to eliminate, streamline, waste reduce that affects the achievement of manufacturing excellence through continuous improvement in the future.

Keywords: *lean six sigma, manufacturing excellence, zero waste*

1. INTRODUCTION

With the increasing number of competitors producing brick stone, the PBR Company designed a business strategy that refers to the company's vision and mission. The company's current KPIs are brand/brand image, quality management system, production efficiency, service, and customer satisfaction. The service provided by the company is to provide the best service for customer satisfaction. Every year PBR serves more than 300 distributors throughout Indonesia, including building projects. Another strategic step is to create a brand image through the number of product promotions through electronic and non-commercial media, which has achieved the expected target. Defect products are expected to achieve 5% of the achievement, but on average each month, it is 7% above the expected target. In addition to the quality that still needs to be improved, the average monthly production efficiency is around 87%, below the company's expected target of 95%. From the performance data above, the company focuses more on achieving performance towards manufacturing excellence by optimizing product quality and

reducing waste on the production floor, and increasing production efficiency through lean six sigma.

From the submission of the KPI above, it will be correlated with the 12 principles of manufacturing excellence into the principles of process capability, product quality, and continuous improvement. The three principles of manufacturing excellence which is directly correlated with the company's KPIs are the main focus of the current research object. Therefore, researchers use lean six sigma tools to improve manufacturing excellence. The improvement method using lean six sigma is expected to be able to improve manufacturing excellence by reducing the company's KPI target gap on the production floor.

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2. LITERATURE REVIEW

Excellence comes from Latin is an excellentia. Several terms are equated with manufacturing excellence. Another, some companies call it world-class manufacturing, there are also use the term value-added manufacturing, which is taken from its goal to reduce waste. Continuous improvement in manufacturing, where every aspect of manufacturing is aimed at making a better way.

Alvarez & Perry (2015) mention that manufacturing excellence is a broader concept that leads to the pursuit of perfection in manufacturing operations, integrating Lean-six sigma blending approaches to reduce process variability. Hector Cortes et al., (2016) stated that the two-method approach, namely lean and Six Sigma can be easily integrated and complement each other to achieve benefits for the company. Leachman et al., (2005) stated that manufacturing performance is built from direct and indirect inputs as well as quantitative and qualitative outputs. Amrina & Yusof (2010) discuss the criteria for manufacturing excellence which is consistent with quality, delivery, cost, time, and labor.

In the book "The 12 Principles Of Manufacturing Excellence", the author of Fast L.E (2016) states that there are 12 principles to achieve superior manufacturing, namely:

1. Safety is work safety as the main foundation.
2. Good housekeeping and organization, good improvement, and good organization.
3. Authorized formal system (discipline follows official permission, formal system).
4. Preventive or predictive maintenance is maintenance and care is needed.
5. Process capability is the process capability to be measured in all main processes.
6. Product quality is a workforce that is responsible for product quality.
7. The delivery performance of products sent to customers must be on time.
8. Visual management is open management that spreads on the production floor.
9. Continuous improvement is continuous improvement in the future.
10. Communication is the purpose of a well-structured communication plan.
11. Training is the objective of a well-structured training plan.
12. Operator-led process control means that all partners help each other, and include the culture of the workforce as an industry in the production process.

The main factors determining success in six sigma are the steps to achieve ME on ME principle criteria no. 5, namely process capability. The author will use a framework of 12 ME principles correlated with lean six sigma as the main tools to achieve manufacturing excellence. Risk analysis is used to determine the cause (root cause analysis) and the impact on the production floor to minimize gaps in time, cost, and labor.

Sharma, M., & Kodali, R. (2016), explained that the main foundation for achieving manufacturing excellence is strong leadership. As the pillar that supports the roof on ME, it

consists of nine main elements, namely manufacturing strategy, green manufacturing, flexible processes, supply chain management, customer relationship management, innovative product planning, Total Quality Management, world-class maintenance systems, and lean manufacturing. Meanwhile, the competitors' objects of the nine main elements are the global focus, environment, flexibility, delivery, customer relations, innovation, quality, reliability, and cost.

In achieving manufacturing excellence, there are several methods or tools, for example using Lean Six Sigma, Line Balancing, Shingo Assessment, Just In Time, Interpretive structural modeling (ISM), Lean Enterprise Self-Assessment (LESAT), Overall Equipment Effectiveness (OEE). Many methods have been used in a study related to the company's achievement towards manufacturing excellence to increase productivity in various institutions, both service, and manufacturing industries. The manufacturing excellence model according to Rusev & Salonitis (2016) explains that building production quality requires standardization of improvements through the development of human resources (operators) by making continuous improvements to reduce the total wasted waiting time. This process is carried out to maintain consistency in the quality that goes well and makes it easier for the company to achieve manufacturing excellence. Rohit Kenge & Zafar Khan (2020), explained a manufacturing excellence model, namely by building a quality foundation for a product, starting with standardizing improvements, building workforce performance potential, making continuous improvements, and reducing total lead time, until manufacturing excellence is achieved

According to Marr (2014), a Key Performance Indicator (KPI) is a measuring tool used to make it easier for management or stakeholders to find out information on the level of performance of a company. KPI provides a clear strategy and helps to monitor and improve the company's performance. Parmenter (2010) states that performance measures are indicators used by management to measure, report, and manage company performance. KPIs should be selected to identify important performance indicators for the company. Inappropriate selection of KPIs can lead to inefficient and counterproductive performance measurement. The following is the flow of KPI determination (Soemohadiwidjojo, 2015):

a. KPI identification and determination of selected KPIs.
b. KPI weighting and approval from the management.
c. Measurement and reporting of KPI achievement.
d. KPI achievement validation, evaluation, and feedback.

Preparation of Key Performance Indicators (KPI) requires careful planning to get optimal results. In addition, the preparation of KPIs should also be supported by the availability of reliable information and data. Anuradha et al., (2014) stated that a study to determine the development of company performance requires a key factor to determine the extent to which the company's achievements in manufacturing excellence are needed. Therefore, the company can easily find out the company's growth conditions and make continuous improvements using the strategic method as the main goal of achieving excellence in all parts of the company's management.

3. METHODS

In the early stages of the study, researchers used the company's KPI (Key Performance Indicator) as a benchmark for achieving manufacturing excellence. Furthermore, the researchers made observations directly following the production process during the process and according to the facts in the field. As an initial identification, this research will refer to the literature review and relate to research topics related to manufacturing excellence. This research is also supported by an understanding of concepts and theories regarding ME achievement using the lean six sigma

method for further development. The researcher uses the define, measurement, analyze improvement and control (DMAIC) stages.

Researchers will make a detailed of map production activities from the beginning to the end of the process by referring to the 12 principles of achieving manufacturing excellence from Larry E Fast. Value stream mapping (VSM) is used to make a detail of the production process into a workflow starting from raw materials to the end of the production process. Next, identify all the factors from root cause analysis that occurs during the production process. Entering the measurement stage, researchers will use the lean method to analyze waste at each work station and production process as an indicator that affects company performance. Six sigma is prepared to analyze the number of defective products so that the sigma level is obtained as a determination of the company's level of success. The stages of the process that will be carried out in this research can be described in the picture below,

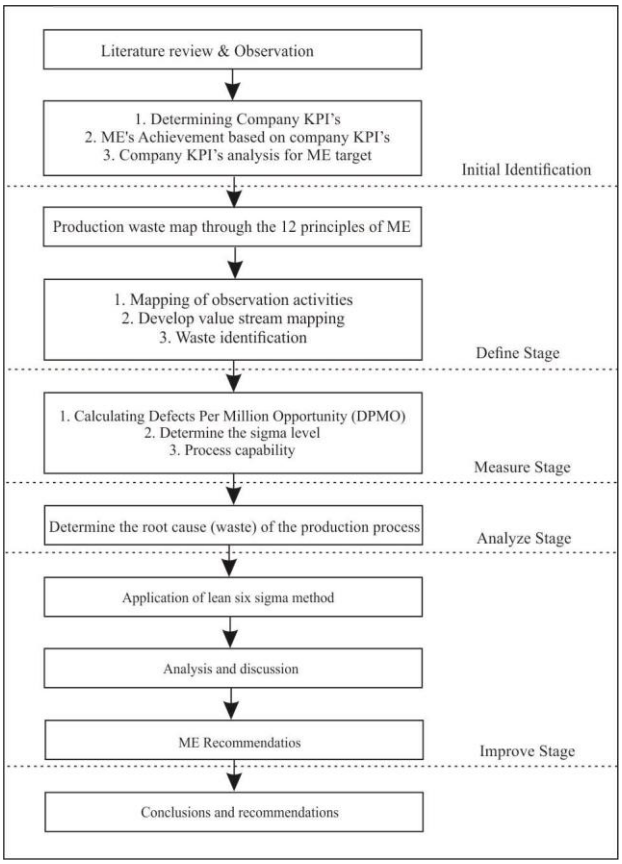


Figure 1. Research Methodology Flowchart

4. RESULTS

The achievement of manufacturing excellence for PBR companies is obtained from the calculation of the DPMO value and sigma level, where the DPMO value is still high at 62975,89. And the obtained process capability value (Cp) of lightweight bricks is currently still low, namely, 1.01, where the Cp value is in the range below the company's target which sets Cp≥1,07.

Table 1. Critical Waste

Process characteristic	% defect	Cp	Sigma Level
Current condition	6,29%	1,01	3,03
Expectation condition	<1%	1,5	4,5

So, to achieve manufacturing excellence, companies must make improvements to reduce waste and product defects. The strategic plan carried out to minimize the company's business losses on the production floor is using the lean six sigma method. Researchers analyzed the initial activities of the production process to produce a good finished product using the VSM method. The cycle time of the production process is 63.4 minutes with value-added activities of 45,6 minutes or equal to 72% of the total cycle time. Meanwhile, the percentage of necessary non-value added activities is 14,4% and 0.05% non-value added of the total cycle time.

Next, an analysis of critical waste was carried out and it was identified that the defect waste had the highest weight of the five respondents with an average weight (Bi%) of 24%. Root cause analysis is carried out to determine the root cause of the emergence of defective products that affect product quality and is equipped with an impact assessment analysis of the root causes of defects. The final result shows that most of the causes of defects are in the extreme risk category.

To help perfect improvement solutions to achieve manufacturing, namely by applying the 5S, Kanban, and Andon system methods. From root cause analysis and company KPI information that is oriented towards reducing defect rates, the 5S method can be used to create an orderly, comfortable and safe work environment. While Kanban is used to regulate the flow of the production process with a communication tool, namely the main card which contains complete information on the issuing of products. And, the andon system is run as a communication tool to convey the condition of the problematic workstation to be repaired immediately so as not to interfere with the next process. With 5S, kanban and andon systems are applied to improve the flow of the production process by eliminating all waste, including reducing product defects until it reaches manufacturing in the future.

6. CONCLUSIONS

1. In the calculation of the manufacturing excellence level, the calculation of the DPMO value of 62975.89 with a sigma level of 3.03 and process capability of 1.01 is still far from the expected target to achieve manufacturing excellence, namely level 6 sigma with a percentage of defective values smaller than 1% with a process capability of 1,01.
2. VSM production process of PBR companies obtained data on the number of activities according to the VA, NNVA, and NVA categories, namely VA activities as many as 26 activities, NNVA = 27 activities, and NVA = 10 activities equivalent to VA = 47%, NNVA = 37%, and NVA = 16% of the total cycle time is 16 hours per mold.
3. Identification of waste from the calculation of the ranking weights, it is known that the defect waste is the highest average weight with an average value of 24%. This shows that the main priority for improvements that must be made on the production floor is related to waste defects. Followed by the types of transportation waste by 19%, motion waste by 17%, waiting for waste by 15%, over process waste by 9%, inventory waste by 8%, and waste over production by 8%.
4. The results of the analysis of the root cause analysis show that most of the activities that cause product defects are in the extreme category, which must be repaired immediately to reduce the

efficiency of defective products. One of the activities that require attention is the activity that causes defective products and continuous improvement is not monitored, even the operators tend to take their repair initiatives without supervision from superiors, which causes high defect rates for lightweight brick products.

5. From the root cause analysis, the first thing to do is to improve the current production process system using the kanban and andon system methods. Kanban is focused on controlling the flow of communication and product transfer at each work station with complete documentation for improvements and solutions to improve company performance to achieve manufacturing excellence.
6. Material handling is focused on the function of tools or tools that provide convenience, flexibility, practicality, comfort, and safety. Material handling standards must also be made to use so that there are no usage errors that harm the quality of the final product.
7. 5S is needed to carry out all work activities within the company. Because 5S trains all employees to be disciplined, and responsible and increases work motivation by creating a good culture within the company environment.

REFERENCES

Barletta, I., Hoffenson, S., and Johansson, B., Organizational sustainability readiness: A model and assessment tool for manufacturing companies, *International Journal of cleaner production,* vol. 284, 2020.

Carvalho, A.M., Sampaio, P., Rebentisch, E., & Saraiva, P. (2017). Operational excellence is a means to achieve an enduring capacity to change-revision and evolution of a conceptual model. Manufacturing Engineering Society International Conference 2017, MESIC 2017, 28-30 June 2017, Vigo (Pontevedra), Spain. *Procedia Manufacturing* 13 (2017) 1328–1335, Elsevier. https://doi.org/10.1016/j.promfg.2017.09.109.

Castro, A., & Riedel, C. Ph.D. (2017). Assessment Of The Implementation Of Manufacturing Excellence In A Fiber-Based Packaging Manufacturing Environment. The 50th CIRP Conference on Manufacturing Systems. *Procedia CIRP* 63 (2017) 113–118, Elsevier. https://doi.org/10.1016/j.procir.2017.03.104.

Chetiya, R.A., & Sharma, S. (2014). An Analysis of Predictor Variables for Operational Excellence through Six Sigma. *Proceedings of the 2014 International Conference on Industrial Engineering and Operations Management Bali, Indonesia,* January 7 – 9, 2014.

Chiarini, A. & Kumar, M. (2020). Lean Six Sigma and Industry 4.0 integration for Operational Excellence: evidence from Italian manufacturing companies, *Production Planning & Control, Taylor & Francis Group*, https://doi.org/10.1080/09537287.2020.1784485.

Cortes, H., Daaboul, J., Duigou, L.J., & Eynard, B. (2016). Strategic Lean Management: Integration of operational Performance Indicators for strategic Lean management. *IFAC-PaperOnline (International Federation of Automatic Control)* 49-12 (2016) 065-070, Elsevier. https://doi.org/10.1016/j.ifacol.2016.07.551.

Dilanthi, M.G.S., & Deegahawature M.M.D.R (2014). Maintenance Function for Manufacturing Excellence Program: a case study of the Sri Lankan manufacturing industry. *International Journal of Engineering Research*, Volume No.3, Issue No.10, pp: 580-583.

Fast, L.E, (2016). 2nd Edition, The 12 Principles of Manufacturing Excellence. A LEAN leader's guide to achieving and sustaining excellence. *International Standard Book Number*-13: 978-1-4987-3092-1.

Gaspersz, V. (2007). *Lean Six Sigma*. Gramedia Pustaka Utama.

George, M.L. (2002). *Lean Six Sigma*, combining six sigma quality with lean production speed,

was published in Spring 2002.

Ghicajanu, M., Irimiea, S., Marica, L., & Munteanu, R. (2015). Criteria for Excellence in Business. *Procedia Economics and Finance* 23 (2015) 445 – 452, Elsevier. https://doi.org/10.1016/S2212-5671(15)00388-3.

Henriquez, R.M., Munoz, V.A., & Santos, J. (2021). Sustainability through Operational Excellence: An Emerging Country Perspective. *Sustainability* 2021, 13, 3165. https://doi.org/10.3390/su13063165.

Hsien, C., Zi-Yu, K., Eisnerc, E., Ying, S.C., Yuan, N.K.L., Donmezc, J., Mennengac, M., Herrmannc, C., & Choong, S.J. (2021). Self-Assessment and Improvement Tool for a Sustainability Excellence Framework in Singapore. 28th CIRP Conference on Life Cycle Engineering. *Procedia CIRP* 98 (2021) 672-677, Elsevier. https://doi.org/10.1016/j.procir.2021.01.173.

Kenge, R. & Khan, Z. (2020). Manufacturing Excellence Model To Solve Operational Risks Due To Product Demand Variations. *Parikalpana - KIIT Journal of Management,* DoI:10.23862/kiit-parikalpana/2020/v16/i1-2/204565.

Kumar, N. & Mathiyazhagan, K. (2019). Manufacturing excellence in the Indian automobile industry through sustainable lean manufacturing: a case study. 'Manufacturing excellence in the Indian automobile industry through sustainable lean manufacturing: a case study, *Int. J. Services and Operations Management*, Vol. 34, No. 2, pp.180–196.

Liu, Y.L., Pen-Fa, K., Chiang, J.T., & Shyr, W.J (2021). Should the EFQM Excellence Model be Adapted for Specific Industries, A Restaurant Sector Example? *International Journal of Hospitality Management* 92 (2021) 102694, Elsevier. https://doi.org/10.1016/j.ijhm.2020.102694.

Marr, B (2014) Need to know Key Performance Indicators. United Kingdom: Edinburgh Gate.

Mukherje, S., Asthana, A., Howarth, M., Mcneill, R., & Frisby, B. (2018). Achieving Operational Excellence for Industrial baking ovens. 2nd International Conference on Sustainable Energy and Resource Use in Food Chains, ICSEF 2018, 17-19 October 2018, Paphos, Cyprus. *Energy Procedia* 161 (2019) 395–402, Elsevier. https://doi.org/10.1016/j.egypro.2019.02.100.

Mousa, A. (2013). Lean, six sigma, and lean six sigma Overview. *International Journal of Scientific & Engineering Research*, *4*(5), 1137–1153.

Michael L.George (2002), *Lean Six Sigma, combining six sigma quality with lean production speed*. George group, McGraw-Hill, published in spring 2002.

Ojha, R., & Vij, K.A., & Vrat, P. (2014). Manufacturing excellence and its critical factors. An interpretive structural methodology application. *Journal of Advances in Management Research*, Vol. 11 Iss 3 pp. 312 – 332, Emerald Insight. http://dx.doi.org/10.1108/JAMR-06-2014-0032.

Paranitharan, K.P., Babu, T.R., Pandi, A.P., and Rajesh, R. (2016). A conceptual model for achieving business excellence in the Indian manufacturing industry. 'A conceptual model for achieving business excellence in Indian manufacturing industry', *Int. J.Enterprise Network Management*, Vol. 7, No. 4, pp.314–321.

Parmenter, David. 2010 Key Performance Indicators. USA: John Wiley & Sons, Inc., Hoboken.

Rusev, J.S., & Salonitis, K. (2016). Operational excellence assessment framework for manufacturing companies. 5th CIRP Global Web Conference Research and Innovation for Future Production. *Procedia CIRP* 55 (2016) 272 – 277, Elsevier. https://doi.org/10.1016/j.procir.2016.08.026.

Sartala, A., & Vázquezb, H.X. (2017). Implementing Information Technologies and Operational Excellence: Planning, emergence, and randomness in the survival of adaptive manufacturing systems. *Journal of Manufacturing Systems* 45 (2017) 1–16, Elsevier. http://dx.doi.org/10.1016/j.jmsy.2017.07.007.

Sather, R.M., Parsons, S., Boardman, D.K., Warren, R.S., Davis-Karim, A., Griffin, K., Betterton, A.J., Jones, S.M., Johnson, H.S., Vertrees, E.J., Hickey, H., Salazar, P.T., & Huang, D.G. (2018). Total integrated performance excellence system (TIPES): A true north direction for a clinical trial support center. *Contemporary Clinical Trials Communications* 9 (2018) 81–92, Elsevier. https://doi.org/10.1016/j.conctc.2017.12.005.

Sharma, M., & Kodali, R. (2016). Development of a framework for manufacturing excellence. *Measuring Business Excellence, Vol. 12 Iss 4 pp. 50 – 66*, Emerald Insight. http://dx.doi.org/10.1108/13683040810919962

Suarez, E., Calvo-Morab, A., Roldánb, L.J., & Nez-Cristóbalca, R.P. (2017). Quantitative research on the EFQM excellence model: A systematicliterature.

Soemohadiwidjojo, Arini T. (2017). Panduan praktis menyusn KPI. Jakarta: Raih Asa Sukses.

review (1991–2015). *European Research on Management and Business Economics* 23 (2017) 147–156, Elsevier. http://dx.doi.org/10.1016/j.iedeen.2017.05.002.

Trebucq, S., & Magnaghia, E. (2017). Using the EFQM excellence model for integrated reporting: A qualitative exploration and evaluation. *Research in International Business and Finance* 42 (2017) 522–531, Elsevier. http://dx.doi.org/10.1016/j.ribaf.2017.04.008.

ANALYSIS OF SERVICE QUALITY IN HEALTH APPLICATIONS (M-HEALTH) USING TEXT MINING METHOD AND SUPPORT VECTOR MACHINE (SVM) ALGORITHM: ALODOKTER AND HALODOC

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ABSTRACT

The presence of the Alodokter and Halodoc applications has provided extensive benefits for the Indonesian people, but there are still a number of disappointments from some users over the quality of the services provided. The issue of the lack of service quality has prompted some users to leave the service, so efforts to improve service quality to meet user expectations are a very important key to maintaining their loyalty. To formulate these service improvements, the m-health service quality analysis and text mining methods such as multiclass classification analysis, sentiment analysis and text network analysis are used. To improve the accuracy of text mining analysis, the SVM algorithm is used which has better performance than the Naïve Bayes algorithm that has been used in previous studies. The results of model testing with SMOTE on Alodokter and Halodoc user review data using k-fold cross validation with 10 repetitions, the multiclass classification gets an accuracy value of 93.71% and 95.18% while the sentiment analysis model gets an accuracy of 95.52% and 97.14%. Then based on the test results using the confusion matrix calculation, the multiclass classification model gets an accuracy value of 81.23% and 81.59% while the sentiment analysis model gets an accuracy value of 93.28% and 94.21%. Based on the text mining analysis, it is known that most of the problems experienced by Alodokter users are related to aspects of the lack of security and privacy of user data and the lack of guarantees of good service which ultimately have an impact on the lack of aspects of the benefits felt by users. On the other hand, the most common problems experienced by Halodoc users relate to the issue of the lack of platform reliability and the lack of a good service guarantee which in turn has an impact on the lack of emotional benefit aspect as well. Based on the findings of these problems, this research will provide recommendations for improvement so that Alodokter and Halodoc can provide services as expected by users.

Keywords: m-health, Text Mining, Multiclass Classification, Sentiment Analysis, Text Network Analysis, Support Vector Machine

1. INTRODUCTION

The development of information and communication technology has provided various conveniences for human life, because human activities that were originally usually carried out manually and conventionally, can now be carried out very easily and systematically with the development of information technology. The utilization of technology in the health sector can help medical services easier and faster to be accessed by the public. Therefore, many startups in

Indonesia who are members of the Indonesian HealthTech Association (AHI) are competing to innovate in providing digital health services in the form of applications installed on smartphones or commonly referred to as m-health (Sunjaya, 2019). Based on research published by DailySocial (2019), it is known that among several m-health applications in Indonesia, two of the most popular m-health applications are Halodoc and Alodokter. In this study, it was found that about 45.3% of the respondents claimed to have used Halodoc and as many as 32.2% have used the Alodokter application.

The presence of the Alodokter and Halodoc applications is considered very useful for the community, especially in the current Covid-19 pandemic situation. By using the m-health application, the public can conduct remote health consultations with doctors safely and easily, buying medicines without leaving the house, making appointment with the hospital without having to queue and various other facilities that allow people to get health services while continuing to do social distancing. Although the presence of the Alodokter and Halodoc applications can provide wide-range benefits, on the other hand there are still some number of disappointments from some users over the quality of services provided, such as the lack of platform reliability, lack of competence of health practitioners, privacy, and user data security. This expression of user dissatisfaction can be seen from the many negative reviews given by users on the Google Playstore platform (Rodhiani et al, 2020). The feeling of disappointment and dissatisfaction from Alodokter and Halodoc users has prompted some of them to leave the service (customer churn) and switch to other m-health applications that are considered more in line with their expectations. Therefore, the efforts to improve service quality as expected by users are very important keys to maintain their loyalty. To help formulate service improvements in the m-health application, an evaluation method is needed to map each issue provided by the user into the relevant service analysis dimensions so that later it can be easily known which service dimensions are considered has good service and which service dimensions still need improvement.

Research conducted by Paramita & Noviarisanti (2021), has applied text mining techniques to identify differences in the quality of m-health services in the Alodokter and Halodoc applications. Based on that research, there are at least three text mining approaches that can be used to carry out the service evaluation process on the m-health application, namely multiclass classification analysis, sentiment analysis and text network analysis. That research also uses the Naïve Bayes method as its classification algorithm and has produced a fairly good model accuracy value. But on the other hand, based on the results of a comparison of algorithms to investigate the best classification method in order to identify critical patient status data in health care social networks in Europe conducted by Carnevale, L., et al (2020), showed that the level of accuracy generated by the SVM algorithm is higher than the accuracy value generated by the Naïve Bayes algorithm. Therefore, this study will collaborate with two studies above by analyzing service quality on m-health applications, especially Alodokter and Halodoc using a text mining approach which includes multiclass classification analysis, sentiment analysis and text network analysis and uses the SVM algorithm as the classification algorithm. The final result of this research is expected to help provide recommendations for more comprehensive service improvements to m-health service providers, especially Alodokter and Halodoc, so that in the future they can provide better quality health services that can meet the expectations of users, which is indirectly will also have direct implications for increasing user satisfaction.

2. LITERATURE REVIEW

Akter, D'Ambra, & Ray (2010) have developed a special service quality evaluation method for m-health applications. This method evaluates the 3 main dimensions of the m-health

application which include the application quality dimension (Perceived Platform Quality), the user perceived interaction quality dimension (Perceived Interaction Quality) and the user perceived outcome quality dimension (Perceived Outcome Quality). The reason of this evaluation method is used because the existing evaluation methods, such as the Health Care Service Quality method by Globenko & Sianova (2012) or the HEALTHQUAL method developed by Lee & Kim (2017), are considered to be inappropriate and too complex for the dimensions of the problem to be solved.

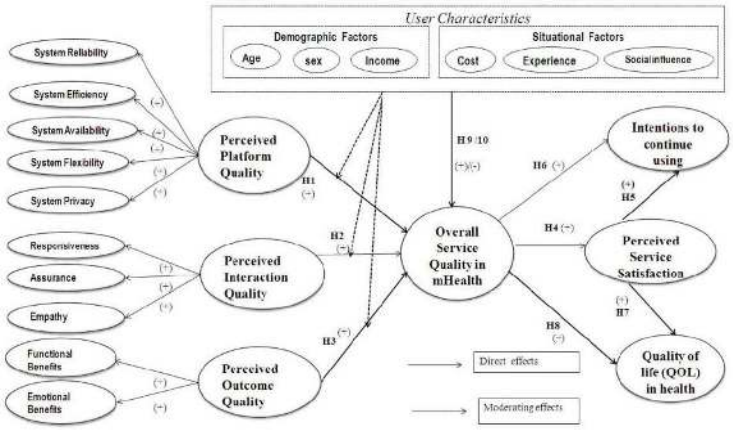


Figure 1. Conceptual model of m-health service quality
(Source: Akter, D'Ambra, & Ray, 2010)

Perceived platform quality in m-health services concerns the level of technical quality in the communication process. This dimension measures the overall service delivery system, which refers to aspects of system reliability (SR), system efficiency (SE), system availability (SA), system flexibility (SF), and user medical data privacy (SP). Perceived interaction quality discusses the intensive interactions between users and doctors during consultations or examinations. There are 3 parameters that can explain this dimension, namely assurance (AS), responsiveness (RS), and empathy (EM). Perceived outcome quality is a dimension that looks at the benefits or experiences of everything that users feel after using the service. This refers to the characteristics of the results offered by the system based on aspects of accuracy, timeliness, and completeness of services. This dimension is very important for health services to evaluate the quality of outcomes based on functional benefit (FB) and emotional benefits (EB). The basis for evaluating these services can refer to the feedback data provided by m-health users on the Google Play Store platform. The process for researching and understanding the three dimensions of m-health service quality based on user review data which has a very large size is certainly very complicated and takes a long time, so implementing a text mining approach is expected to help speed up the analysis process for improving service quality in the m-health application (Al-Ramahi & Noteboom, 2020).

Support Vector Machine (SVM) algorithm is a classification analysis that uses a hyperplane in classifying. In d-dimensional space, the dividing plane will be d−1. SVM can generate various possible separator fields. The best dividing plane is the one with the largest margin (maximum margin hyperplane). Margin is the closest distance between the training data observations and the separation plane while the observations that have the closest distance to the separation plane are called support (James, et al., 2013). SVM algorithm is widely used in various fields, it is often be used for the text classification process. Based on the results of an investigation

conducted by Carnevale, L., et al (2020) who have compared various supervised learning classification methods which include BernaulliNB, MultinomialNB, Logistic Regression, Stochastic Gradient Descent (SGD), Support vector Machine (SVM) and Linear SVM, it was concluded that the Linear SVM method produced the best accuracy value compared to others.

3. METHODS

This study intends to analyze the quality of service in the m-health application using Text Mining and the Support Vector Machine (SVM) algorithm. Therefore, in this chapter, it will be explained related to the stages carried out during the research process as shown by the following research diagram.

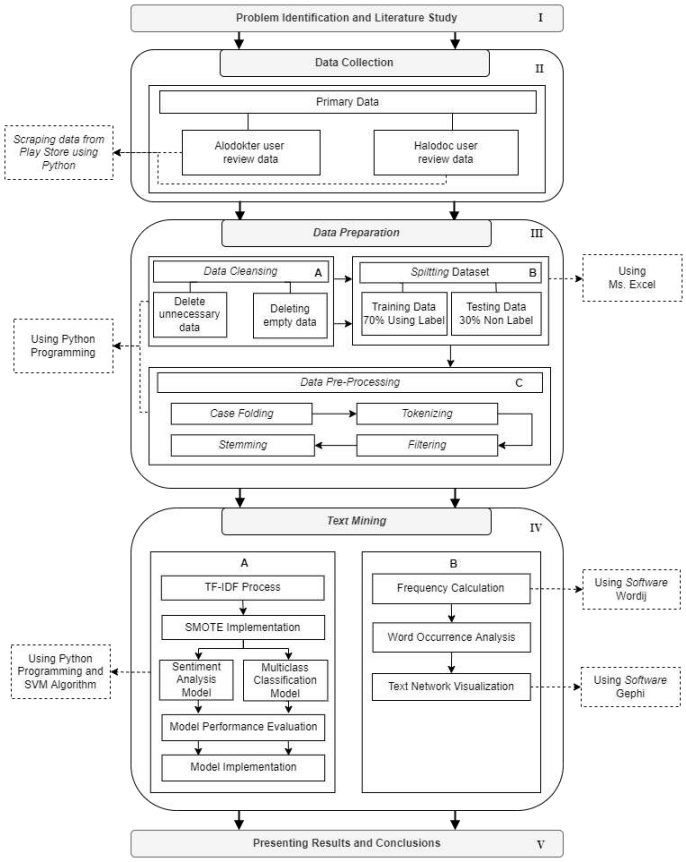


Figure 2. Research methodology diagram

3.1 Data Collection

The data was collected from user reviews of Alodokter and Halodoc found on the Google Playstore platform, obtained by using data scraping techniques using the Python programming. The data used in this study has a time span of 2 years starting from January 2020 to December 2021. During this time span, 71,867 data were obtained for the Alodokter application and 59,811 data for the Halodoc application.

3.2 Data Preparation

Data preparation starts from the data cleaning process, which of the many data features obtained, only a few features are used in this study, namely the content feature which contains feedback provided by the user and the time feature when the review was written, some features other data will be deleted because it is not used for the analysis process. The next process is to

check the data content feature, whether there is empty data or not. If there is empty data, then the data will be deleted. The final result of this data cleaning process, obtained 71,367 data for the Alodokter application and 58,913 data for the Halodoc application.

The next step is to do the splitting of the dataset or separate the data into 2 parts, namely training data and testing data. The data separation process is carried out manually with a composition of 70% of the total dataset being training data and the remaining 30% being testing data (Ting & Tsang, 2011). Based on these provisions, the amount of training data for making multiclass classification models and sentiment analysis models on Alodokter is 49,958 and testing data is 21,025. Meanwhile, to build a multiclass classification model and a sentiment analysis model on Halodoc, the total training data is 41,240 and the testing data is 17,434. After the dataset separation process is complete, the next process is to labeling the training data classes. The training data will be used as a reference for conducting machine learning for multiclass classification analysis and sentiment analysis. Based on the results of labeling the training data, a condition is obtained where the distribution of the number of classes in the data is not balanced (imbalanced dataset), or in the context of sentiment analysis, the amount of data in the positive class is much more than the amount of data in the negative class and this condition also occurs in a multiclass classification case that will identify each user review data into the m-health service quality dimension parameters proposed by Akter, D'Ambra, & Ray (2010). The handling on imbalanced dataset condition is very important to do before creating a machine learning model because it will cause the machine learning model to produce pseudo-accuracy values which make the classification model only able to work well in the majority class while in the minority class, the model tends to fail or be wrong in making predictions. Therefore, an oversampling technique is needed that is used to synthesize new data for the minority class so that the distribution of the dataset can be balanced. Pak, C., et al (2018) said the technique commonly used to solve class imbalance problems is the Synthetic Minority Oversampling Technique (SMOTE). Furthermore, after obtaining the test and training data, the training data will go through the pre-processing data process before becoming machine learning input. Pre-processing data is the preparation of data for use when the classification process reviews Service Quality Health. Monali, P., & Sandip, K. (2014) said there are 4 main stages in data preprocessing consisting of case folding, tokenizing, filtering and stemming.

3.3 Text Mining

The first text mining model created was a model for multiclass classification analysis. The analytical model was created with the aim of mapping each issue contained in the user review data into the dimensions of service quality analysis as the conceptual model of m-health service quality proposed by Akter, D'Ambra, & Ray (2010). Next, perform a sentiment analysis to identify the meaning of each review data that has been identified in the previous analysis into 2 categories of analysis, namely reviews that have a meaning of satisfaction (positive sentiment) and reviews that have the meaning of dissatisfaction or disappointment with the quality of services provided (negative sentiment). The analysis model will be made with 2 scenarios. First, create a model based on training data that is not oversampled using SMOTE. Second, create a model based on training data with oversampling process using SMOTE. It is intended to know the difference in model performance from the two scenarios.

Text network analysis is used to strengthen understanding regarding the quality of m-health services described by user reviews on the Google Play Store platform. In simple terms, the text network analysis process starts from calculating the frequency of occurrence of words using Wordij. After that, the relationship between word pairs is visualized using Gephi in the form of a

text network consisting of nodes and edges. Nodes are representations of words contained in user review data, while edges represent relationships or relationships between words. The node with the most significant size indicates the word that appears most frequently in user review data. Nodes or words that are related will be connected by lines. The thicker the line connecting a node, the stronger the relationship between the words. To visualize the layout of the text network, the Fruchtman Reingold model which has been provided in the Gephi is used.

4. RESULTS

4.1 Model Validation

K-Fold Cross Validation is the first text mining evaluation method that is used to get maximum accuracy. This method works by dividing the sample data randomly and in the same amount and grouping the data according to the desired repetition parameter (k-fold). In this study, the number of k parameters used to evaluate is 10-fold, meaning that the sample data will be divided into 10 parts, of which 9 parts will be used as data for the model training process and the remaining part will be used as data for validation. The process will be repeated as many folds are made with a different combination of training and test data in each iteration. The following figure will present the accuracy value of the model validation using k-fold cross validation on each iteration along with the average value.

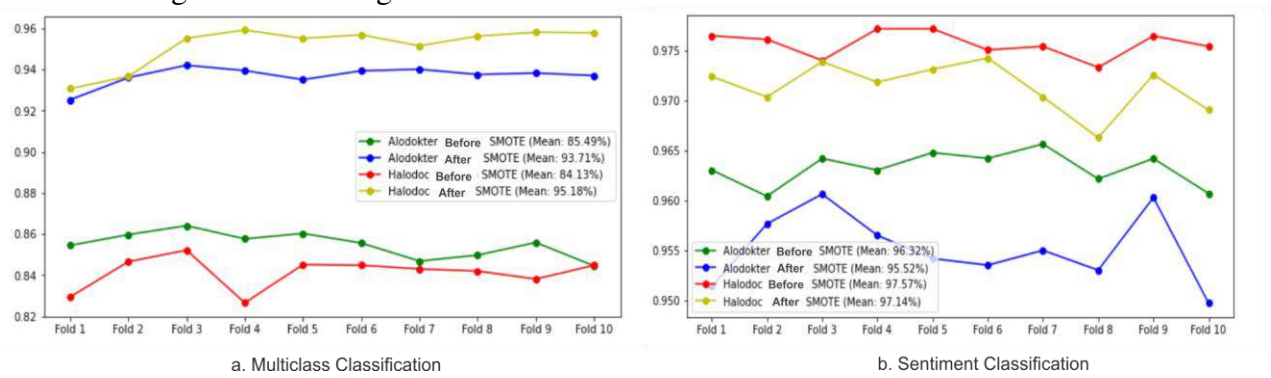


Figure 3. The results of model validation using the 10-fold cross validation

Based on the test results shown in Figure 3 above, it can be concluded that in the multiclass classification model there is a very significant increase in the accuracy value after the oversampling process using the SMOTE method, but the sentiment analysis model gets different conditions, after the oversampling process the accuracy value tends to be constant and get slight decrease. However, the results of the two models above are excellent because they have an accuracy value above 90%. In addition, based on model testing with the smote process using the confusion matrix calculation, it also shows a pretty good performance on both models. In the Alodokter application, the accuracy value of the multiclass classification model is 81.32% and the accuracy value for the sentiment analysis model is 96.29%. while in the Halodoc application, the accuracy value of the multiclass classification model and sentiment analysis model is greater than that of Alodokter, which has an accuracy of 83.93% and 97.57%, respectively. Both models also received precision, recall and f1 scores above 60%. This indicates that the model that has been made can work well on all the data used in this study.

4.2 Text Classification

Based on the results of a multiclass classification analysis to identify each user review into 3 dimensions of m-health service quality, it is known that the dimensions most discussed by Alodokter users and Halodoc users tend to be the same, namely the perceived platform quality dimension, then followed by the perceived interaction quality dimension and finally the perceived platform quality dimension. The results of sentiment analysis, the Alodokter application is dominated by positive reviews with a percentage of 86.62% and negative reviews by 13.38%, while in the Halodoc application, the percentage of positive reviews from users is higher than Alodokter, which is 93.10% and negative reviews by 6.90%. The next analysis tries to find out user sentiment on each service quality dimension by combining the results of multiclass analysis and sentiment analysis. Figure 4 below will explain the distribution of user sentiment on each parameter of the m-health service quality dimension.

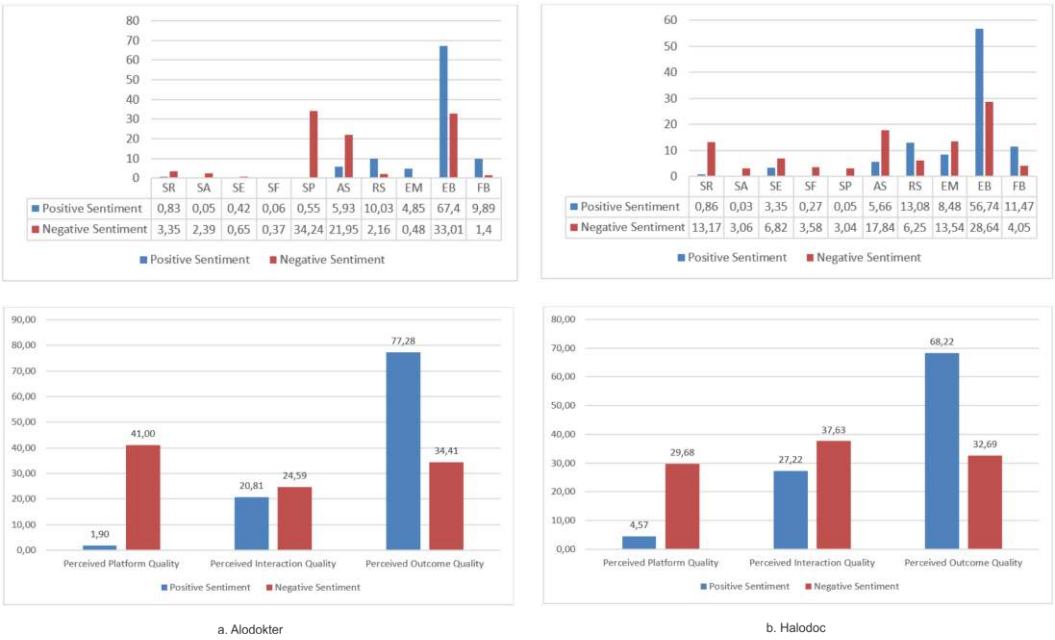


Figure 4. Percentage of sentiment on each dimension of m-health service quality

Based on Figure 4 above, negative reviews from Alodokter users are mostly related to the issue of lack of user data security (system privacy), lack of guarantees for good and quality services from health practitioners (assurance), and these two problems ultimately have an impact on users' emotional satisfaction after using application. On the other hand, the negative reviews on Halodoc application relate to the issue of the number of bugs in the application (system reliability), the lack of guarantees for good and quality service from health practitioners (assurance) and these problems also have an impact on the lack of benefits felt by users (emotional benefits). In addition, at the dimension level, in the Alodokter application the dimensions that get the most negative reviews are the dimensions of perceived platform quality, perceived outcome quality and perceived interaction quality. Meanwhile, in the Halodoc application, the dimensions that get the most negative reviews are perceived interaction quality, perceived outcome quality and perceived platform quality. To understand the context of the problems that are most often conveyed by users, it will be explained in text network analysis.

4.3 Text Network Analysis

In this study, text network analysis will be applied to each dimension of m-health service quality to identify user review data, especially reviews that have negative meanings such as criticism and expressions of disappointment, so that keywords or problems that are often expressed by users can be identified. The activity to find keywords in each dimension of service quality is very important, because it will be used as the basis for providing recommendations for improvement to the m-health service provider.

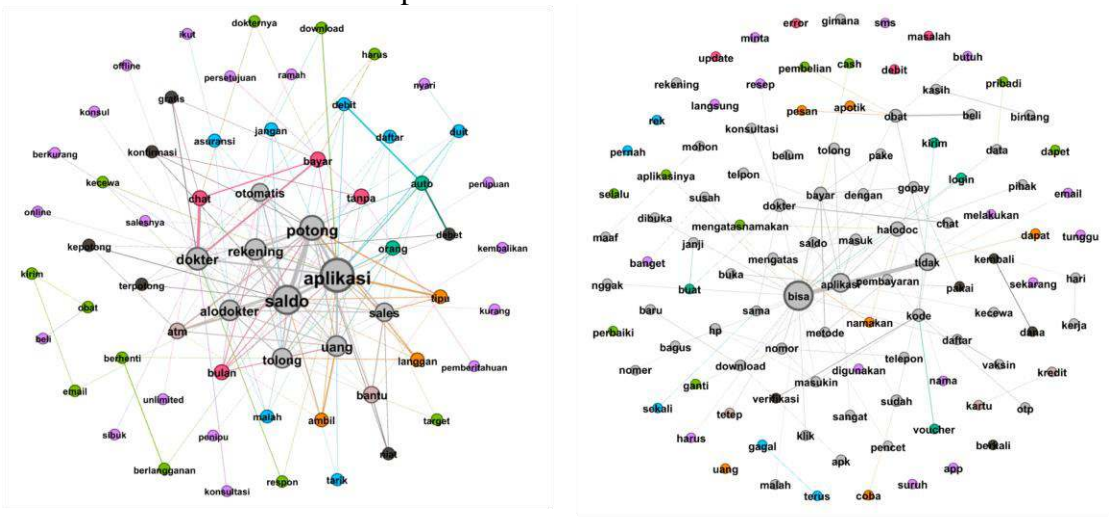


Figure 5. percentage of sentiment on each dimension of m-health service quality

Based on Figure 5 above, there are several insights that can explain the context conveyed by the user. In the Alodokter application there are several words such as “salesnya”, “asuransi”, “penipuan”, “potong”, “otomatis”, “atm”, “response”, “dokter”, “offline”, “sibuk”, “kembalikan”, “berhenti”, “langganan”. These words describe the context that users who gave negative reviews to Alodokter, most of them raised issues related to the lack of security and privacy of user data, where they felt disturbed after getting calls from Alodokter who often offered insurance programs and asked for personal data such as addresses, ID cards, and account numbers. In addition, not a few users only realized that they had joined the Alodokter insurance program after noticing that there was an automatic monthly balance deduction in their account. Alodokter users also discuss the lack of guarantees for good service, where when they have made a payment, they do not get the service they expected, for example when consulting an old doctor or a busy doctor and ending the consultation session prematurely or the chat feature not working properly due to a system failure. These factors ultimately have an impact on the number of users who are dissatisfied with the benefits provided and decide to stop using the service and ask Alodokter to close their accounts.

Meanwhile, In the Alodokter application there are several words such as “aplikasi”, “tidak”, “login”, “kode”, “otp”, “susah”, “buka”, “dokter”, “chat”, “gagal”, “error”, “kecewa” These words describe the context that users who gave negative reviews to Halodoc, most of them conveyed issues related to platform reliability, which included problems logging in because they didn't get an OTP code, force closing the application, the application could not be opened and several other obstacles. Halodoc users also discussed the lack of guarantees for good service as felt by Alodokter users. Where when the user has made a payment, they do not get the service as they

expected, for example during a consultation the old doctor responds or the doctor is busy and ends the consultation session prematurely or the chat feature does not function properly due to a system failure. User disappointment increases when there are problems during a consultation with a doctor, the transaction is considered a success and there are no refunds or complicated refunds. These factors ultimately have an impact on the number of users who are dissatisfied with the benefits provided and decide to stop using the service. Based on the problems found above, the authors try to provide some recommendations to improve Alodokter and Halodoc performances.

The Alodokter should evaluate its telemarketing strategy for its insurance products by resetting potential users so as not to get rejected, avoiding requests for personal data over the phone, using authorized telesales, avoiding coercive actions on users, explaining in detail the offers provided including how the mechanism works. payments when users take product offers, display insurance program participation data and provide an insurance unsubscribe feature in the application. To guarantee a good and reliable service, Alodokter also needs to provide a guarantee of refunds that have been paid by the user, when the user does not get his rights due to an error or system failure. In addition, to avoid closing the consultation session prematurely by the doctor, it is better for the consultation feature, the doctor is not given access to end the consultation session. So only the user or the system can end the session.

The Halodoc application should evaluate the reliability aspect of the platform, by conducting more rigorous application testing in order to deliver a more reliable application. Expanding payment methods, including the cash method, as suggested by many users. In order to guarantee a good and reliable service, Halodoc also needs to provide a guarantee of refunds that have been paid by the user, when the user does not get his rights due to an error or system failure. Similar to the recommendations given to Alodokter, to avoid closing the consultation session prematurely by the doctor, it is better for the consultation feature, Halodoc does not give access to doctors to end the consultation session. So only the user or the system can end the session.

5. CONCLUSIONS

To analyze the service quality of Alodokter and Halodoc applications, this study uses text mining methods which include sentiment analysis and multiclass classification and text network analysis. The multi-class classification model and the sentiment analysis model on Alodokter and Halodoc can work well on all datasets, because based on the k-fold cross validation and confusion matrix testing, the two multiclass classification models with oversampling techniques have an accuracy above 80% and the accuracy of the sentiment analysis model with the oversampling process has an accuracy above 90%. After the entire series of text mining analysis processes were carried out, information was obtained that all dimensions on Alodokter and Halodoc needed to be improved, because on all dimensions of service quality there were significant negative reviews. Based on user reviews, the most common problems in the Alodokter application are related to the issue of lack of user data security (system privacy), lack of guarantees for good and quality services from health practitioners (assurance), and these two problems ultimately have an impact. on users' emotional satisfaction after using application. Meanwhile, the negative reviews on the Halodoc application are mostly related to the issue of the number of bugs in the application (system reliability), the lack of good and quality service guarantees from health practitioners (assurance) and these problems also have an impact on the lack of benefits felt by users. Based on the findings of the problems that are most felt by users, the authors try to provide some recommendations for improvement to Alodokter and Halodoc, with the hope that in the future they can provide better health services as expected by users.

REFERENCES

Akter, S., D'Ambra, J., & Ray, P. (2010). User Perceived Service Quality of M-health Services in Developing Countries. 18th European Conference on Information Systems, 1-12. DOI: http: //aisel.aisnet.org/ecis2010/134-riendi

Al-Ramahi, M., & Noteboom, C. (2020). Mining User-Generated Content of Mobile PatientPortal: Dimensions of User Experience. ACM Transactions on Social Computing, 3(3), 1-24.

Canivale, L,.et al. (2020). Investigating Classification Supervised Learning Approaches for The Identification of Critical Patients' Posts in A Healthcare Social Network. Applied Soft Computing Journal 90 (2020) 106-155.

DailySocial, R. (2019). The Penetration of Active and Healthy Urban Lifestyle, The Understanding. White Paper.

Globenko, A., & Sianova, Z. 2012. Service Quality in Healthcare:Quality Improvement Initiatives Through the Prism of Patients' and Providers' Perspectives. Unpublished Master Thesis: Umeå School of Business and Economics.

James G, Witten D, Hastie T, Tibshirani R. (2013). An Introduction to Statistical Learning: With Applications in R. New York:Springer.

Lee, D., & Kim, K. K. (2017). Assessing Healthcare Service Quality: A Comparative Study of Patient Treatment Types. International Journal of Quality Innovation, 3(1), 1-15. doi:10.1186/s40887-016-0010-5.

Monali, P., & Sandip, K. (2014). A Concise Survey on Text Data mining. International Journal of Advanced Research in Computer and Communication Engineering, 3(9), 8040-8043.

Pagliari, C., et al. 2005. What is Ehealth (4): A Scoping Exercise to Map the Field. Journal Medical Internet Vol. 7 (1).

Pak, C., Wang. T.T., Su, X.H. (2018). An empirical study on software defect prediction using over-sampling by SMOTE, Int. J. Softw. Eng. Knowl. Eng. 28 (06), 811–830.

Paramita, N., & Noviarisanti, S. (2021). Service Quality Analysis of M-health Services Using Text Mining Method: Alodokter and Halodoc. International Journal of Management, Finance and Accounting.

Rodhiani, A. N., Nurcahyo, R., & Dachyar, M. (2020). Analysis of Service Quality in m- Health. International Journal of Advanced Science and Technology, 29(7), 3511- 3517.

Sunjaya, A.P. (2019. Potential, Application and Development of Digital Health in Indonesia. Journal of the Indonesian Medical Association, 69(4), 167-169.

Ting, S., & Tsang, A. H. 2011. Is Naive Bayes a Good Classifier for Document Classification? International Journal of Software Engineering and Its Applications,5(3), 37-46.

FINANCIAL FEASIBILITY ANALYSIS OF CLAY MINING PROJECT BASED ON PROBABILISTIC NPV AT RISK

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ABSTRACT

Feasibility analysis is a step that must be carried out before investing in clay mining. Similar to any other investments, mining also has potential risks and problems that could affects the viability of the investment. Because mining activities have risks (uncertainty), the feasibility calculation is not only carried out in a deterministic manner but also requires a probabilistic approach. Therefore, the purpose of this study are to identify and analyze the risks in mining activities, and also analyze the effects of these risks in assessing the financial feasibility of mining activities. This study utilize NPV at risk method to reach the goals. The method consists of compiling the data on risks in mining activities through an in-depth literature review and interviewing the experts from mining sector. Furthermore, the data is modeled in the form of a probabilistic cash flow analysis using *@risk for excel* application. The result indicates that the risk of market demand has the most significant influence on changes in the NPV of clay mining activities with 93.5% of the diversity of NPV values. Sensitivity analysis is also carried out with scenarios of changes in market demand with a range of +/-30%. The simulation results in the +30% increase on market demand scenario, the mean NPV is Rp 1,514,000,000 with a standard deviation of Rp 460,681,602. Meanwhile, for a -30% decrease in market demand, the NPV was Rp 730,777,609 with a standard deviation of Rp 400,098,533. The probability of this mining to suffer a loss (getting NPV < Rp 0), is 19%. This results shows that the risk of loss is low (<20%). From these results it can be concluded that this clay mining project is feasible and can be implemented.

Keywords: Financial Feasibility Analysis, Risk, NPV at Risk, Clay Mining

1. INTRODUCTION

Mining is a sector that significantly contributes to the Indonesian economy. In 2019, sectoral income from taxes was 52.49 T or contributed about 5.0% of the APBN (Ministry of Finance, 2019). East Java is a province with abundant potential for mining materials, especially clay (raw material for ceramics), Trenggalek Regency is one of the districts within the province with abundant clay potential (Muslim 2014). Any entrepreneur should obtain the mining permit from ESDM in order to mine these materials (ESDM Jatim, 2016). One of the condition to obtain these permit is the applicant must be able to prove the feasibility of investing in mining activities and the impact of these mining activities on the local and regional economy (ESDM Jatim, 2016).

Like any investment, mining has potential risks and problems that could possibly occur. (Dehghani and Pour, 2012). So far, the most commonly used method to assess the financial feasibility of a project is the discounted cashflow method. However, this method has drawbacks, namely being deterministic, while mining projects are dynamic. cashflow analysis is needed to assess the effect of risk on this cashflow.

The most common methods used to relate risk to investment decisions are the dual risk-return and

risk adjusted discounted rate methods (Ye and Tiong, 2000). Both methods have the disadvantage of not being able to provide a level of confidence in the results, so a probabilistic and statistical approach is needed to obtain the level of confidence.

Based on the background, it is clear that mining activities cannot be separated from uncertainty and risk factors. Therefore, this study aims to identify the risks that may arise in the clay mining process, analyze the effect of risk on cashflow projections, and analyze the financial feasibility of clay mining, so that the financial feasibility of clay mining becomes more realistic.

2. LITERATURE REVIEW

a. Risk

Capital owners need proof of feasibility if they are going to invest in a project, in practice they will consider the risks that arise to protect their equity (Dou et al., 2020).

According to Dou et al (2020) mining activities have risks. These risks include:

1. Reserve Thickness Risk
2. Market Price Risk
3. Reserve Quality Risk
4. Operational Cost Risk
5. Risk of Temporary Termination
6. Financial risk

Dou et al (2020) say there are several stages in controlling and reducing risk. Among them are risk identification, risk assessment, risk sequencing and risk control.

b. Investment valuation method in uncertain conditions (NPV at Risk method)

There are 3 categories of methods used in analyzing a project (Ye and Tiong, 2000), methods based on returns, based on risk, and based on returns and risks (Ye and Tiong, 2000) There are many flaws in determining investment decisions based only by return or risk, so we need a method that combines these two methods.

CAPM (Capital Asset Pricing Model), Arbitrage pricing theory (APT), and WACC (Weighted Average Cost of Capita) are the three methods focused in determining the discount rate to tolerate uncertainty. However, this method does not show the confidence level of the specified discount rate (Ye and Tiong, 2000). Another approach that can be used is probabilistic and statistical analysis using NPV at Risk.

NPV at risk is a market risk calculation that is used to calculate the maximum risk of loss that may occur in an investment activity (Best, 1998). NPV at risk uses Monte Carlo Simulation, this method has advantages in terms of accuracy, but has a weakness in complex computational calculations compared to other methods (Best, 1998).

3. METHODS

This research is quantitative research that will determine the risks involved in mining activities. This research analyzed which risks have the greatest impact in mining activities. The magnitude of the influence of these risks will later be used for modeling using the @risk application to get a more realistic NPV based on the existing risks.

The primary data taken in this study relates to risks that have occurred in clay mining, and the influence that these risks have. Data collection is carried out by interviewing practitioners and investors in illegal mining. Data collecting process begins by mapping out which risks are likely to arise and hinder mining activities. Determination of risk is based on its potential to affect cash flow. Furthermore, this research aims to reveal which risks that has significant influence on mining activities, and the range of values from each risk variable.

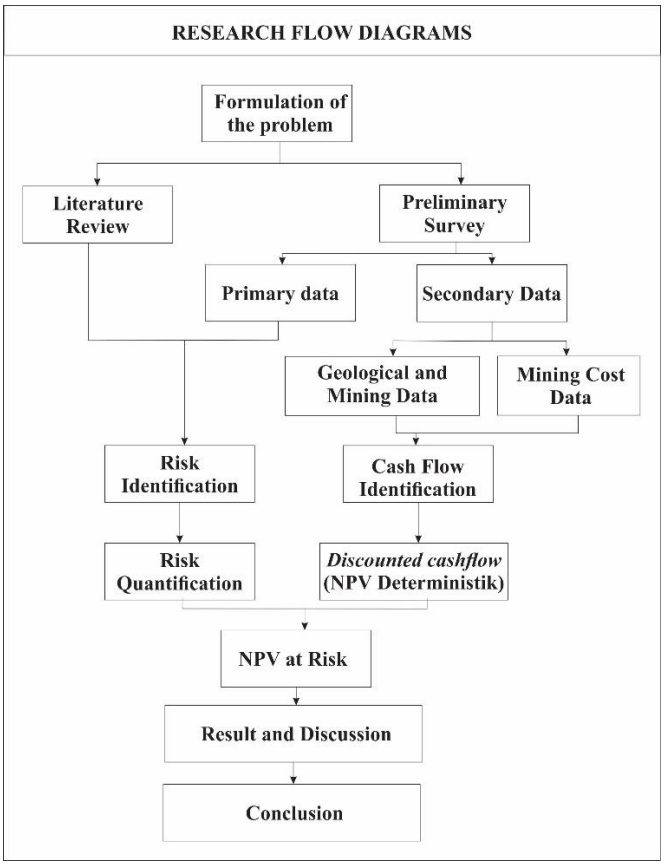


Figure 1 Research Flowchart

This research combines investment return analysis with risk analysis using probabilistic method and assisted by using @risk software. This probabilistic modeling will later show the amount of probability of the calculated NPV. The modeling will be based on the probability distribution function (PDF) and the cumulative distribution function (CDF).

4. RESULT AND DISCUSSION



Figure 2 Risk Breakdown Structure

a. Risk Identification

There are at least 5 risks (Fig 2) that have a significant impact on clay mining activities in Trenggalek Regency: permission risk, shipping cost risk, social risk, market demand risk and financial risk. These five risks uses pert distribution. This distribution can be determined by the minimum, maximum and most frequently occurring values. Meanwhile, financial risk has a normal distribution (Fig 3).

Risk Variable	Value	Effect	Distribution	Min	Most likely	Max
Permission Risk	Rp 120,000,000	Investation	Pert	Rp100,000,000	Rp120,000,000	Rp250,000,000
Shipping Cost Risk	Rp 56,000	Operasional Cost	Pert	Rp 54,000	Rp 56,000	Rp 62,000
Social Risk	Rp 180,000,000	Operasional Cost	Pert	Rp 160,000,000	Rp180,000,000	Rp344,000,000
Market Demand Risk	35	Revenue	Pert	22	35	46
				Mean	**Standard Deviation**	
Financial Risk (inflation)	4.48%		Normal	4.48%	2.32%	

Figure 3 Risk variables and their minimum and maximum values

b. NPV at Risk Analysis

Based on the analysis of discounted cashflow, the deterministic NPV value is Rp. 1,280,752,813 with an IRR of 102% and a payback period of 1.03 years. After doing a deterministic calculation related to clay mining cash flow analysis, and adding a risk parameter in the cash flow calculation, the addition of this risk variable will provide a probabilistic picture related to changes in the NPV of emerging risks or NPV at risk. NPV at risk analysis will be assisted using @risk software from Palisade. After the simulation (Fig 4), the probability distribution function (PDF) and cumulative distribution function (CDF) curves are obtained as shown below.

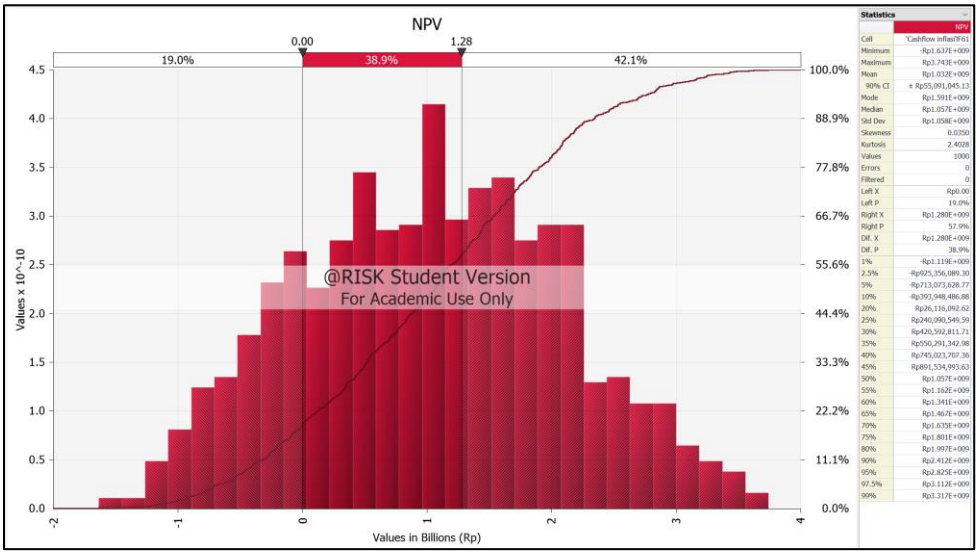


Figure 4 Probability Distribution Function (PDF) and Cummulative Distribution Function (CDF)

Based on the simulation results above, it is known that the expected NPV E(NPV)/NPV at Risk is Rp 1,032,000,000 with a standard deviation of Rp 1,053,000,000. The possibility of this

mining activity having an NPV <0 or this mining activity losing about 19%, based on the Jiskani DKK (2020) categorization the possibility of this mining activity losing is rare. (Fig 5) This calculations shows that when market demand increases by 30%, the average NPV is Rp. 1,514,000,000 with a standard deviation of Rp. 460,681,602. whereas if market demand falls by -30% then the average value of NPV is Rp 730,777,609 with a standard deviation of Rp 400,098.5.

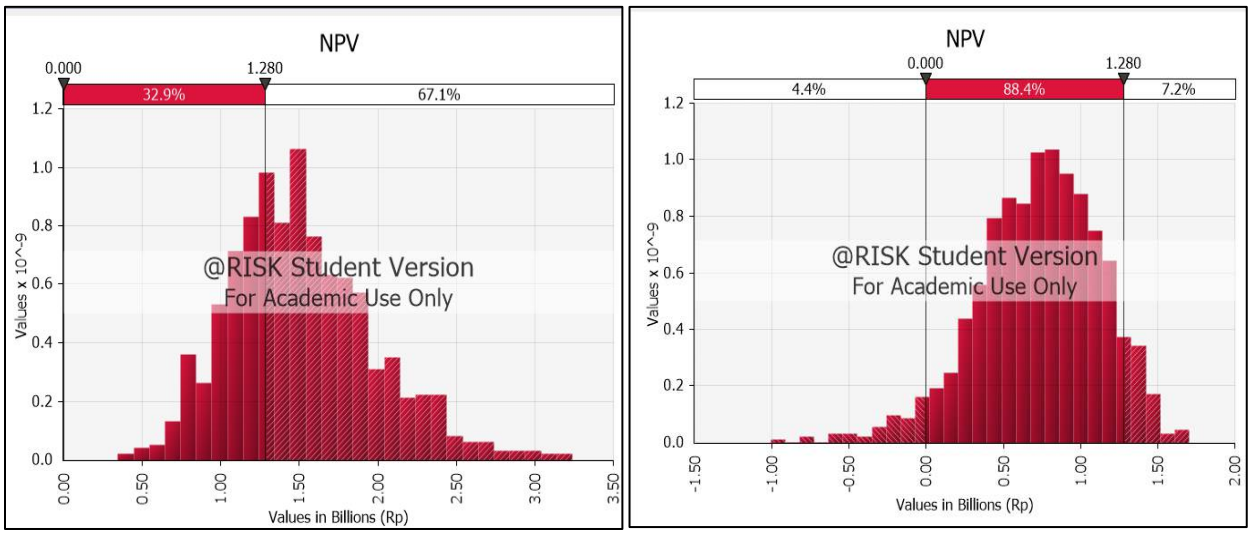


Figure 5 Market demand +30% (left) and -30%(right)

Sensitivity Analysis

Based on the tornado diagram (Fig 6), it can be said that market demand risk has a major influence on changes in the NPV value. Market demand risk can cause the NPV value to be in the range of -Rp 700,771,443 to Rp 2,747,000,000. and has an impact of about 93% to the diversity of NPV (Fig 7).

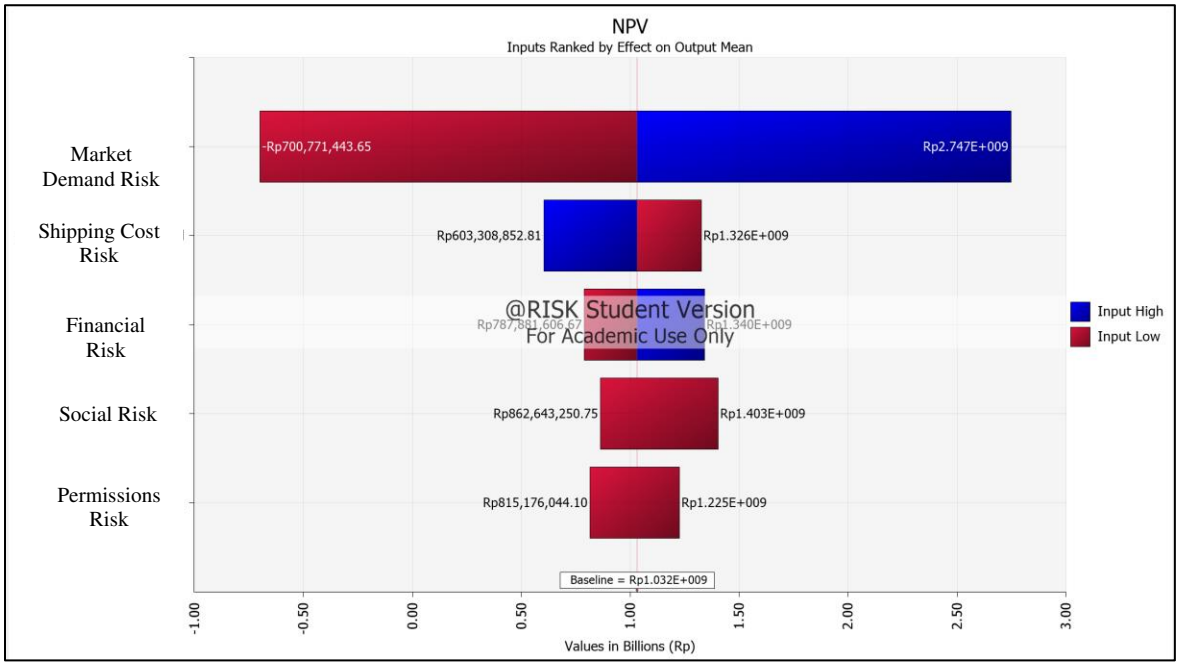


Figure 6 Changes that each risk can bring

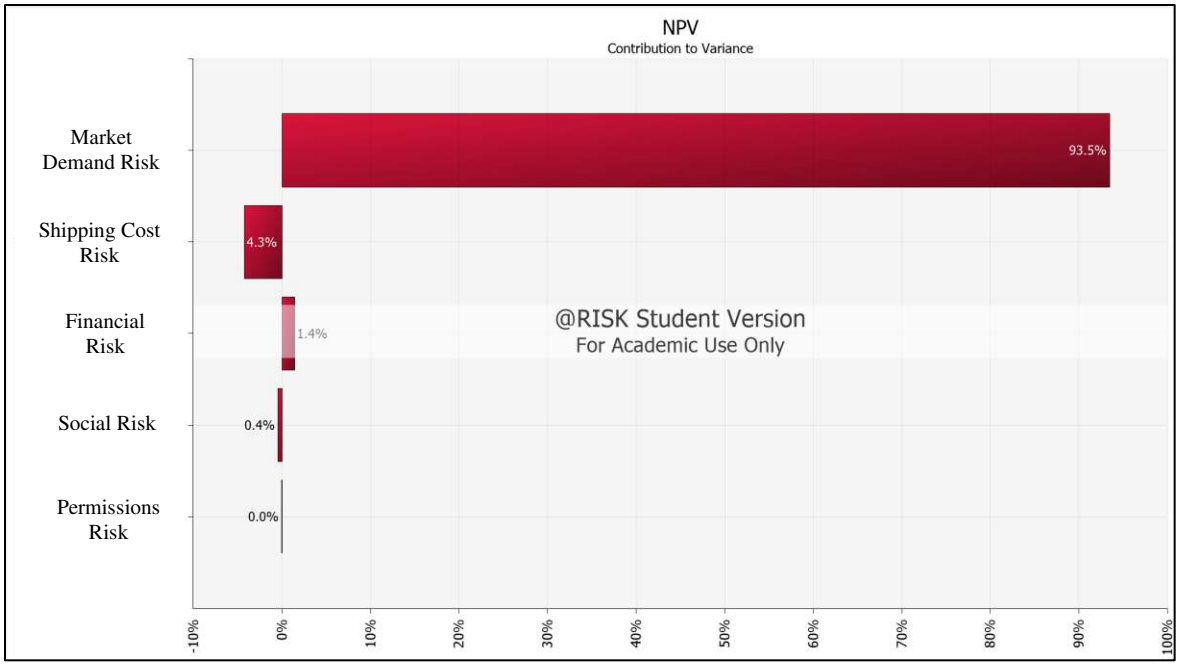


Figure 7 Contribution of each risk to the diversity of NPV values

5. CONCLUSION

a. The risks that arise in clay mining activities are market demand risk, material delivery cost risk, financial risk (inflation), social risk and licensing risk.

b. The risk that has a significant effect on changes in NPV is market demand risk. This risk has a positive correlation with the contribution of 93.5% of the diversity of NPV values. The risk of shipping costs has a negative correlation with the NPV with a 4.3% contribution to the diversity of the NPV, while other risks have a non-significant contribution

c. This clay mine has a deterministic NPV of Rp 1,280,752,813.51. After entering the risk, the expected NPV E(NPV)/NPV at Risk is Rp.1,032,000,000 with a standard deviation of Rp. 1,053,000,000. The probability of NPV <0 or this mining activity experiencing a loss is 19% or rarely occurs. Thus, this mining activity can be said to be feasible to carry out

6. REFERENCES

Best, Philip. (1998). *Implementing Value at Risk*. Chicester: John Wiley & Sons

Bowles, J. E. (1986). SIFAT-SIFAT FISIS DAN GEOTEKNIS TANAH. (J. K. Hainim, Trans). Jakarta: Erlangga.

Dehghani, Hesam dan Majid Ataee-pour, 2012, *Determination of the effect of operating cost uncertainty on mining project evaluation* : Resource Policy, p.109-117

Dou, Shi-quan., Jiang-yi Liu., Jian-zhong Xiao, 2020, *Economic feasibility valuing of deep mineral resources based on risk analysis: Songtaomanganese ore - China case study* : ELSEVIER Resource Policy, p.1- 12

Finnerty, John.D, 2013, *Project Financing Third Edition Asset-Bassed Financial Engineering* : New Jersey, Wiley Finance Series, 543p

Gotze, Uwe., Deryl Northcott., Peter Schuster, 2015, *Investment Appraisal Methods and Model* : Schmalkalden, Springer Texts in Business and Economics, 366p

Jiskani Izhar Mithal, Qingxiang Cai, Wei Zhou, Xiang Lu (2020), *Assessment of risks impeding sustainable mining in Pakistan using fuzzy synthetic valuation*, Elsevier

Resource Policy 13p.
Kementrian Keuangan Republik Indonesia, 2019, *APBN kita kinerja dan fakta* : Jakarta, Kementria Keuangan Republik Indonesia, 31p
Ye, Sudong dan L.K Tiong, 2000, *NPV at Risk method in infrastructure project Investment valuation* : J. Constr. Eng. Manage, p.227-233.

USER PERSONA TYPOLOGY ANALYSIS OF CUSTOMER ENGAGEMENT ON BODYCARE B's INSTAGRAM FEED CONTENT WITH A DESIGN THINKING APPROACH

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ABSTRACT

Instagram is a social networking platform utilized in digital marketing. Based on its appealing layout, Instagram facilitates user-to-user sharing of thoughts and serves as a platform for online promotion. In 2021, Instagram was the most widely utilized and popular social media platform. Instagram users reach 86.6% of the entire population of social media users in Indonesia. Instagram posts have the potential to expand the reach and promote brand recognition. "Feed" is one of the Instagram features utilized for promotion. "Feed" content on Instagram can strengthen interactions with consumers. On "feed," people can respond to one another through likes, comments, and shares. Users can provide various opinions according to their characteristics. Business actors can identify the personal characteristics of brand users based on their responses to this Instagram feed as a basis for analyzing the target market. Bodycare B is a beauty brand that utilizes Instagram user responses as a form of customer engagement with its feed content. Bodycare B received variable responses for each of its feeds. It indicates that Bodycare B feed content caters to different types of user personas. As a brand that just debuted in 2021, the company utilizes its Instagram feed to enhance user/customer engagement. This research was conducted to identify the typology of user personas and the level of customer engagement on Bodycare B feed content. Identification of user personas on Instagram feed content is needed to determine the type of user interaction (followers) formed. The approach used is design thinking with qualitative descriptive analysis. This research will apply to two of the five phases of design thinking, namely "Empathize" and "Define". "Empathize" is used to understand the perceptions and experiences of Bodycare B followers when observing feed content. "Empathize" process is carried out through in-depth interviews with 20 respondents. Interview results were analyzed to understand the persona's point of view on Brand B. The Empathize process was visualized in the form of a User Persona Map, an Empathy Map, and a User Journey Map. The mapping process is needed to define the problem from the point of view of user/customer (PoV Madlib). The result of this research is the identification of user persona typology and their needs.

Keywords: User Persona, Instagram, Feed Content, Interaction, Customer Engagement.

1. INTRODUCTION

Social media can be an easy medium for online communication and promotion to offer a brand's products (Mangold & Faulds, 2009). By 2021, the number of active social media users

from around the world will be 4.62 billion. In Indonesia, there are 191.4 million social media users. One of the social media that has many users, as many as 99.15 million users is Instagram (Datareportal, 2022).

Instagram offers new opportunities for marketing because it has the potential to significantly increase reach and brand awareness. Akdeniz (2016) describes data that Instagram has more than 400 million users worldwide with more than 1,000 engagements per second through the search, likes, and comments features. Uploads on Instagram reach more than 100 million (posts) per day. This phenomenon causes Instagram to be the social media with the brightest growth among all other social media. The potential possessed by Instagram is an opportunity for business actors to increase brand popularity, consumer loyalty, and communication with consumers. This can be done by uploading feed content with various types and characteristics that adapt to the persona of the target market (Santoso, Baihaqi, & Persada, 2017).

Consumer behavior and different responses will be the parameters of a marketing communication process (Danisworo, 2018). The process consists of Attention, Interest, Exploring Information, Action, and Share, which are used as dimensions to measure the level of promotion effectiveness on Instagram. Several factors that influence promotional activities, one of which is consumer characteristics. Consumer characteristics will greatly influence the behavior of individual characters during the process of choosing a product (Nafis, 2018).

At this time Instagram followers are often used as marketing targets which are then called consumers. Differences in the characteristics of followers can be categorized based on age, employment status, religion, lifestyle, income, education, lifestyle, and so on (Sangadji, Mamang, & Sopiah, 2013). These differences in characteristics will affect followers' acceptance of promotions and can affect tastes and consumption patterns for a product. Therefore, the advertisements that are displayed must be made according to the needs of followers and the target audience that has been determined.

Bodycare B is a beauty brand that utilizes Instagram user responses as a form of customer engagement with its feed content. Bodycare B was launched in December 2020 by Yainudin Yahya, a beauty brand practitioner from Surabaya. Currently, Bodycare B has 11,500 Instagram followers as of December 2021 with several likes between 100 and 300 likes per post, as well as some feedback from consumers in the form of comments on the post. Bodycare B has tried to package Instagram feed content in an attractive and informative way using visual communication design principles.

Bodycare B is one of the local beauty brands that is rapidly attracting the interest of the regional community. Although it was only established at the end of 2020, sales of Bodycare B products in early 2021 can penetrate sales of up to 1000 products for 3 months (January – March 2021). This is an achievement in itself for Bodycare B, which is a new medium-scale beauty brand. The sales focus of Bodycare B itself is in the cities of Surabaya and East Java due to the distributor relations owned by the brand owners in those cities.

For approximately one year, from December 2020 to December 2021, Bodycare B has been actively promoting products through Instagram. Bodycare B feels that it is less than optimal compared to competitors who have been involved in the past because Bodycare B still doesn't fully understand the types and characteristics of its consumer personas. Bodycare B has a desire to understand more and wants to be better relied on by its consumers. So far, there has been no evaluation regarding the identification of the user persona that has been established between Bodycare B and consumers through Instagram feed content and how to increase the type of interaction in a more intensive direction.

In this study, the design thinking method with a qualitative approach will be used to find the most effective and efficient solution. In the design method, it will apply two of the five stages of the Design Thinking method, namely, Empathize and Define. The research also requires a depth interview process that is conducted face-to-face or online as a way to get input from sources who are followers of Instagram Bodycare B. This research focuses on the responses of Instagram users who have previously interacted with them.

2. LITERATURE REVIEW

This research uses a literature review by previous researchers as a reference and writing data collection. The case studies, research objectives, and research results can be seen in the table below.

Table 2.1. Literature Review

No.	Research	Method	Summary
1.	(Juliaristanti, Ramdan, & Jhoansyah, 2020) Follower Characteristics and Ad Content Analysis in Measuring the Effectiveness of Instagram Stories Advertisement on Wardah Cosmetic Products	- Non probability - Narrative descriptive analysis	Wardah's cosmetic product advertisement on Instagram stories advertisement has been maximized and is able to attract the attention of potential consumers and is considered very effective. So it is expected to continue to maintain the quality of advertisements, and continue to innovate to create advertising content that is more attractive to potential consumers. However, the interest in purchasing products is still less than optimal, therefore it is better to increase the advertising content that can increase sales.
2.	(Fraß & Luana, 2021) Sustainability Sells: Appeals driving Customer Engagement of Green Skincare Brands	- Depth Interview - Narrative descriptive analysis	Knowing the mutually influencing relationship between Instagram elements and customer engagement factors. The formation of the Attractiveness framework creates interaction with users, namely: Cognitive Processing (psychology), Affection (care) and Activation (user reactions). "Attractiveness" content is divided into 3 types, namely 1. Affective (content that provokes emotion); 2. Identification & Spokesperson (perception planting content assisted by endorsers); 3. Factual (presentation of facts about the real composition).
3.	(Szalaty & Derda, 2020) Revolutionizing Beauty Industry: Co-Creation and Customer Engagement for Brand Image Development: Case study research of a crowdsource-driven cosmetics company Volition Beauty	- Sampling data, - Narrative descriptive analysis	Volition Beauty, a beauty brand that builds a communication strategy through the concept of Crowdsourcing and consumer participation. Investigating collaboration, communication and customer engagement strategies in its social media. Consumers can be divided into several personal characters which will later be divided based on the form of their participation to distinguish potential consumers who are in accordance with the target market and which are not, so that the communication strategy is right on target and a purchase decision occurs.
4.	(Vignisdóttir, 2017) Customer Engagement On Instagram Brand Pages In The Make-Up Cosmetics	- Reliability test - Regression	The factors that influence customer engagement on Instagram for make-up cosmetics are promotional content. It is important to know the characteristics of the customer to show the brand's vision and mission. On the Instagram account of a makeup

	Industry		cosmetic brand, there is an analysis of customer activities that occur, namely: 1. Product-based content drives more customer engagement. 2. Image Content receives more likes than Videos. 3. Video Content receives more comments than Image Content. 4. Question-based texts receive more comments than other texts. 5. Design the content (feed layout) to get more likes.
5.	(Akhmad & Sarah, 2020) The Role of Instagram Post Content on Online Customer Engagement in the Cosmetics Industry in Indonesia	- Kruskal-Wallis test - Post Hoc test	Visual content in a digital marketing strategy refers to the level of clarity of the message conveyed and its categorization because it will affect online engagement. The higher the level of user engagement with a brand on social media, the higher the likelihood of recommending the brand to others on social media. Product content not only contains general things such as prices, catalogs, or product types, but can also present product information with interesting and innovative presentations.

3. METHODS

The Design Thinking method is a comprehensive method of creative problem-solving that involves the user in the thinking process and makes the user's perspective the main consideration of the problem solving process. This method works to find value for consumers or users against the overall market opportunity. Design Thinking assesses various aspects that are seen based on human character and then integrates the variables to be studied in a focused and in-depth manner (Brown, 2008).

This research applies two of the five stages of the Design Thinking method, namely Empathize and Define. This research stage is focused on the Define stage only because the researcher wants to analyze the input data to find out to identify the user persona typology and the level of customer engagement that Bodycare B has formed and achieved on its Instagram feed content.

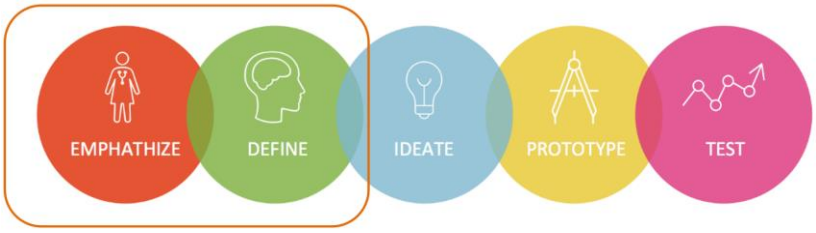


Figure 2.1 Stages of the design thinking method

Empathize is used to understand respondents' perceptions and experiences when viewing and paying attention to feed content. While Define is the process of analysis in understanding the point of view of the persona and knowing the actual needs of the persona. Empathize begins with conducting in-depth interviews with respondents and then analyzed to produce User Persona, Empathy Map and User Journey Mapping. Furthermore, the Define Process is carried out with theme analysis or affinity diagramming to produce an explanation of the problem and the point of view of the needs of the user.

Under certain conditions in Design Thinking the stages do not always run sequentially. So that it can be carried out according to user needs, can be run in parallel and can be repeated to stages that are considered less than optimal in order to get a solution that answers the problem (D.school, 2008).

3.1 EMPATHIZE PHASE

The first stage in design thinking is the empathize stage, this stage has a goal in the process of collecting respondent data by exploring user problems through Depth Interviews conducted with respondents online and face-to-face. This stage is done by compiling questions for the interview process starting from determining the objectives and framework of the interview. The results that will be obtained from this stage are in the form of analysis results in the form of user personas, empathy maps, and user journey mapping.

3.2 DEPTH-INTERVIEW

It is a stage that is carried out on respondents or sources who have been selected by researchers. In collecting data, researchers used depth interviews which were conducted face-to-face or online as a way to get input from sources who were followers of Instagram Bodycare B. Depth interviews were conducted for approximately 60 minutes for each individual. Aspects of the question framework in the questionnaire are as follows :

- Personality: Respondent's identity, name, age, occupation, income, lifestyle behavior.
- Brand Review: Opinion on Bodycare B brand, product suitability, first impression, impression on Bodycare B feed, duration of use, and respondent's description of Bodycare B.
- Feed Engagement: Respondents' emotions that occur, respondent activities, user responses, user activities responding to BodycareB feeds, emotions that occur, results of observing respondents towards Bodycare B, and identification of respondents in expressing opinions.
- Bodycare B’s feed: Bodycare B feed samples were selected and had the best analysis, tested for narrative identification.
- Strategy & Suggestion: Suggestions and recommendations of respondents, evaluations submitted by respondents, respondents' concerns and recommendations of respondents for improving Bodycare B feeds.

3.3 RESOURCE CRITERIA

In selecting resource persons for this research, researchers have had specific criteria for the informants to be selected for further analysis and qualitative data collection through the Design Thinking method. The parameter for the sources that have been determined are :

Table 3.1 Resource Criteria

Criteria	Interaction Time Range
• Woman • Respondents : 20 people • Age : 25 - 35 years • Bodycare B Instagram account follower • Actively using Instagram • Understand the topic and insight of care or beauty products • Users of several skin care products • Have interacted with Instagram Bodycare B by doing Likes, Comments and/or Shared Posts on Bodycare B's Instagram feed • Live in Surabaya	January - Desember 2021

3.4 DEFINE PHASE

The next stage of design thinking is define which aims to analyze user problems and needs. The output obtained from the empathize stage will be analyzed at the define stage so that it will get problem points and point of view analysis from the user's point of view.

4. RESULTS

At this stage the author explains about the results of the research stages that have been carried out. The stages carried out in this research are starting from a preliminary study, User Persona analysis on Bodycare B feed content during 2021 which is the current case study. Then proceed with the Design Thinking method process, by applying two of the five stages of the Design Thinking method, namely Empathize and Define.

4.1 EMPATHIZE PHASE

The first stage in Design Thinking is to Empathize, in the process the researcher collects input data by exploring the problems and backgrounds of Bodycare B Instagram followers. This stage is done by compiling several questions for in-depth interviews face-to-face or online using the Zoom application. The results that will be obtained at this stage are the identification of the Empathize stage which will be divided into empathy maps, user personas and user journey mapping. From in-depth interviews that have been carried out, there are several facts and phenomena regarding respondents who are also followers of Instagram Bodycare B, including the following :

- As many as 75% of respondents to the Bodycare B feed research are Generation Y or Millennials and 25% are respondents from Generation Z.
- Bodycare B Instagram followers are individuals who like to use Instagram as a medium to find information on a topic that is needed.
- Bodycare B Instagram followers are characters who are accustomed to a modern lifestyle, like to use beauty brands and share information with their colleagues.
- Bodycare B Instagram followers interact using smartphones and modern devices in carrying out their activities. Some of them use Personal Computers (PCs) in the office, laptops and tablets. Smartphones are the main devices in supporting business.

- Bodycare B feed research respondents have busy activities which are divided into 50% of respondents doing outdoor activities and 50% of respondents doing indoor activities.
- The research respondents feed Bodycare B as much as 50% have jobs as office employees as many as 10 respondents and as many as 50% work from home or flexible, totaling 10 respondents.
- Bodycare B feed research respondents who are also followers of Bodycare B Instagram are divided into two parts, namely as many as 90% of Bodycare B users of which there are 18 respondents and as many as 10% who are not Bodycare B users totaling 2 respondents.
- Social media Instagram is the first application opened by respondents when they feel bored.
- Skin care brand is a standard requirement for modern women and all respondents agree with this statement. However, as many as 13 out of 20 respondents complete their skin care needs by visiting a specialist or expert.
- Colleagues who have references to similar skin care brands, have the potential to suggest the same product through shared-post Instagram.
- Respondents of the Bodycare B feed research who use Bodycare B products have an average of 2-3 months of users, which proves that this brand is relatively new to the public.
- Bodycare B Instagram followers do not always fully respond to Bodycare B feed uploads. Those who are moved to respond are followers who feel their mood is in line with Bodycare B feed uploads.
- A total of 12 respondents stated that they studied Bodycare B's feed on their own accord because they wanted to know more about local products which stole the attention.

From the findings of the facts and the phenomenon of the depth interview process of respondents who are also followers of Instagram Bodycare B, it is found that 3 aspects are the parameters of customer needs. This Customer Needs parameter is useful for identifying User Persona priorities that occur on Instagram Bodycare B. These parameters are grouped in the Affinity Diagram which is described in Figure 4.1.

This Empathizeprocess results in the identification of User Persona, Empathy Map, and User Journey Mapping. User personas in this study are divided into 3 User Personas, namely User Persona Users Bodycare B Indoor Workers, Bodycare B Users Outdoor Workers, and Non-Bodycare B Users as described in Figure 4.2

Based on the picture in Figure 4.2, User Persona 1 describes a 29-year-old woman, a single, office worker, who cares about her care & beauty. She likes self-care activities by using well-known brand products to go to beauty clinics. She doesn't like it when he gets left behind on things that are going viral. She also does not like individuals who are indifferent to themselves, especially about appearance.

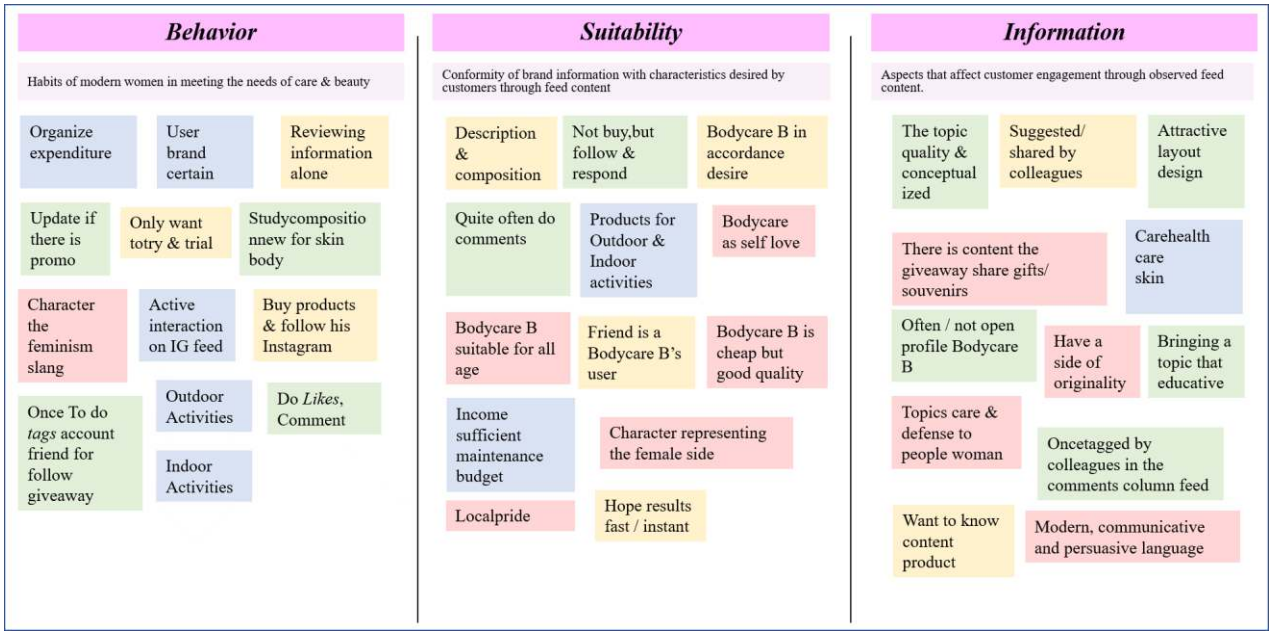


Figure 4.1 Customer Needs parameter

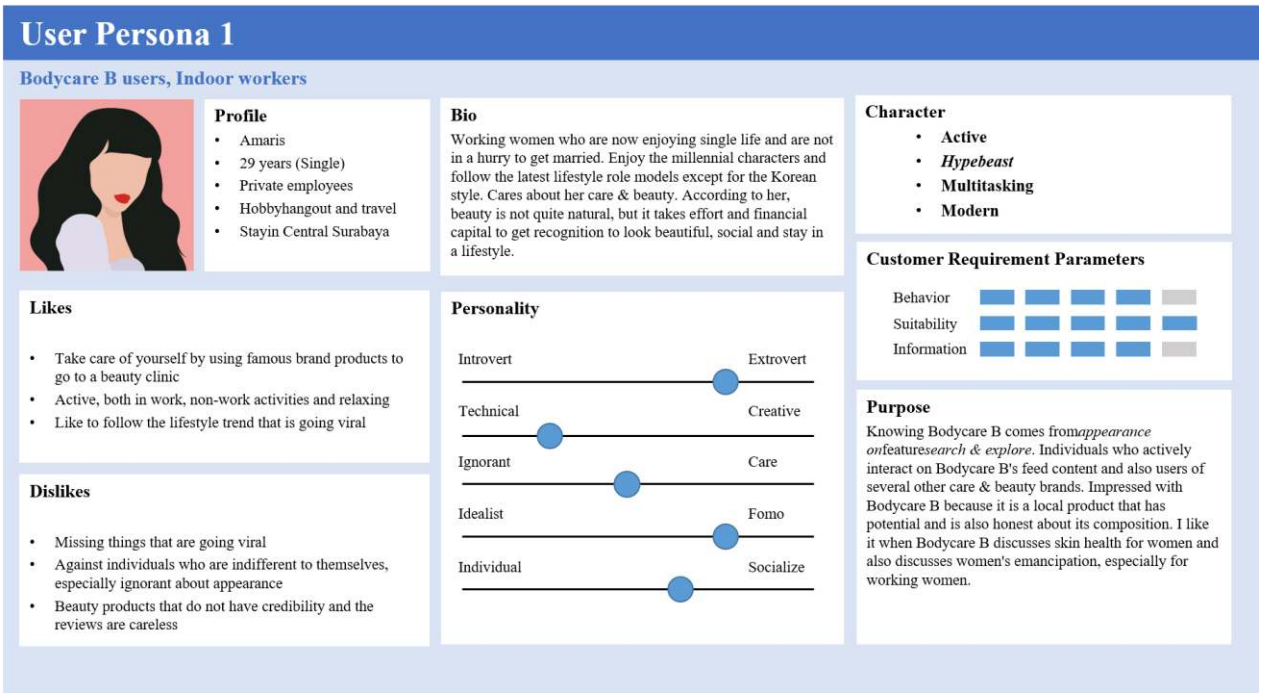


Figure 4.2 User Persona 1 (Indoor Workers)

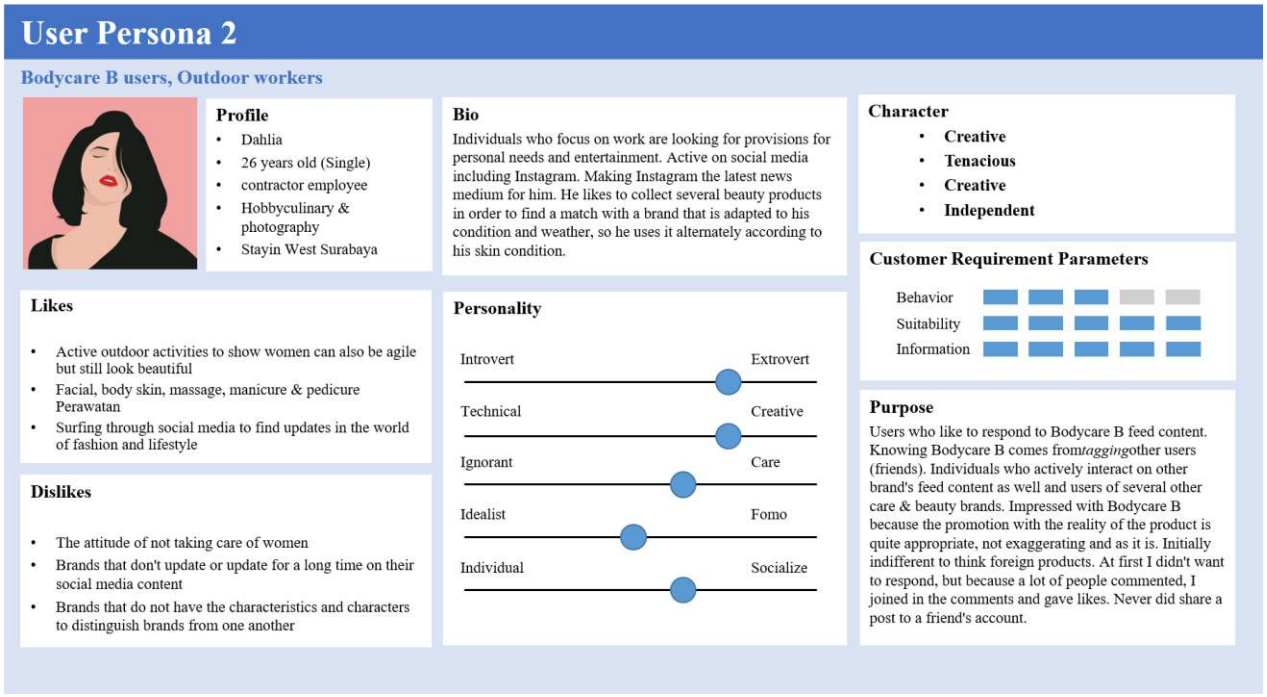


Figure 4.3 User Persona 2 (Outdoor Workers)

Based on the picture in Figure 4.3, User Persona 2 depicts a 26-year-old woman, a single, field worker who is easily exposed to the sun. She is an active person on social media including Instagram. She made Instagram the latest news medium for her. She collects several beauty products to find a match with a brand that is adapted to the conditions and weather, so they use it alternately according to her skin condition. She likes surfing through social media to find updates on the world of fashion and lifestyle. She doesn't like bands that don't update or take a long time to update their social media content and brands that don't have their characteristics.

Based on the picture in Figure 4.4, User Persona 3 depicts a 33-year-old housewife who works at home in the form of an independent business, a reseller of care & beauty products. Even though she has become a wife and has children, She stated that she must take time to take care of herself because looking beautiful makes her look younger and provides a pleasant atmosphere for her family. She enjoys learning to gain insight into the aspects of skin health and self-care and often pays attention to local brands due to the critical demands of work on lifestyle renewal. She doesn't like sharing too many posts with other people because it can disturb the comfort of certain people.

Furthermore, the findings are described in the form of an empathy map to explore the needs and desires of users. The Empathy Map in this study is divided into 3 categories, the same as the User Persona in the previous stage. The analysis of Empathy Maps in this study is explained in Figure 4.5

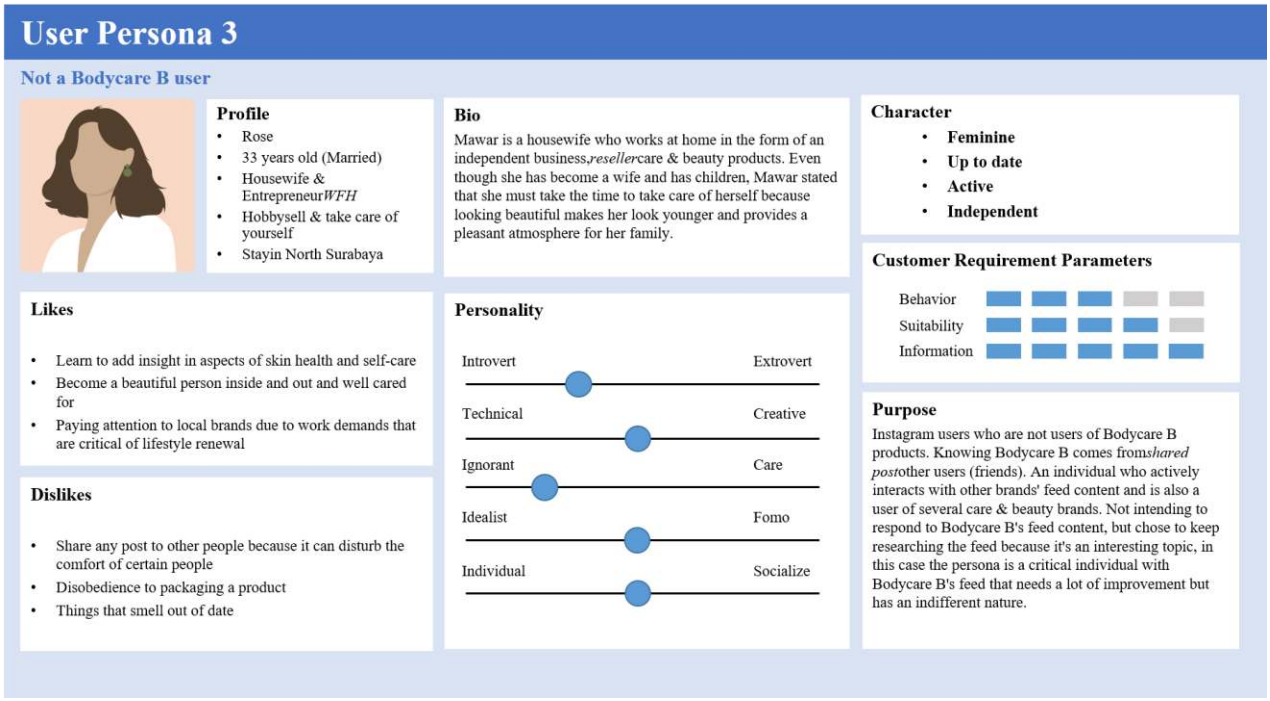


Figure 4.4 User Persona 3 (Non-Bodycare B users)

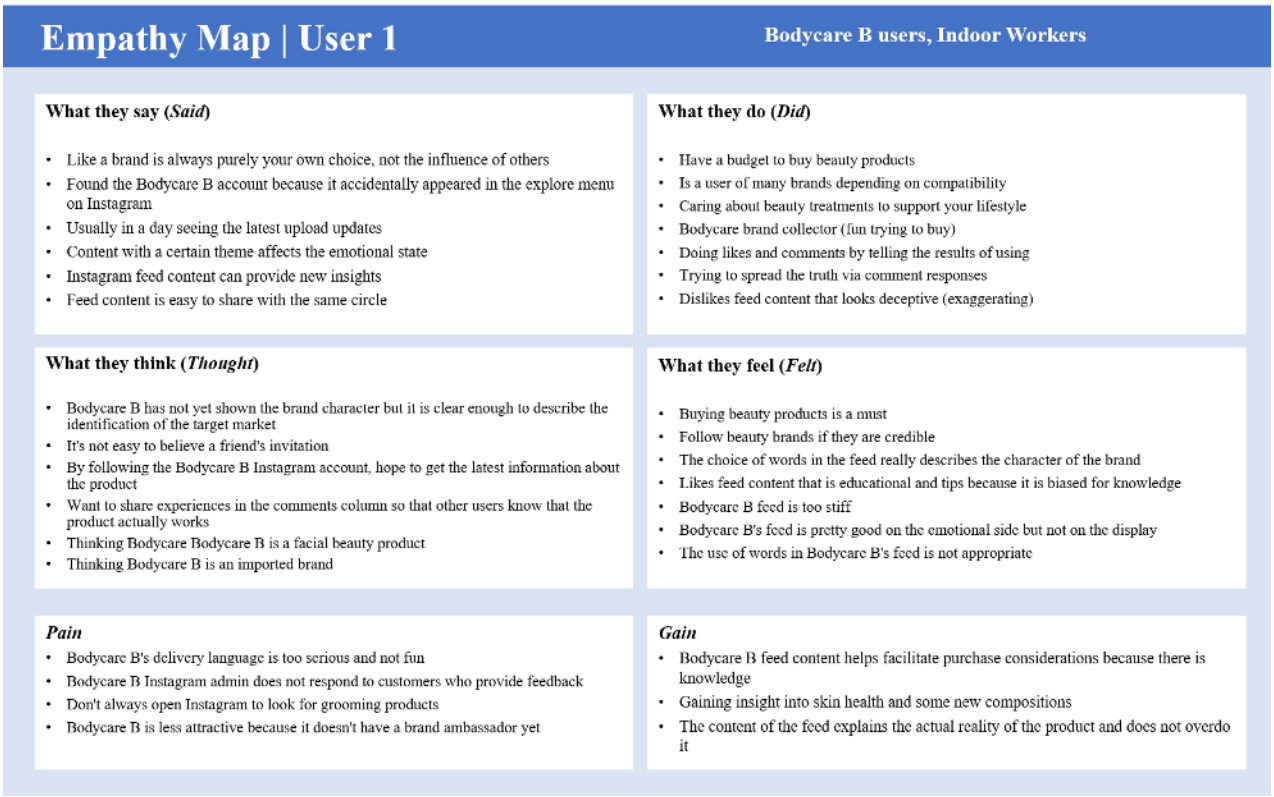


Figure 4.5 Empathy Maps User 1

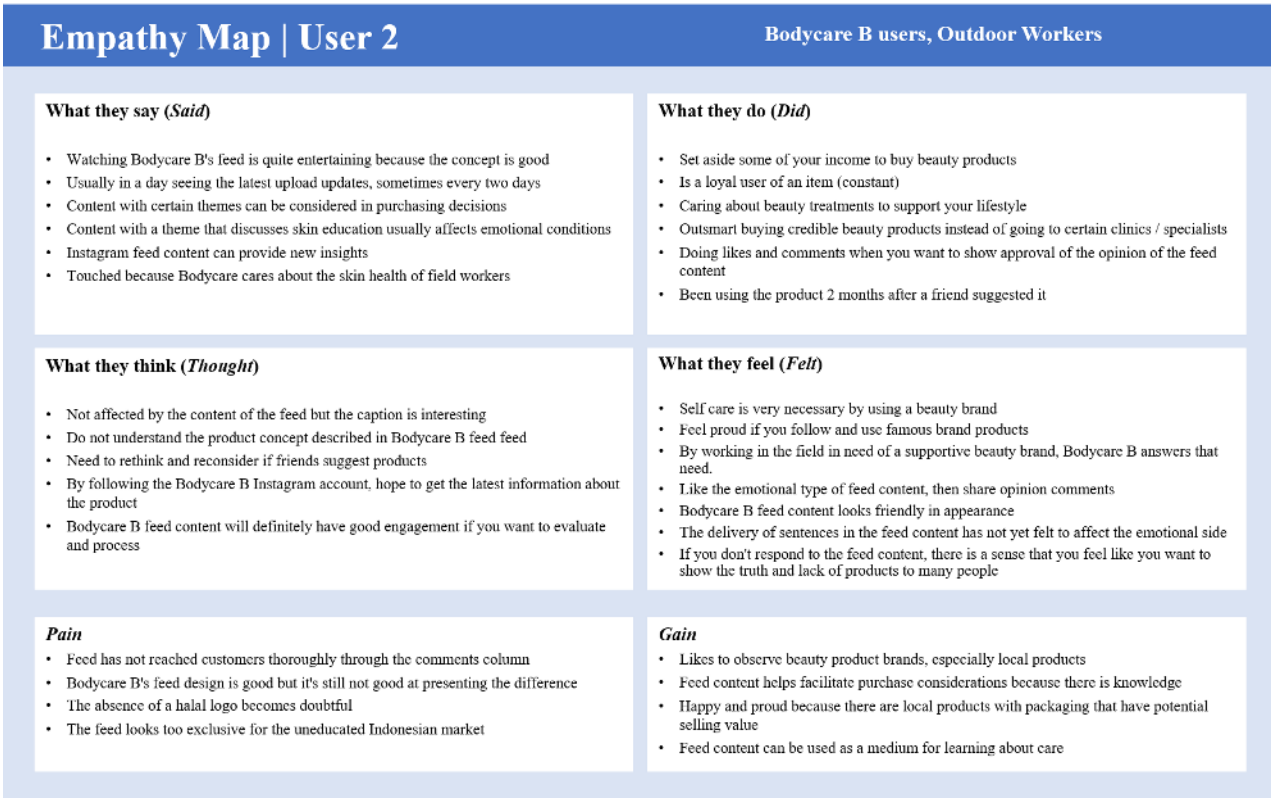


Figure 4.6 Empathy Maps User 2

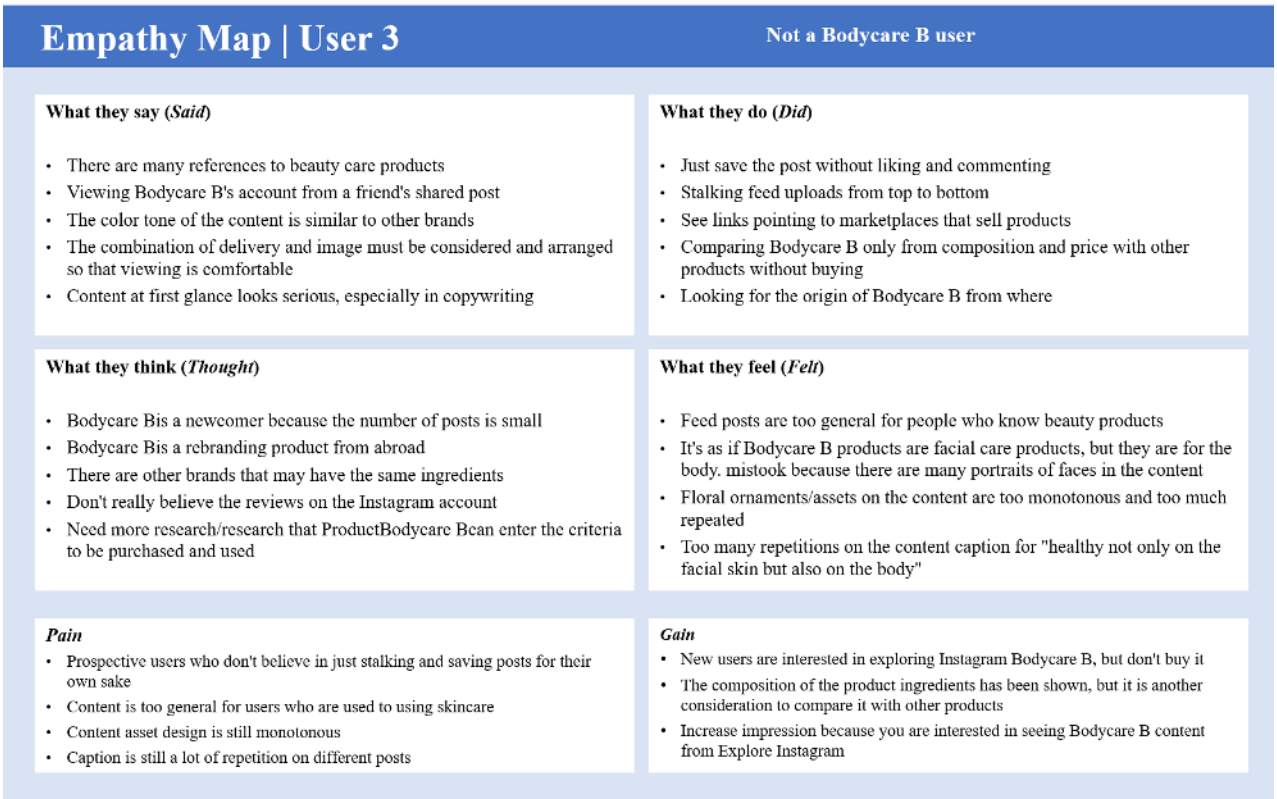
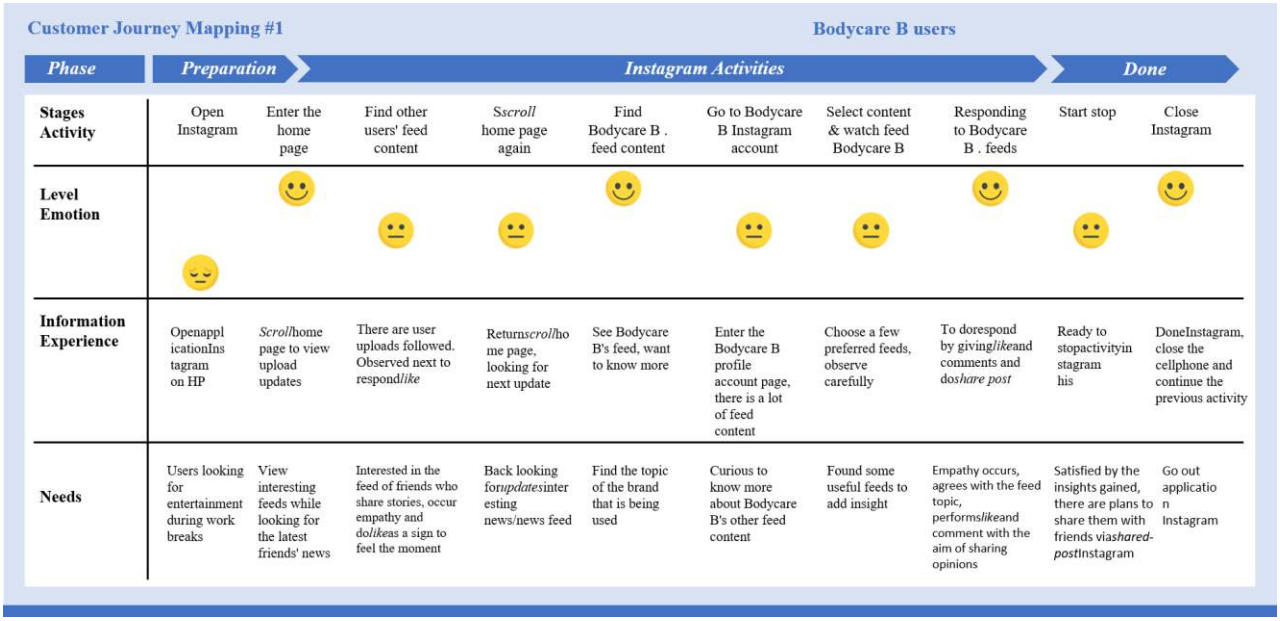


Figure 4.7 Empathy Maps User 3

The picture above is an Empathy Maps from User Persona 1, User Persona 2 and User Persona 3, which tells the things he experienced while observing Bodycare B's Instagram feed content. Empathy Map is an aspect that User Persona says, does, thinks and feels. And the positives and negatives things they get.

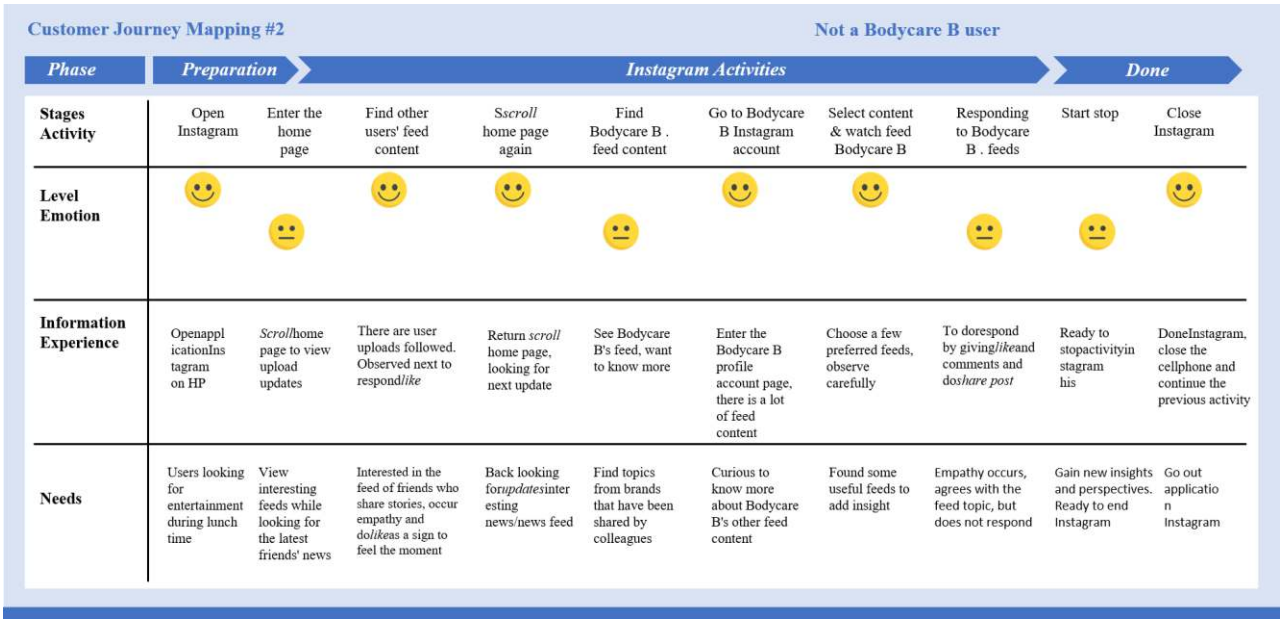
The next stage is to process the results of the interview into the form of a user journey map. The user journey map is used to compile user scenarios when carrying out activities, so that it can assist researchers in knowing at which point the user's needs will be more focused. Because User Persona 1 and User Persona 2 have similarities, namely both workers and users of Bodycare B products, eating on User Journey Mapping will be categorized into only 2 categories, which are as follows :



Customer Journey Mapping #1 — **Bodycare B users**

Phase	Preparation	Instagram Activities							Done
Stages Activity	Open Instagram	Enter the home page	Find other users' feed content	S*scroll* home page again	Find Bodycare B . feed content	Go to Bodycare B Instagram account	Select content & watch feed Bodycare B	Responding to Bodycare B . feeds	Start stop	Close Instagram
Level Emotion	😔	🙂	😐	😐	🙂	😐	😐	🙂	😐	🙂
Information Experience	Openappl icationIns tagram on HP	*Scroll*home page to view upload updates	There are user uploads followed. Observed next to respond*like*	Return*scroll*ho me page, looking for next update	See Bodycare B's feed, want to know more	Enter the Bodycare B profile account page, there is a lot of feed content	Choose a few preferred feeds, observe carefully	To dorespond by giving*like*and comments and do*share post*	Ready to stopactivityin stagram his	DoneInstagram, close the cellphone and continue the previous activity
Needs	Users looking for entertainment during work breaks	View interesting feeds while looking for the latest friends' news	Interested in the feed of friends who share stories, occur empathy and do*like*as a sign to feel the moment	Back looking for*update*sinter esting news/news feed	Find the topic of the brand that is being used	Curious to know more about Bodycare B's other feed content	Found some useful feeds to add insight	Empathy occurs, agrees with the feed topic, performs*like*and comment with the aim of sharing opinions	Satisfied by the insights gained, there are plans to share them with friends via*shared-post*Instagram	Go out applicatio n Instagram

Figure 4.8 Customer Journey Mapping Bodycare B Users



Customer Journey Mapping #2 — **Not a Bodycare B user**

Phase	Preparation	Instagram Activities							Done
Stages Activity	Open Instagram	Enter the home page	Find other users' feed content	S*scroll* home page again	Find Bodycare B . feed content	Go to Bodycare B Instagram account	Select content & watch feed Bodycare B	Responding to Bodycare B . feeds	Start stop	Close Instagram
Level Emotion	🙂	😐	🙂	🙂	😐	🙂	🙂	😐	😐	🙂
Information Experience	Openappl icationIns tagram on HP	*Scroll*home page to view upload updates	There are user uploads followed. Observed next to respond*like*	Return *scroll* home page, looking for next update	See Bodycare B's feed, want to know more	Enter the Bodycare B profile account page, there is a lot of feed content	Choose a few preferred feeds, observe carefully	To dorespond by giving*like*and comments and do*share post*	Ready to stopactivityin stagram his	DoneInstagram, close the cellphone and continue the previous activity
Needs	Users looking for entertainment during lunch time	View interesting feeds while looking for the latest friends' news	Interested in the feed of friends who share stories, occur empathy and do*like*as a sign to feel the moment	Back looking for*update*sinter esting news/news feed	Find topics from brands that have been shared by colleagues	Curious to know more about Bodycare B's other feed content	Found some useful feeds to add insight	Empathy occurs, agrees with the feed topic, but does not respond	Gain new insights and perspectives. Ready to end Instagram	Go out applicatio n Instagram

Figure 4.9 Customer Journey Mapping Non-Bodycare B Users

Based on the pictures above, it can be concluded that there will be different experiences between Bodycare B users and non-Bodycare B users in responding to Instagram feeds. The difference in experience tends to appear at the level of emotion felt by each user in each stage of the activity of observing the Instagram feed. The results of this description of the user journey map are in the form of a needs analysis tailored to each description of the experience experienced by the user.

4.2 DEFINE PHASE

Define the problem phase is done by defining the problem based on the Point of View (PoV) Analysis obtained from the synthesis of the empathy map from each category of users.

PoV Madlib #1

User	*Needs*	*Insight*
• Bodycare B users, (Worker*indoor&outdoor*)  	• Open Instagram	• The atmosphere is tired during work, opening Instagram is the first activity to look for entertainment as well as the latest news at the same time
	• To do*scrol*home page to search & view upload updates • Find other users' feed content, provide feedback	• Looking for friends' news in photo uploads with captions*feed*be a story / positive news. Respond like and comment if necessary • Looking for updates from accounts that issued sales promotions
	• Back to doing*scrol*home page	• Not satisfied with just finding a handful of news updates • Continuing to search*updates*news feed / other interesting newsothers at that time
	• Find and view Bodycare B . feed content	• Finding the topic of the brand that is being used, there is empathy because they feel that what is being discussed is him • Feeling happy because Bodycare B updates the feed right when the user opens Instagram, feels like being noticed
	• Go to Bodycare B Instagram account • Choose one of the preferred feeds, carefully observe each type of feed	• Curious to find sales promotions / discounts • Explore other topics in the column*feed*more interesting • Convince yourself that the brand you use provides advantages over other brands • There are several feeds that are more suitable for conditions and make them a medium to add insight into skin health
	• Respond by giving*like*and comments by conveying personal opinions • Opinions are conveyed in the form of narratives with the aim of building	• There is a conformity of views, customers agree and like the content of the feed and share their opinions so that other customers read the explanation of the review • Giving reviews allows users to have a positive influence on the brand
	• Stop Instagram activities. Break session over • There are plans to share with colleagues • Continuing previous work	• Instagram sessions are much more useful because while looking for entertainment they also get new insights that are ready to be shared with other friends

Figure 4.10 PoV Analys Users Bodycare B

PoV Madlib #2

User	*Needs*	*Insight*
• Not a Bodycare User B 	• Open Instagram	• Filling time because working at home so that time is more flexible • Done during lunch break while having lunch
	• To do*scroll*home page to search & view upload updates • Looking for content updates*feed*other user or business account	• Looking for friends' news in photo uploads with captions*feed*become a story / positive news • Looking for updates from the account that is the job reference
	• Back to doing*scroll*home page	• Continuing to view upload updates without any specific purpose • Just want to update the news and news
	• Find and view Bodycare B . feed content	• Find topics from brands that have been shared and suggested by their colleagues some time ago
	• Go to Bodycare B Instagram account • Choose one of the preferred feeds, carefully observe each type of feed	• There is curiosity to explore all the content of the feed • Observed carefully for visual reference • Understand the content and composition • Understand the presentation of other topics in the column*feed* • Doing credibility research on the brand is it true? • There are several feeds that are more suitable for conditions and make them a medium to add insight into skin health
	• Observe*feed*and learn from the design and communication aspects of language	• There is a conformity of views, the customer agrees • Maybe will do*like post*but don't feel compelled to comment • Do not have*sense of belonging*because I'm not a user of a related brand • Will not share with colleagues • The insights gained will be kept for personal use
	• Stop Instagram activities. • Continuing activities as before	• Instagram session ends and respondents benefit • The insights gained will be used for the development of their own business • It is likely that the skin health insights gained will be applied only to his family

Figure 4.11 PoV Analys Non-Bodycare B user

Based on the pictures above, it is explained that the results of the Define analysis produce an explanation of the problem and the point of view of the real needs of the user (PoV Madlib). The respondent's point of view occurs in every response in the Bodycare B Instagram feed content.

5. CONCLUSIONS

Based on the results of data processing and analysis that has been done previously, it can be concluded that the resulting :

1. There are 3 types of User Persona typology on Bodycare B Instagram followers. There are: (1)Bodycare B users for indoor workers, (2)Bodycare B users for outdoor workers, and (3)Non-users for Bodycare B products.
2. The use of the Design Thinking method can be applied to research that is oriented toward user behavior. The Design Thinking method is a comprehensive research method focusing on creative problem-solving. Design Thinking involves the user in the thinking process and makes the user's perspective the main consideration in the problem-solving process so that the user will become the object of research to identify the characteristics of their needs according to the user's point of view.
3. The differences in User Persona Typology can be used by business actors to improve and evaluate feed content according to their target market through their delivery strategy. Bodycare B can make "User Persona: Not a User of Bodycare B Products" a potential target market to change their mindset.
4. The results of the respondent's analysis in the Empathize phase, namely "Affinity Diagram: Customer Needs Parameter" (Information column), can be used as recommendations for the concept of Instagram feed content for Bodycare B in the future.

5. From the results of the needs analysis in the Define phase, Bodycare B can find out more about the needs from the customer's point of view, so that it can help meet the company's targets and goals.
6. The results of this research as a whole are expected to be a reference for developing similar product and brand promotions through the Instagram platform.

REFERENCES

Akdeniz, C. (2016). *Instagram Marketing.* Introbooks.

Akhmad, S. P., & Sarah, I. S. (2020). Peran Konten Post Instagram terhadap Keterlibatan Pelanggan Secara Daring pada Industri Kosmetik di Indonesia. *Seminar Nasional Terapan Riset Inovatif (SENTRINOV). 6.* Banyuwangi: ISEAS Publishing.

Brown, T. (2008). *Design Thinking Dalam Harvard Business Review.* Harvard Business School Publishing Corporation.

Danisworo, M. C. (2018). Pengaruh Personalisasi pada Iklan Aplikasi terhadap Sikap Pengguna (Survei Pengaruh Personalisasi pada Mobile Advertising terhadap Sikap Pengguna pada Iklan Aplikasi Instagram).

D.school, S. (2008). *Introduction to Design Thinking.* Bootcamp Bootlag.

Fraß, S., & Luana, W. (2021). Sustainability Sells : Appeals driving Consumer Engagement of Green Skincare Brands.

Juliaristanti, V., Ramdan, A. M., & Jhoansyah, D. (2020, Agustus). Analisis Karakteristik Followers dan Konten Iklan dalam Mengukur Efektivitas Instagram Stories Advertisement pada Produk Kosmetik Wardah. *Syntax Idea, 2*(8).

Kemp, S. (2022, January 8). *Data Reportal*. Retrieved from Digital 2021 : Indonesia: https://datareportal.com/reports/digital-2021-indonesia

Mangold, W. G., & Faulds, D. J. (2009). Social media: The new hybrid element of the.

Nafis, A. G. (2018). Efektivitas Media Sosial Instagram sebagai Media Promosi Pada Produk Jilbab Afra.

Sangadji, Mamang, E., & Sopiah. (2013). Perilaku Konsumen Pendekatan Praktis. *Himpunan Jurnal Penelitian CV Andi Offset*.

Santoso, A. P., Baihaqi, I., & Persada, S. F. (2017). Pengaruh Konten Post Instagram terhadap Online Engagement: Studi Kasus pada Lima Merek Pakaian Wanita. *JURNAL TEKNIK ITS, 6*(1), 220.

Szalaty, P., & Derda, I. (2020). Revolutionizing Beauty Industry": Co-Creation and Customer Engagement for Brand Image Development: Case study research of a crowdsource-driven cosmetics company Volition Beauty.

Tonkinwise, C. (2017). *A Taste for Practices: Unrepressing Style in Design Thinking.* Design Studies.

Vignisdóttir, A. (2017). Customer Engagement On Instagram Brand Pages In The Make-Up Cosmetics Industry.

DETERMINATION OF THE RENTAL AND PURCHASE SCHEME OF HEAVY EQUIPMENT USING THE MONTE CARLO SIMULATION BY CONSIDERING FLUCTUATIONS IN THE NEED FOR LOADING AND UNLOADING CARGO (CASE STUDY OF SOLID PORT OPERATION)

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ABSTRACT

In order to increase the competitive advantage of the company in a sustainable manner, companies need to make improvements and developments in their business fields. In carrying out business development, it is necessary to invest effectively and efficiently in the acquisition of the company's productive assets. To meet the needs of large market demands from the global market, large volumes of transport capacity are needed, by using ships for inter-island or cross-country export and import activities with a maximum volume of shiploads in accordance with the DUKS port design (Port for Own Interests) and heavy equipment facilities at the port for loading and unloading of row material and production.

For loading and unloading activities at solid ports, data for 2021 there is still a large cost gap between own heavy equipment assets (42%) compared to rentals (58%), for excavators external rental costs reach 86% of the total external lease, while for wheel loaders external rental costs reach 14% of total external leases. With the condition of heavy equipment needs, it is necessary to examine how many units of assets need to be purchased and how many units of equipment need to be leasing externally. The need for this heavy equipment also depends on the fluctuating schedule of the ship's berth, so the methodology used to predict the need for heavy equipment in the Future year was chosen using Monte Carlo simulations. All costs related to investment costs (initial costs), maintenance costs, overhaul costs, spare-part costs, service fees, are important things to consider in investing in heavy equipment assets to be simulated using financial methods with NPV, IRR, and PP.

The results of the Optimization Analysis obtained are that a decision needs to be purchased to increase fixed assets by 1 units of excavators so that they become 3 units, an NPV of Rp2,764,760,000.00 an IRR of 56%, PP of 2 years and 5 days, while the analysis results for wheel loaders do not need to be purchased again assets enough 2 existing units because the SMC results obtained the needs of 2 units. As for the needs of other heavy equipment at this solid port, it will be met through external leases.

Keywords: *Analysis, Heavy equipment, Solid Port, Monte Carlo.*

1. INTRODUCTION

For the smooth running of export and import activities, the company has DUKS (Pier for Its Own Interests) and heavy equipment facilities at the dock for loading and unloading activities for row materials and production products, there are 2 types of loading and unloading materials at the DUKS port, namely liquid materials (such as Crude Palm Oil, Crude Palm Kernel Oil, Refined Palm Stearin, Refined Palm Olein, Palm kernel fatty acids and etc) and solid materials (such as row material of rock phosphate fertilizer, urea, MOP / KCL, Borate, TSP, clay, palm kernel, coal, wheat, palm kernel expeller, Fertilizer in bags in the form of NPK, MOP, NK, KCL and etc.).

Operational activities at the port (DUKS) play an important role, to accelerate material loading and unloading activities so that resources are needed that can support so that activities can run smoothly, in accordance with the target of the docked ship. Ships that are docked are tried not to be late in loading and unloading activities (delay) which can cause clame costs for delays in loading / unloading ships in the form of demurage costs. For this reason, support is needed in terms of ship loading and unloading equipment in the form of HE (Heavy Equipment) heavy equipment, which is sufficient in number with adequate performance, starting from unloading materials from cargo ships, transferring materials to the ware house and compiling materials in the ware house. The following is an illustration of the use of HE in solid ports on **figure 1**.

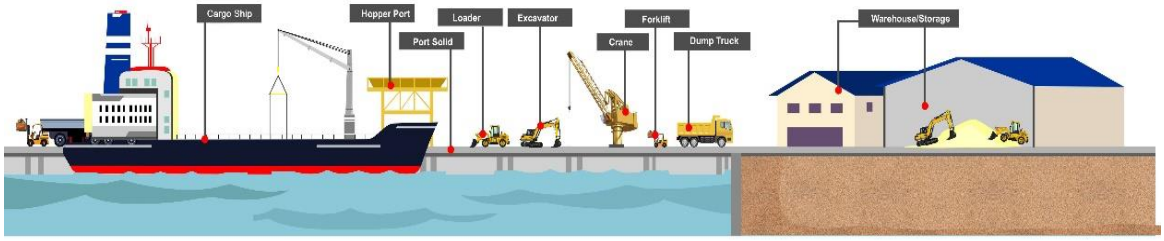


Figure 1. Solid port ilustration

Heavy equipment is not only needed in infrastructure development but also by other sectors in the fields of ports, mining, agriculture, forestry, and industry for the purpose of mobilizing goods and services. The limited national supply of heavy equipment manufacturers affects the availability of heavy equipment for construction(Simatupang et al, 2012). At some of the largest and most experienced mass terminals (ports of biomass) in the Port of Rotterdam, it provides an opportunity to get a detailed explanation of the conditions of the biomass handling industry.(Dafnomilis et al., 2018) on solid port.

This investment decision to procure heavy equipment is certainly not an easy thing to do because it involves various considerations and variables that influence the decision, including the volume of ships (cargo) that must be transported, the schedule of ship berths, the influence of loading and unloading labor, the distance of warehouse accumulation, the availability of own assets, HE rental costs, maintenance costs and he investment costs, here is a picture of the use of HE excavator **figure 2** and HE whell loader **figure 3.**

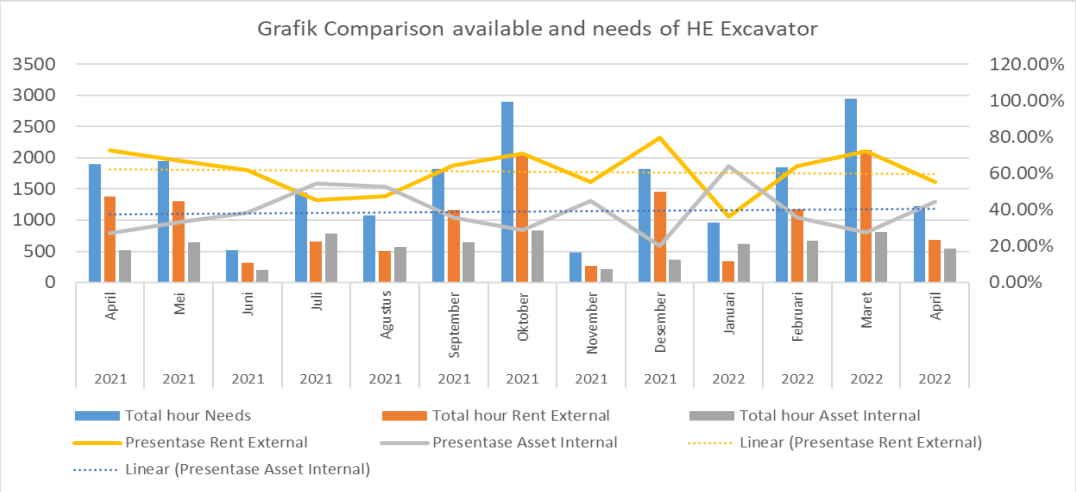


Figure 2. Grafik used of excavator in April 2021 until April 2022.

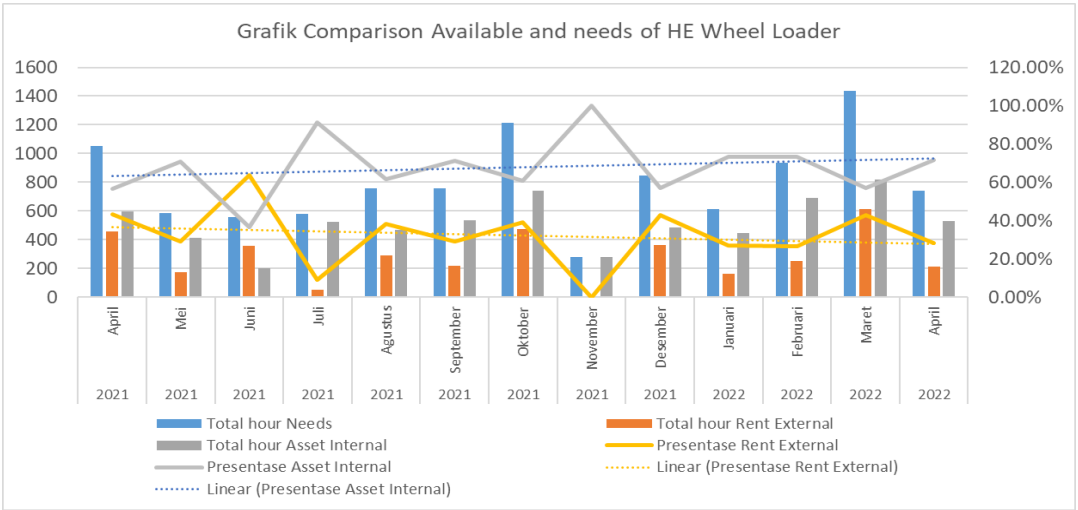


Figure 3. Grafik used of wheel loader in April 2021 until April 2022.

To maximize the selection of the type of HE equipment and the number of each type to be used on a particular project, based on the working capacity of each unit and the speed at which each HE unit needs to move properly and maximally(Shehadeh et al., 2022). Maintenance services are important supporting activities that extend the life and improve the performance of equipment(Kang et al., 2020). According to the data of the law of distribution of transient energy flows on HE analyzed (Zhu et al., 2022) needs to be considered for further research. (Mafokwane et.al, 2019)The use of 16-ton HE forklifts in the indoor manufacturing industry poses a health hazard to employees, so they are only used outdoors.

In the case study, the subject matter is on excavator equipment and whell loaders, where currently there is still a considerable cost comparison between external rental activities and owned assets, as in figure 4 below. HE needs vary and fluctuate every day, adjusting the loading and unloading activities of cargo ships, so that a solution is needed with a simulation approach to the needs of HE units in the future, in this study the author will use Monte Carlo Simulation (MCS). Using historical data, MCS can be used for the right choice to predict (Barbu, A., Zhu, SC.2020)

the needs of HE units in the future. In addition, it will also be described related to the financial analysis of the HE Asset investment.

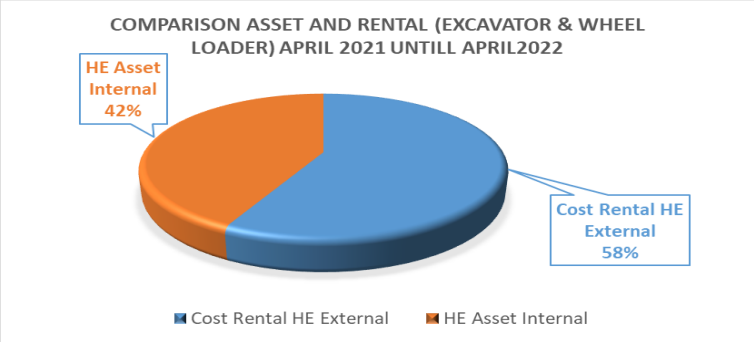


Figure 4. Comparison asset and cost rental

2. LITERATURE REVIEW

Solid Port is a port used for the operation of loading and unloading activities of solid materials. Solid materials in solid ports can be wheat, rice, corn, kernels, kernel pulp, fertilizers, coal, soya (soybeans) and other materials, to support the smooth loading and unloading activities in heavy equipment (HE) is needed. At first the meaning of a sea port was that the waters were protected as a place to dock ships safely by docking moored at the mooring dolphin or by throwing anchors into the sea to the ground. The meaning of the port is a closed water area and also protected from nature (typhoons, storms, big waves) so that ships can dock safely, comfortably and smoothly (smoothly) for loading and unloading goods, passengers, refueling, ship repairs and other needs. The port with a broader meaning is a gateway where land-to-sea transportation, sea-to-land transportation, terminal currents from sea to sea transportation move. (Budiarta, 2015).

2.1 Definition of heavy equipment (HE)

HE is a tool used to assist humans in carrying out construction work on a building structure. Heavy equipment is an important factor in projects, especially construction and mining projects and other activities on a large scale(Rostiyanti, 2009).

An excavator is a machine consisting of a boom (backhoe), a bucket (bucket) and a taxi on a rotating platform (known as a house). Excavator is a heavy equipment used for digging and transporting (loading and unloading), a material (soil, coal, sand and so on). Based on the type of drive, excavators are divided into two, namely: 1. Crawler excavator or centipede wheel excavator, this type of excavator uses centipede wheels on the undercarriage. This type of excavator uses a hydrostatic transmission powertrain where the power from the hydraulic motor is flowed to the planetary gear system contained in the final drive, sprocket to the track shoe so that the excavator can move. 2. Wheel excavator or excavator uses rubber wheels, this type of excavator uses rubber wheels where the excavator does not need an undercarriage as in the excavator staggler.

The functions of the excavator in general are 1.Working on mining activities (mining capacity), 2.Clearing of forest land for agricultural land and plantations, 3.Digging the soil, leveling the soil surface, 4.Creation of ditches, irrigation canals, pits and building foundations, 5. Dredging, filling, and moving raw materials, 6.Working on loading and unloading activities of raw materials at ports such as coal, fertilizers, wheat and other materials.

Basically, there are two excavator driving forces, namely machine species (diesel) and battery species (electric motors). In general, the main driving force of a hydraulic excavator is a diesel engine whose mechanical energy becomes hydraulic energy through pump pressure which

is then distributed to the hydraulic cylinder to produce movement. While the electric motor is to start and supply energy electrical components such as dynamos, lighting, motorist measuring instruments, experimenters / panels and so on.

Wheel loaders can be used on construction sites to load material rows into dumpers, or trucks. Row material can be excavated soil, demolition waste, raw materials, and/or other solid materials. Wheel loaders are heavy equipment used to lift material to be loaded into a dumptruck or move material to another place. The loader has a large bucket in front of it with shorter moving arms. Wheel loader is a tractor with whell rubber (rubber wheels) equipped with a bucket at the front (front load). This tool is suitable (efficient) to be used in dry work areas flat and sturdy because it has high mobility and is simple. The Wheel Loader also moves with articulated which provides easy wiggle room (flexible in activity) that a crawler loader (loader with iron wheels) cannot do.

2.2 HE Investment

The main purpose of the investment is to get a decent range of profits in the future. These benefits can be economic or non-economic benefits, or a combination of both. Investment is basically an attempt to invest production factors in a particular project, both in industry and elsewhere. The project itself can be an extension of a new or existing project/development extension(Pebriana, 2005).

According to the two experts, the purpose of stock investment is to invest assets in the hope that the company will make a profit in the future(Martono et. all, (2002). An investor will buy a number of current shares and hopes to benefit from the increase in the stock price and dividends (the company's profit returns) in the future as a result of the investment made(Tandelilin, 2010). Internally, the investment objective is a step towards the development of wealth (acceleration of wealth) obtained through investment results such as interest, dividends and royalties.

According to Martono et. all, (2010), Financial management has three main functions. It is: 1. Investment Decision Investment is defined as an investment of a company. 2. Funding Decisions include several things, including: a. The decision to determine the source of funding needed to fund an investment. The source of funding used to fund these investments can be short-term debt, long-term debt, and equity, b.Determining the optimal balance of expenditures, or often referred to as optimal capital structure. The optimal capital structure is the balance between long-term debt and capital at the lowest average cost of capital, 3. Asset Management Decisions.

Investing can be interpreted as making investments in the long term with various fields of business activities(Kasmir,2003). Investment is the investment of business capital or money in the hope that it will bring additional or special benefits to the fund or money. Investment activities are important activities that require large costs and have a long-term impact on business continuity(Giatman, 2006). Based on this understanding, an investment made by the company is something important in order to maximize the wealth of the company's shareholders(Alexandri, 2008). Financial investment is the purchase of securities such as investment purchase of shares, bonds and certificates of deposit(Husnan, 2004).

According to Sjahrial (2008), Long-term investments can be divided into four types:

1. Exchange investment (Replacement) which is an exchange of assets that are obsolete or no longer feasible for the latest operations or technologies. 2. Expansion Investment, which is in the form of increasing production capacity due to better business opportunities.

3. Growth Investment(Growth), which concerns the addition of new products or diversification.

4. Other Investments (Others), namely investments that are not included in the three categories above include pollution control equipment and investments in improving work safety. According

to (Haming et.all, 2003), the amount of funding required to finance the investment plan largely depends on the type of project and the size of the project. Large projects require large funds, while small projects require relatively small investments.

To determine the length of investment time, the thing that needs to be done is to identify what variables can affect in determining the length of an investment. According to (Handoko et all, 2021), Construction Period (construction period) begins at the time of signing the approval for the start of the project until the completion of the construction of the project. Operational peride (operational period) begins when the project product is opened/utilized for the public interest and begins to get income.

Maintenance costs are the costs needed for the maintenance of fixed assets in the form of heavy equipment, so that the heavy equipment can operate properly and is suitable for normal use in accordance with its function and investment period. According to Assauri (2008), Maintenance is the activity of maintaining or maintaining or maintaining facilities (equipment) by making repairs or adjustments to the necessary replacements so that the operational state of production can run according to plan (planning). Activity maintenance is needed within the company because:

a. Each piece of equipment has a service life, there is a time limit that will be damaged or failed.
b. The damage or failure of a piece of equipment cannot be known for certain.
c. It is necessary to make sure that the service life can be more durable.

To avoid unknown equipment failure/damage, routine/periodic maintenance is required. Basic maintenance concepts include planned maintenance and unplanned mintenance.(*Modern Diesel Technology*, 2017)

a. Planned maintenance (planned/periodic), an organized, controlled, scheduled, coordinated equipment maintenance activity, in a maintenance program. This periodic maintenance may include Preventive Maintenance (PM), Corective Maintenance (CM), Predictive Maintenance and scheduled overhaul of equipment.
b. Unplanned mintenance, an activity in the form of equipment maintenance measures, which is not planned, this is like an emergency breakdown.

2.3 HE requests/needs

Needs/Demand is the total amount of goods and services that consumers want to buy at different price levels. The law of demand states that the amount required for an item is always inversely proportional to its price. This means that if the price of an item increases, the number of goods requested will decrease. Conversely, if the price of an item falls, the quantity of goods requested will increase. Demand is the desire for a particular product that is supported by the ability to pay (Kotler and Keller, 2015). In this study, the definition of demand is the need for heavy equipment in activities at solid ports to support the smooth running of loading and unloading activities at solid ports.

2.4. Monte Carlo Simulation (MCS)

MCS is a process of randomly deriving the value of an indeterminate variable repeatedly to simulate a model. Stanislaw Ulam as a brilliant mathematician working on the United State's Manhattan project, is considered the inventor of mcs in 1946. (Matthew et. all, 2009).

This MCS process is a repeat cycle. The distribution resulting from this repetition process can be described in the form of a graph as a frequency distibustion, then the picture obtained will be used as a consideration for company management decisions.(Prihatono et all, 2009).

2.5. Financial HE

Equivalence Method Giatman (2006) reveals that the equivalence method is a method used to calculate the tendency of the value of money based on one moment to another. The future value

of money F (future) as the current P (present) equivalent in interest rate i, using thus: ($F = P (1+i)^n$)

Multiplier factor $(1 + i)^n$ is called the compound amount factor of a single payment. (Single payment compund amount factor).

Giatman (2006) states that there are several ways (methode) to assess the feasibility of an investment and are generally used. It is:

a. Net Present Value (NPV) from time to point (now).

The NPV method converts all cash flows into present values (P) and sums the P earned to reflect the net (net) value of the overall caseflow that occurred during the planning period(Pujawan, 2003). To calculate the NPV, data on the estimated cost of capital, operating and maintenance costs, as well as the estimated profitability of the proposed project are required(Afriyeni, 2008). The interest rate used for the conversion is MARR. Mathematically, the current Value of Caseflow can be expressed as:

Pi = N. At. P/F; i%,t

Where: P(i) = the current value of the overall cash flow at an interest rate i %

At = cash flow at the end of the time period t

i = MARR

N = planning horizon (period)

To find out whether the investment plan is economically feasible or not, a certain measure / criterion is needed in the NPV method, namely if: NPV > 0 means that the investment will be feasible / provide a profit. NPV < 0 means that the investment will not be feaseble. (Sugiyono et al, 2021) Concluding in his research that the alternative chosen to supply additional heavy equipment is through service contracts / service contracts, companies will get another advantage, namely there is no need to provide large investment costs in advance, the company can distribute the burden of investment costs into operational costs.

Most companies carry out projects with the aim of making a profit, and profitability is often measured as a discounted value of the project's cash flow. It is very important to use the right data in calculating the NPV, since the feasibility of a project may change with fluctuating data. (Hanafizadeh et al 2011).

b. Internal Rate of Return methode (IRR)

Pujawan (2009) explaining that there are still several RRIs known in engineering economics including the Internal Rate of Return (IRR), the IRR assumes that any personally obtained output is reinvested using the same level of RORAccording to Giatman (2006), The IRR method looks for interest rates at the same TIME NPV using zero. So in this IRR method, the news obtained is related to using the level of cash flow capability to return the investment described in the form of % per time period.

c. Payback Period (PP)

PP is the period from the start of business activities until the return of principal or income with break-even costs after the tax is calculated. Giatman (2006) states that if the cash flow component is annual, the length of the break-even point (Break Even Point) can be calculated as follows:

PP = (Investation / Annual Benefit) x Period of time),

It is necessary to determine the feasibility of a particular basic investment Payback Method The period indicates that investment planning will be called feasible if: PP = n or vice versa. Where: PP = Payback Period ; n = investment age

3. METHODS

This research (observation) is an observation of a case study, in the form of a detailed observation of various types of information regarding several entities or cases over a certain period of time.(Neuman, 2013;47). While Stake in Creswell (2010;20) posits that case studies as a research strategy are carefully researched against a program, event, activity, process or group of individuals. Cases are limited by time and activity, and researchers use a variety of data collection methods to collect complete information based on the allotted time.

The type of research used is descriptive research, which is research that provides the most important possible picture of a certain object, condition, or symptom in order to answer research questions (Neuman, 2013;44).

3.1 Data Analysis/Processing Techniques

Data analysis in this study uses quantitative descriptive analysis methods with descriptive statistical analysis techniques, namely statistics that are used to analyze data by describing or describing the data that has been collected in such a way as to draw generalizations or conclusions for the general public. In descriptive statistics the presentation of data through tables, graphs, diagrams, calculations of modes, medians, mean, calculation of deciles, percentiles, deviations, calculation of percentages. (Sugiyono,2006;164-165). It is argued by Neuman (2013;428) that descriptive statistics are a general type of simple statistic used to describe and explain archetypes in data.

The research design in the preparation of this research consists of several stages as contained in **Figure 5**

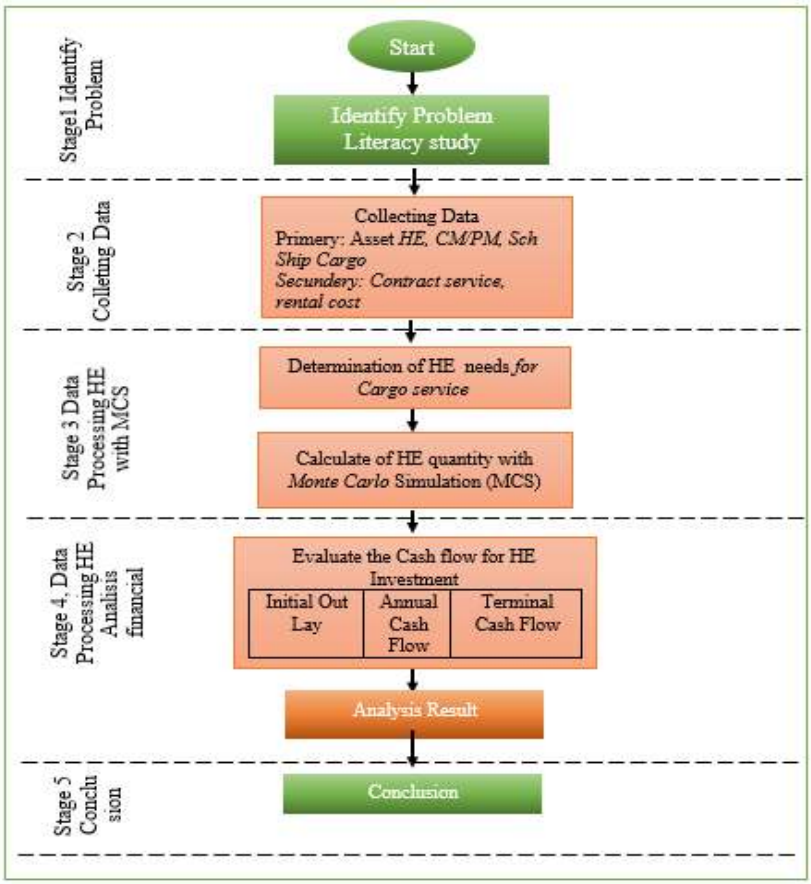


Figure 5. The scheme of research

3.2 Monte Carlo Simulation Aspect

To determine the optimum amount of heavy equipment for the future in this study using monte carlo simulation (MCS). MCS is a probabilistic type of simulation to find problem solving by sampling data from random processes.

The basis of MCM is to conduct experiments on probabilistic elements through random sampling. So that MCS can provide an overview, to propose the best (optimal) amount of HE as a policy for the progress of the company, here are the research steps using MCS:a.Establishing probability distributions analyzing historical data, b.Establishing cumulative distributions, c.Determining intervals of random numbers, d.Running simulations with a computer, generating random numbers with Microsoft exel from a series of experiments, with random numbers by typing in cell: Rand(), e.Averaging MCS prediction results.

In this study, predictions were taken for needs for the next 30 days, so that the number of needs per day would be divided by 30 days, f.The average result was compared with current ownership assets. For this data input process, it can be seen in table 1 below.Next step, get a random value by typing in cell: Ran(). After that, the Random value that comes out in the cell in the copy is then changed to the number in the cell, this is so that when there are other instructions in the exel software the random value that we have copied does not change again, until the process is complete. It can be seen in **table 2** below.

MCS can be viewed in the following ways of expectations:

$$E = \sum_{i=0}^{30} \text{(probablitas of HE) x (request HE)}$$

If done 30 times or 365 times the withdrawal of random numbers will be clearly visible HE requests according to the simulated past data.

From the results of this MCS, an Average (average) will be taken, and this figure can already be the result of predicting HE needs, so that we can compare with the condition of the existing HE asset, the amount of HE needs needed for the next 30 days can be obtained. The predicted results of the processed MCS > the number of existing HE; then it is worth considering for he fixed asset investment, and if the mcs processed prediction results ≤ the amount of existing HE; then there is no need to increase HE investment, which means that if there is a need for HE beyond the amount of existing assets, it will be done through an external HE lease scheme, this can be a managerial input to the company's leadership. After obtaining a prediction of the optimal amount of HE, then continue data processing to financial analysis.

3.3 Finansial Aspect

In the review of aspects of Financial Analysis is carried out as follows

1) Net Present Value (NPV), If NPV > 0, then the project is acceptable. (profitable).

2) IRR, Jika IRR > diskonto value, then then the project can be implemented. (profitable).

3)Payback period (PP), If PP < Investment time, then the project can be implemented. (profitable)

3.4 The conclusion plan stage

This stage includes drawing conclusions from the results of the analysis of the most profitable decisions. The conclusion is the point to answer the description of the problem and assess whether the research objectives have been achieved. Analysis of the best results with he fixed asset ownership can provide benefits such as reducing external rental costs, and when needed heavy equipment is available quickly without waiting too long, which means shortening ship berthing times and streamlining solid port operations.

4. RESULTS

4.1 Result Monte Carlo Simulation analysis

MCS for prediction of the need for the number of HE excavators and wheel loaders. HE data retrieved primary data within 395 days. Currently, the fixed assets owned by the company in the port are solid, for excavators 2 units and for wheel loaders 2 units. In the daily activities at the solid port the use of HE fluctuates greatly, ranging from 0 units to 12 units of excavators. As for the current condition, if you use 12 units of excavators in the same day, 2 units of fixed assets and the remaining 10 units will use external HE rental. The following is explained the HE Excavator data with used 0 units to 12 units, within 395 days, from April 2021 to April 2022 as in table 1 below.

Table 1. Excavator in frequency and distribution

No.	EXCV (Unit)	Frequency of Used	Density Distribution	Comulatif Distribution	*100 Tag Number
1	0	106	0.268	0.268	0,00 - 26,8
2	1	45	0.114	0.382	26,9 - 38,2
3	2	85	0.215	0.597	38,3 - 59,7
4	3	34	0.086	0.684	59,8 - 68,4
5	4	26	0.066	0.749	68,5 - 74,9
6	5	20	0.051	0.800	75,0 - 80,0
7	6	15	0.038	0.838	80,1 - 83,8
8	7	15	0.038	0.876	83,9 - 87,6
9	8	14	0.035	0.911	87,7 - 91,1
10	9	16	0.041	0.952	91,2 - 95,2
11	10	11	0.028	0.980	95,3 -98,1
12	11	5	0.013	0.992	98,2 - 99,2
13	12	3	0.008	1.000	99,3 - 100,0
SUM		**395**	**Probability**	**Prob Com**	**Projection**

Furthermore, from table 1, it is continued by calculating the prediction of HE Excavator orders in the future, in this calculation is carried out several times the count, we also do the calculation for predictions for the next 1 year with almost the same results. In this paper, the table that we present is the prediction of HE Excavator orders for the next 30 days, which can be seen in **table 2.**

Tabel 2. HE Excavator order in Prediction

Value =Rand ()	Daily Request	Random Value (RV)	(RV)*100	Order In Prediction (Unit)	Copy (RV)
0.876323935	1	0.866119815	86.61	7	0.866119815
0.987151046	2	0.155776172	15.58	0	0.155776172
0.826849398	3	0.670801033	67.08	3	0.670801033
0.748118124	4	0.206475406	20.65	0	0.206475406
0.910051374	5	0.576828953	57.68	2	0.576828953
0.931310251	6	0.247475882	24.75	0	0.247475882
0.256659849	7	0.488715147	48.87	2	0.488715147
0.61440643	8	0.997833992	99.78	12	0.997833992
0.181649328	9	0.516544142	51.65	2	0.516544142

Value =Rand ()	Daily Request	Random Value (RV)	(RV)*100	Order In Prediction (Unit)	Copy (RV)
0.267548359	10	0.321661743	32.17	1	0.321661743
0.003796328	11	0.283560256	28.36	1	0.283560256
0.1610513	12	0.489927979	48.99	2	0.489927979
0.476057478	13	0.634591949	63.46	3	0.634591949
0.811382734	14	0.56436714	56.44	2	0.56436714
0.647139087	15	0.492087385	49.21	2	0.492087385
0.937805184	16	0.045561633	4.56	0	0.045561633
0.336366027	17	0.490973851	49.10	2	0.490973851
0.387904729	18	0.255747731	25.57	0	0.255747731
0.596185379	19	0.090367768	9.04	0	0.090367768
0.492836317	20	0.986158802	98.62	11	0.986158802
0.143067463	21	0.048536042	4.85	0	0.048536042
0.29898184	22	0.25608016	25.61	0	0.25608016
0.69506493	23	0.366781391	36.68	1	0.366781391
0.920891644	24	0.603664974	60.37	3	0.603664974
0.059411109	25	0.896145823	89.61	8	0.896145823
0.914404051	26	0.469123751	46.91	2	0.469123751
0.854446309	27	0.472419834	47.24	2	0.472419834
0.44643989	28	0.772200888	77.22	5	0.772200888
0.359523138	29	0.991056909	99.11	11	0.991056909
0.79503465	30	0.849943868	84.99	7	0.849943868
			SUM	91	
			AVERAGE	**3 UNITS**	

Way of expectation: sum order HE / request HE ➔ 91/30 = 3,01 the meaning need **3 units.**

$$E = \sum_{i=0}^{30} (\text{probablitas HE}) \times (\text{request HE})$$

= (0,268)(0) + (0,114)(1) + (0,215)(2) + (0,086)(3) + (0,066)(4) + (0,051)(5) + (0,038)(6) + (0,038)(7)+ (0,035)(8)+ (0,041)(9) + (0,028)(10) + (0,013x)(11) + (0,008)(12)

= 2,97 HE = **3 units HE.**

The results of the MCS process with random numbers, a prediction for the next 30 days is that 3 units of Excavators must be provided for loading and unloading activities at solid ports.
Likewise, for HE Whell loader data used from 0 units to 7 units, in a span of 395 days from April 2021 to April 2022, as in table 3 below.

4.2 Result of Finacial Analysis

The data obtained from the site, it is then analyzed in the form of financial. The following are the provisions or data obtained as in **table 3.**

Table 3. Constrain Investment of Excavator Lonking CDM6225

CONSTRAINT EXCAVATOR Lonking CDM6225 (in million Rupiah)

No.	Description	UN	Amount (Rp)			Total cost (Rp)	Remark
A	**INITIAL COST/ LAY OUT COST**	1 lot	1,150	1		Rp 1,150	8 years
B	**REVENUE**						
	PROVIDENCE (EXTERNAL RENTAL COST)	1 years	1,032	1.0		Rp 1,032	every year
	Escalation Providence per year						2%
C	**MAINTENANCE COST**						
	Fuel, Overhaule, service cost, oli, filter, grease.						
						Rp 204	
	Escalation Maintenance Cost per year						2%
D	**OPERATIONAL COST**						
D1	Salary Operator/month	2 person	Rp 7.5	12.0	years	Rp 180	2 shift
	Escalation Operational Cost per year						2%
E	CAPEX (every 4 years)	2 times	Rp 40	1		Rp 40	repainting/body
F	Salvage/Residu (8 years)		Rp 200			Rp 200	
		per month	Rp 25			Rp 25	year 8th
G	DEPRESIATION	8 years	Rp 950	1/8		Rp 119	per year
H	MARR	12%		12%			
I	I (interest)	8%		8%			
J	n (nominal year)	8 year		8.0			
K	PMT (PAYMENT)		-Rp 200				
L	WACC	0%					100% Own Modal
M	RENTAL COST EXTERNAL EXCV / Hour	/Hour	Rp 0.45	480	years	Rp 2,592	Incl Operator/excl Fuel
N	RENTAL COST EXTERNAL EXCV / Month	month	Rp 86	12	years	Rp 1,032	Incl Operator/excl Fuel
O	FUEL	1 hour	Rp 29	18	ltr/hour	Rp 517	(by Owner) balance

From the excavator data above, then calculated cashflow for HE excavator see **table 4.**

Tabel 4. Calculate Cashflow of Excavator Lonking CDM6225

CASHFLOW AND FINANCE Of EXCAVATOR Lonking CDM6225

Value in million rupiah

Periode (year)	0	1	2	3	4	5	6	7	8
Initial cost/ Lay Cost	(1,150.00)								
Revenue (up 2%)		1,032.00	1,052.64	1,073.69	1,095.17	1,117.07	1,139.41	1,162.20	1,185.44
Maintenance Cost (up 2%)		(203.62)	(207.70)	(211.85)	(216.09)	(220.41)	(224.82)	(229.31)	(233.90)
Operational Cost (OPEX) up 2%		(180.00)	(183.60)	(187.27)	(191.02)	(194.84)	(198.73)	(202.71)	(206.76)
Capex					(40.00)				(40.00)
Net Operation Income (NOI)	(1,150.00)	648.38	661.34	674.57	648.06	701.82	715.86	730.18	704.78
Deprresiasi									
Discounted Factor (8%)	1.00	1.08	1.17	1.26	1.36	1.47	1.59	1.71	1.85
Discounted Cash Flow (DCF)	(1,150.00)	600.35	566.99	535.50	476.34	477.65	451.11	426.05	380.77
Payback Periode (PP)	(1,150.00)	(549.65)	**17.34**	552.84	1,029.18	1,506.83	1,957.94	2,383.99	2,764.76
Net Present Value (NPV)	**2,764.76**		**6**						
Internal Rate Return (IRR)	**56%**								

Conclusion:

PP is 2y and 6d < 8 years; NPV is 2,764.78 > 0; IRR is 56% ⇨ **So The investment is FEASIBLE.**

5. CONCLUSIONS

From the results of previous data processing through MCS, the number of HE needed for the prediction of the next 30 days is 3 units of excavators, and 2 units of whell loaders. With several experiments with MCS for the prediction of 365 days (1 year) the prediction also obtained the prediction result was 3 units of excavators, as well as for the prediction of wheel loaders obtained 2 units. The results of the finacial excavator analysis obtained the npv results are Rp2,764,760,000.00, IRR of 56%, PP for 2 years and 6 days, this is feasible to implement. The results of the finacial whell loader analysis obtained the results of NPV is Rp. 380,400,000.00, IRR of 23%, PP for 5 years and 40 days, this is also still feasible to be implemented, but based on

MCS predictions the need for wheel loaders does not need to be added for now and 1 year in the future. This conslusion can make consideration to management where with the purchase of 1 additional unit of excavator, so that the total assets of 3 units of excavators. This will be more profitable. However, there are also some excavators that are still carried out with an external rental scheme, this is done if the use of excavators simultaneously exceeds 3 units of existing assets. Likewise, for whell loaders, an external lease is needed, if the need for a unit of use simultaneously exceeds 2 units of existing assets.

REFERENCES

Alexandri, C., & Luca, L. (2008). Romania and CAP reform. Agricultural Economics and Rural Development, 3(4), 161-180.

Dafnomilis, I., Duinkerken, M. B., Junginger, M., Lodewijks, G., & Schott, D. L. (2018). Optimal equipment deployment for biomass terminal operations. Transportation Research Part E: Logistics and Transportation Review, 115, 147–163. https://doi.org/10.1016/j.tre.2018.05.001

Dudek, G. and Stadtler, H. (2005). Negotiation-Based Collaborative Planning between Supply Chains Partners. European Journal of Operational Research, 163(3), 668-687.

Douglas, Emery. dan John, Finnerty. (1997), Corporate Financial Management, International Edition, New Jersey, Prentice Hall.

Hanafizadeh, P., Kazazi, A., & Bolhasani, A. J. (2011). Portfolio design for investment companies through scenario planning. Management Decision, 49(4), 513-532.

Kang, K., Zhong, R. Y., & Nassehi, A. (2020). Integrated Disassembly and Assembly Model for Heavy Duty Equipment Maintenance. Procedia CIRP, 93, 995–1000. https://doi.org/10.1016/j.procir.2020.04.086

Kang, Kai, Ray Y. Zhong, and Aydin Nassehi. 2020. "Integrated Disassembly and Assembly Model for Heavy Duty Equipment Maintenance." Procedia CIRP 93:995–1000. doi: 10.1016/j.procir.2020.04.086.

Liu, R., Kumar, A. and van der Aalst, W. (2007). A Formal Modeling Approach for Supply Chain Event Management. Journal of Decision Support Systems. 43(3), 761-778.

Mafokwane, S. Z., Kallon, D. V. V., Nkosi, M., & Chiromo, F. (2019). Design of a tri-adjustable automated heavy-duty handling system based on Industry 4.0 principles. Procedia Manufacturing, 35, 187–196. https://doi.org/10.1016/j.promfg.2019.05.026

Mafokwane, S. Z., D. V. V. Kallon, M. Nkosi, and F. Chiromo. 2019. "Design of a Tri-Adjustable Automated Heavy-Duty Handling System Based on Industry 4.0 Principles." Procedia Manufacturing 35:187–96. doi: 10.1016/j.promfg.2019.05.026.

Matthew, C. T., & Sternberg, R. J. (2009). Developing experience-based (tacit) knowledge through reflection. Learning and individual differences, 19(4), 530-540.

Prihatono, F. A., & Gunarta, I. K. (2009). ANALISIS RISIKO KETERLAMBATAN KAPAL TERHADAP KINERJA KEUANGAN PERUSAHAAN ANGKUTAN LAUT DENGAN MENGGUNAKAN SIMULASI MONTE CARLO STUDI KASUS : PT X. 16.

Shehadeh, A., Alshboul, O., Tatari, O., Alzubaidi, M. A., & Hamed El-Sayed Salama, A. (2022). Selection of heavy machinery for earthwork activities: A multi-objective optimization approach using a genetic algorithm. Alexandria Engineering Journal, 61(10), 7555–7569. https://doi.org/10.1016/j.aej.2022.01.010

Simatupang, T. M., & Hendarman, A. F. (2012). AN ANALYSIS OF HEAVY EQUIPMENT SUPPLY CHAIN IN SUPPORTING INFRASTRUCTURE CONSTRUCTION. 8.

Sugiyono, L. A., & Syairudin, B. (2021). Economic Analysis of Heavy equipment Supply for Fulfilling Raw Materials. Sao Paulo, 13.

Sugiyono, Lilik Agus, and Bambang Syairudin. 2021. "Economic Analysis of Heavy equipment Supply for Fulfilling Raw Materials." Sao Paulo 13.

Zhu, G., Zhen, D., Chen, W., Zuo, Q., Zhao, M., Wang, Y., Chen, Z., & Yang, J. (2022). Experimental study on the engine energy flow of a heavy-duty vehicle under C-WTVC. Energy Reports, 8, 4430–4442. https://doi.org/10.1016/j.egyr.2022.03.079

Kotler Dan Keller, (2015), Manajemen Pemasaran, Jilid 1, Edisi 13, Jakarta: Erlangga

Afriyeni, Endang. 2008. Penilaian Kinerja Keuangan Dengan Menggunakan Analisis Rasio. Jurnal Ekonomi dan Bisnis. Vol.3, No.2:109.

Agus D. Harjito, Martono. (2002). Manajemen Keuangan. Edisi Pertama. Yogyakarta: Ekonosia.

Assauri, Sofyan, 2008, Manajemen Pemasaran, edisi pertama, cetakan kedelapan, Penerbit : Raja Grafindo, Jakarta

A.Ross, Stephen, et all (2009). Pengantar Keuangan Perusahaan 1. Jakarta: Salemba Empat.

Barbu, A., Zhu, SC. (2020). Pengantar Metode Monte Carlo. Dalam: Metode Monte Carlo. Springer, Singapura. https://doi.org/10.1007/978-981-13-2971-5_1

Budiartha, Nyoman. (2015). Pelabuhan: Perencanaan dan Perancangan Konstruksi Bangunan Laut dan Pantai. Buku Arti, Bali.

Gittinger, J. Price. 1986. Analisa Ekonomi Proyek-proyek Pertanian. Penerjemah Slamet.

Giatman, M. "Ekonomi Teknik". PT. Raja Grafindo Persada, Jakarta. 2006

Hidayat, Lukman and Puspitasari, R and Tantina, T (2011) Analisis Sensitivitas Sebagai Faktor Penting Dalam Suatu Pengambilan Keputusan Investasi. Jurnal Ilmiah Ranggagading (JIR), 11 (2). pp. 134-141.

Husnan, Suad., Enny Pudjiastuti, 2004. Dasar-Dasar Manajemen Keuangan. Edisi Keempat, Yogyakarta, UPP AMP YKPN.

Kasmir, 2003, Manajemen Perbankan. Jakarta: PT Rajawali Grafindo Persada.

Modern diesel technology: Heavy equipment systems (3rd edition). (2017). Boston, Cengage Learning.

Neuman, W. Lawrence. 2013. Metodologi Penelitian Sosial: Pendekatan Kualitatif dan Kuantitaif. Jakarta: PT Indeks.

Pebriana, D. S. (2005). Penerapan strategi Marketing Mix pada UD. Agus Mebel di Karanganyar.

Pujawan, I Nyoman. 2003. Ekonomi Teknik. Surabaya: Prima Ginting.

Pujawan, I Nyoman, 2009, Ekonomi Teknik, Edisi Kedua Jilid Pertama, Guna Widya, Surabaya.

Rostiyanti, S.F. 2008. Alat Berat Untuk Proyek Konstruksi – Edisi kedua. Jakarta: Rineka Cipta

Sugiyono, 2020. Metode Penelitian Kualitatif. Bandung: Alfabeta.

Tandelilin, E. (2010). Dasar-dasar manajemen investasi.

Wiratama, William Jefferson, and Ketut Budiartha. "Pengaruh Independensi, Pengalaman Kerja, Due Professional Care dan Akuntabilitas Terhadap Kualitas Audit." E-jurnal Akuntansi 10.1 (2015): 91-106.

INVESMENT FINANCING ANALYSIS OF PT JASAMARGA TOLLROAD MAINTENANCE

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ABSTRACT

PT Jasamarga Tollroad Maintenance (JMTM) is a subsidiary of PT Jasa Marga (Persero) Tbk (JM), JMTM is engaged in toll road maintenance to support Jasa Marga's main business lines, especially in terms of meeting the Minimum Service Standards (SPM) for toll roads. In 2021 the value of the maintenance management contract has increased almost 2 times compared to 2020. The impact of the Covid-19 pandemic greatly affected JM's financial performance in 2020. With the large value of work and the impact of the Covid-19 pandemic which resulted in JM's financial performance being negative, This resulted in limited capital from JM. Therefore, JMTM was asked to find other financing solutions apart from its own capital. It is planned that in 2021 JMTM will carry out financing solutions other than own capital in the form of bank loans and shares, but do not yet know the method that will be used to find the most optimal financing structure. By using a theoretical mapping of leading journals, 8 journals were obtained from 2013-2020 with the results that there are various methods, both in a project, company, and investment in determining the financing structure. From the results of the theoretical mapping analysis, the method for finding the most optimal financing structure is WACC and Leverage. The method used to calculate the lightest cost of capital financing structure is to use the WACC method and to find out the lightest rate of return using the Leverage method.

Keywords: Financing Analysis, Sensitivity Analysis, Cost of Capital, Toll Road, Maintenance.

1. INTRODUCTION

PT Jasamarga Tollroad Maintenance (JMTM) is a subsidiary of PT Jasa Marga (Persero) Tbk (JM), the largest freeway provider in Indonesia, where 99.82% of its ownership belongs to Jasa Marga as the parent company. Well known as engaged in toll road maintenance to support Jasa Marga's main business lines, especially in case of fulfilling the Minimum Service Standards (SPM) for toll roads. In 2019, JMTM assumed greater trust from PT Jasa Marga (Persero) Tbk. to carry out toll road maintenance with the concept of total maintenance solutions (Management Contracts) on toll road sections operated by JM.

In 2021 the value of maintenance management contracts increased by almost two times compared to 2020. The impact of the Covid-19 pandemic greatly affected JM's financial performance in 2020. Based on JM's financial report, in 2020 operating revenues from JM decreased compared to 2019, from 10.984 billion to 9.588 billion, the most noticeable is that JM

in 2020 experienced a loss of 42 billion and compared to 2019 previously experienced a profit of 2,074 billion.

With the magnitude value of work and the impact of the Covid-19 pandemic, which resulted in JM's financial performance becoming negative, this resulted in limited capital from JM. Therefore, JMTM asked to find other financing solutions apart from its capital.

It's planned that in 2021 JMTM will carry out financing solutions other than its capital in the form of Bank and Share loans but didn't know yet the method that will be used to find the most optimal financing structure.

2. LITERATURE REVIEW

2.1 Toll Road Financing

Funding for toll road construction projects in Indonesia can come from the government, foreign aid, or other sources. Business Entities can participate in building and operating toll roads within a certain period and have the right to collect service usage fees from users to return investment capital, operating and maintenance costs, as well as reasonable profits (Karsaman, Rodhiatun, Al Rasyid, & Santoso, 2015).

2.2 Project Financing

Financing is the provision of money or bills that can be equated with it, based on an agreement or agreement between the bank and another party that obliges the financed party to return the money or bill after a certain period in exchange for profit-sharing (Kasmir, 2001).

Noor (2007) stated that project financing is the fulfillment of the need for funds for business development which is usually calculated in feasibility studies. These fundraisers include fixed capital and working capital. Fixed capital is an investment for the needs of capital goods, while working capital is capital to start operations that are exhausted in one production.

According to Miles, Berens, Eppli, & Weiss (2007), the source of project financing comes from own capital, loans, and a combination of the two.

2.3 Capital Structure

According to Dare & Sola (2010), there are various alternative ratios of debt and capital, including 100% equity, 100% debt, and the composition of X% equity and Y% debt (in Akeem, et al., 2014).

Sirait's research (2017) suggested that there is an optimal range of capital structures, although there is no methodology that companies use in determining their optimal capital structure.

2.4 Debt Policy Theory

1. Trade off theory

The Trade-Off Theory was first introduced in 1958 by Modigliani and Miller. Trade-Off Theory has considered various factors such as corporate tax, bankruptcy costs, and personal tax in explaining why a company chooses a specific capital structure (Husnan, 2000).

2. Pecking Order Theory

The Pecking Order Theory was developed by Myers and Majluf (1984). This theory explains that Company Managers like internal financing (e.g., retained earnings). Gitman and Zutter (2015) illustrate: "If the manager of a company has an investment opportunity with high profitability and

needs funding, then the manager will tell the investor about this opportunity, but the investor does not believe it..

3. Market Timing Theory

The Market Timing Theory states that companies will issue equity at times of high market value and will repurchase equity at a time when market value is low (Baker and Wurgler, 2002). In research conducted by (Baker & Wurgler, 2002), it was found that market timing affects the capital structure and market price fluctuations have a great influence on the capital structure for at least a decade

2.5 Cash Flow Concept

According to Noor (2007), investment cash flow is the amount or volume of net cash generated from investment activities that are presented in a cash flow to be easily understood, controlled, and evaluated.

2.6 Cost of Capital

According to Suharto (2002) consider that projects require large amounts of funds. This funding generally involves more than one source with a different capital cost. The cost of capital can be calculate based on the cost for each source of funds or so-called individual costs of capital. Individual capital costs are calculated for each type of capital. However, if the company uses several source of equity, the calculated cost of equity is the weighted average cost of capital (WACC) of all equity used.

2.7 *Leverage*

According to Noor (2011), Leverage is an opportunity or opportunity to magnify profits either through increased operations, the addition of outside funds, or a combination of both.

According to Miles (2000), there are several advantages and disadvantages of using loans in project financing with an effect on cash flow, including :

1. The use of debit/loans can increase or decrease the percentage of return to equity (return on capital).
2. The use of debt can increase the diversity of cash flows to capital.

In loan reviews, it's known that there is a terms of positive leverage and negative leverage in this case. Leverage said to be positive if the investor's capital increases the return on capital by using the loan. Conversely, negative leverage occurs when the return on capital decreases due to using a loan.

3. METHODS

The studies used in theoretical mapping are research obtained from reputable journals. That was to ensure the academic standards of the literature analyzed in the paper. In this literature review, there are eight publications from 2013-2020. Next, theoretical mapping of the collected literature was carried out, the results of which there are various methods in a project, company, and investment in determining the financing structure. Table 1 will present the results of the explanation of the theoretical mapping.

Table 1. Theoretical mapping from previous research

No.	Author/Year	Title	Method	Result
1	Putra, Utomo, & Nurcahyo, 2013	Investment Enrichment Analysis of Puncak Kertajaya Apartment Project	NPV and WACC (*Weighted Averaged Cost of Capital*)	The best financing is with 30% of own capital and 70% of loans that have the lightest cost of capital of 10.98% at positive leverage.
2	Wibisono & Utomo, 2013	Financing Analysis of the Gresik Petrochemical Hospital Development Project	IRR (Internal Rate of Return), NPV (Net Present Value), PI (Profitability Index), and Payback Period	Alternatives with the highest cost of the capital value of 11.4%, the shortest Payback period of 6.57 years, NPV with a value of Rp 17,872,629,730.00, the highest IRR of 18.55%, the highest PI of 1,707, which is a combination of 30% debt with a loan interest rate of 10% per year and 70% of own capital.
3	Ningsih & Utomo, 2014	Investment Financing Analysis of Puri Park View Tower E Kebon Jeruk Apartment – West Jakarta	*Discounted Cash Flow* (DCF), WACC (*Weighted Averaged Cost of Capital*) and *leverage method.*	The result of the composition of alternative financing that has the smallest cost of capital is 30% of own capital and 70% of loans with a value of 10.98% on positive leverage.
4	Maulanasari & Utomo, 2015	Analysis of Office Property Investment Financing in South Jakarta	*Discounted Cash Flow* (DCF), WACC (*Weighted Averaged Cost of Capital*) and metode *leverage*	The result of the composition of alternative financing that has the smallest cost of capital is 40% of own capital and 60% of loans with a value of 11.69% on positive leverage.
5	Bean, Blazquez, & Nezamuddin, 2017	*Assessing the cost of renewable energy policy options e A Spanish wind case study*	WACC and NPV	Projects with higher factor capacity tend to be more to be financed with debt than with equity, thus having a lower average cost of capital
6	Savolainen,	*The trade-off between*	*Monte carlo* and	The decision to use debt

No.	Author/Year	Title	Method	Result
	Collan, Kyl€aheiko, & Luukka, 2017	*the leverage effect and real options thinking: A simulation-based model on metal mining investment*	system dynamic model	financing has a significant influence on the value of the project and the wealth of equity holders and the selection of the financial structure has an important role for investment profitability
7	Lai et al, 2019	A *financial model for lithium-ion storage in a photovoltaic and biogas energy system*	DCF, NPV, and IRR	The profitability of the EES is difficult to ascertain due to the uncertainty of two aspects, namely the technical aspects such as the decrease in EES and the operating life. Then economic aspects such as the cost of EES capital and the retail price of electricity.
8	Sakka, Bilionis, Vanvatsikos, & Gantes, 2020	*Onshore wind farm siting prioritization based on investment profitability for Greece*	NPV, IRR, dan WACC	

4. RESULTS

Based on the theoretical mapping in part 3 above, the method used to find the most optimal financing structure is with WACC and Leverage. WACC method for finding the lightest cost of capital in a financing structure. Then Leverage is a method to find out the lightest loan return rate. In Table 2 and Table 3, it will be explained how the variables will be used and how to measure it..

Table 2. Conceptualization of Variables

Variabel	Source	Information
Investment costs, financing, income, Cost of Capital (WACC), NPV, IRR, ROA, ROE	Maulanasari and Utomo (2015), Ningsih and Utomo (2014), Putra, Utomo and Nurcahyo (2013), Sakka, dkk (2020), Wibisono and Utomo (2013)	Investment and financing analysis: • Cash flow analysis using Discounted Cash Flow method • Analysis of financing costs with Cost of Capital (WACC) • Debt analysis using the leverage method

Variabel	Source	Information
Investment costs, financing, income, NPV	Savolainen, dkk (2017)	Analysis of the effect of debt financing on the feasibility of a mining project investment.
Investment costs, financing, income,CBA, NPV	Bean, dkk (2017)	Cost-Benefit Analysis is used to determine the effect of debt on the sustainability of a project investment.
Investment costs, financing, income, profitability, NPV, IRR, Payback Period	Lai, dkk (2017)	Financial analysis is used to measure the financial performance of electrical energy storage projects (EES) and calculate the need for debt to its financial feasibility.

Source: Processed writers

Table 3. Variable Measurement

Variabel	Indicator	Type of Data	Source of Data	Reference
Investment costs	1. Construction Cost 2. HARI Cost 3. Administration Cost 4. Tax	Secondary	PT JMTM	Maulanasari and Utomo (2015), Ningsih and Utomo (2014), Putra, Utomo and Nurcahyo (2013), Sakka, dkk (2020), Wibisono and Utomo (2013)
Financing	1. Equity 2. Debt 3. Public subsidy	Secondary	The results of previous research	Maulanasari and Utomo (2015), Ningsih and Utomo (2014), Putra, Utomo and Nurcahyo (2013), Sakka, dkk (2020), Wibisono and Utomo (2013)
Income	Termyn payments	Secondary	PT JMTM	Maulanasari and Utomo (2015), Ningsih and Utomo (2014), Putra, Utomo and Nurcahyo (2013), Sakka, dkk (2020), Wibisono and Utomo (2013)
Cost of Capital (WACC)	1. Weight of Debt 2. Equitable Weight 3. Cost of Debt after Tax 4. Cost of Equitable after Tax	Secondary	The results of previous research	Maulanasari and Utomo (2015), Ningsih and Utomo (2014), Putra, Utomo and Nurcahyo (2013), Sakka, dkk (2020), Wibisono and Utomo (2013)
NPV	1. Net Cash Flow 2. Investment Cost	Secondary	The results of previous research	Maulanasari and Utomo (2015), Ningsih and Utomo (2014), Putra,

Variabel	Indicator	Type of Data	Source of Data	Reference
				Utomo and Nurcahyo (2013), Sakka, dkk (2020), Wibisono and Utomo (2013)
IRR	NPV	Secondary	The results of previous research	Maulanasari and Utomo (2015), Ningsih and Utomo (2014), Putra, Utomo and Nurcahyo (2013), Sakka, dkk (2020), Wibisono and Utomo (2013)
ROR	1. Net Income 2. Construction value	Secondary	The results of previous research	Maulanasari and Utomo (2015), Ningsih and Utomo (2014), Putra, Utomo and Nurcahyo (2013), Sakka, dkk (2020), Wibisono and Utomo (2013)
ROE	1. Cash Flow before Tax 2. First Capital Investment	Secondary	The results of previous research	Maulanasari and Utomo (2015), Ningsih and Utomo (2014), Putra, Utomo and Nurcahyo (2013), Sakka, dkk (2020), Wibisono and Utomo (2013)

Source: Processed writers

5. CONCLUSIONS

The method used to calculate the financing structure of the lightest cost of capital is to use the WACC method and to find out the lightest rate of return using the Leverage method.

REFERENCES

Baker, M., & Wurgler, J. (2002). Market timing and capital structure. *The Journal of Finance*, 57(1), 1e32.

Bean, P., Blazquez, J., & Nezamuddin, N. (2017). Assessing the cost of renewable energy policy options e A Spanish wind case study. *Renewable Energy*, 180 - 186.

Dare, F., & Sola, O. (2010). Capital Structure and Corporate Performance in Nigeria. *Panel Data Analysis Journal of Mathematics and Statistics 6(2)*, 168-173.

Gitman, L., & C.J, Z. (2015). *Principles of Managerial Finance. Fourteenth Edition.* California: Pearson.

Husnan, S. (2000). *Dasar-dasar Teori Portofolio dan Analisis Sekuritas.* Yogyakarta : UPP AMP YKPN.

Karsaman, R. H., Rodhiatun, Al Rasyid, H., & Santoso, I. (2015). Kajian Investasi Pembangunan Jalan Tol di Indonesia Berdasarkan Sistem Syariah: Studi Kasus Jalan Tol Cikampek-Palimanan. *Jurnal Perencanaan Wilayah dan Kota*, 86-99.

Kasmir. (2001). *Manajemen Perbankan.* Jakarta: PT Raja Grafindo Persada.

Kasmir. (2012). *Analisis Laporan Keuangan.* Jakarta: Rajawali Pers.

Lai, C. S., Locatellib, G., Pimm, A., Taoa, Y., Lia, X., & Laia, L. L. (2019). A financial model for lithium-ion storage in a photovoltaic and biogas energy system. *Applied Energy*, 1-16.

Maulanasari, A., & Utomo, C. (2015). Analisa Pembiayaan Investasi Properti Perkantoran di Jakarta Selatan. *JURNAL TEKNIK ITS*.

Miles. (2000). *Real Estate Development.* Washington: Urban Land Institute.

Miles, M., Berens, G., Eppli, M., & Weiss, M. (2007). *Real Estate Development Priciples and Process Fourth Edition.* USA: ULI.

Ningsih, M., & Utomo, C. (2014). Analisa Pembiayaan Investasi Apartemen Puri Park View Tower E Kebon Jeruk - Jakarta Barat. *JURNAL TEKNIK POMITS*.

Noor. (2011). *Ekonomi Manajerial.* Jakarta: PT Rajagrafindo Persada.

Noor, H. (2007). *Ekonomi Manajerial.* Jakarta: PT. Rajagrafindo Persada.

Putra, M., Utomo, C., & Nurcahyo, C. (2013). Analisa Pembeayaan Invesitasi Proyek Apartemen Puncak Kertajaya. *JURNAL TEKNIK POMITS*.

Sakka, E., Bilionis, D., Vanvatsikos, D., & Gantes, C. (2020). Onshore Wind Farm Siting Prioritization Based on Invesment Profitability for Greece. *Renewable Energy*.

Savolainen, J., Collan, M., Kyl€aheiko, K., & Luukka, P. (2017). On the trade-off between the leverage effect and real options thinking: A simulation-based model on metal mining investment. *International Journal of Production Economics*, 1-9.

Sirait, P. (2017). *Analisis Laporan Keuangan.* Yogyakarta: Ekuilibria.

Soeharto. (2002). *Manajemen Proyek Jilid 2: Konsep Studi Kelayakan dan Jarigan Kerja.* Jakarta: Erlangga.

Wibisono, G., & Utomo, C. (2013). Analisa Pembiayaan Proyek Pengembangan Rumah Sakit Petrokimia Gres. *JURNAL TEKNIK POMITS Vol. 1, No. 1*, 1-4.

Gitman, L., & C.J, Z. (2015). *Pr*

Dare, F., & Sola, O. (2010). Capital Structure and Corporate Performance in Nigeria. *Panel Data Analysis Journal of Mathematics and Statistics 6(2)*, 168-173.

Gitman, L., & C.J, Z. (2015). *Principles of Managerial Finance. Fourteenth Edition.* California: Pearson.

Karsaman, R. H., Rodhiatun, Al Rasyid, H., & Santoso, I. (2015). Kajian Investasi Pembangunan Jalan Tol di Indonesia Berdasarkan Sistem Syariah: Studi Kasus Jalan Tol Cikampek-Palimanan. *Jurnal Perencanaan Wilayah dan Kota*, 86-99.

Kasmir. (2001). *Manajemen Perbankan.* Jakarta: PT Raja Grafindo Persada.

Kasmir. (2012). *Analisis Laporan Keuangan.* Jakarta: Rajawali Pers.

Miles. (2000). *Real Estate Development.* Washington: Urban Land Institute.

Miles, M., Berens, G., Eppli, M., & Weiss, M. (2007). *Real Estate Development Priciples and Process Fourth Edition.* USA: ULI.

Noor. (2011). *Ekonomi Manajerial.* Jakarta: PT Rajagrafindo Persada.

Noor, H. (2007). *Ekonomi Manajerial.* Jakarta: PT. Rajagrafindo Persada.

inciples of Managerial Finance. Fourteenth Edition. California: Pearson.

Karsaman, R. H., Rodhiatun, Al Rasyid, H., & Santoso, I. (2015). Kajian Investasi Pembangunan Jalan Tol di Indonesia Berdasarkan Sistem Syariah: Studi Kasus Jalan Tol Cikampek-Palimanan. *Jurnal Perencanaan Wilayah dan Kota*, 86-99.

Kasmir. (2012). *Analisis Laporan Keuangan.* Jakarta: Rajawali Pers.

Miles. (2000). *Real Estate Development.* Washington: Urban Land Institute.

Noor. (2011). *Ekonomi Manajerial.* Jakarta: PT Rajagrafindo Persada.

CARGO VOLUME OPTIMIZATION OF CONTAINER SHIPPING COMPANIES IN INDONESIA WITH SEGMENTATION AND FORECASTING METHODS

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ABSTRACT

The increasing competition among container shipping companies in Indonesia, container shipping companies are required to be able to optimize profits by optimizing vessel space and tonnage in order to get optimal profits. However, Freight Forwarder customers are not transparent in providing cargo volumes. The volume of cargo provided by the Freight Forwarder does not match the potential it should have. It is necessary to forecast the volume of cargo provided by the Freight Forwarder to be able to optimize profits. With a large number of Freight Forwarders with different behavior, it is necessary to create segmentation to facilitate identification and monitoring of cargo volumes. The segmentation based on the analysis of customer behavior. Customer behavior can be known from RFM (Recency, Frequency, Monetary) analysis. This research use K-Means clustering method to create new segmentation. The optimal segment results totaling 3 segments. From the results of segmentation, cluster 1 is tier 2 customers who requires maintenance activities, cluster 2 is tier 3 customers who require acquisition activities, cluster 3 is tier 1 customers who require maintenance and development activities. The estimated cargo volume for each segment is forecasted using the seasonal naive method with 5% increment from the previous year.

Keywords: Customer Segmentation, RFM Model, K-Means Clustering, seasonal naïve forecast.

1. INTRODUCTION

Indonesia is an archipelagic country which has 17,508 islands and two-thirds of Indonesia's territory is ocean. So that the distribution of goods between islands is very dependent on the sea transportation. Container ship is the most widely used type of sea transportation in shipping goods by sea. So that container shipping companies in Indonesia is increasing in number both in terms of number and size. This creates a price competition. So that shipping companies are required to be able to optimize profits by optimizing the volume of cargo, space and tonnage of the ship in order to get optimal profit. Container ships have limited tonnage and space according to the type of ship. So that the volume of cargo must also be able to adjust to the capacity of the container ship. So that forecasting the volume of cargo is important in determining the type of ship used and also the amount of space that will be given to each route. This forecasting is similar with forecasting demand in other industrial fields such as research related to forecasting of demand conducted by Fattah *et al.* (2018) so that supply can match demand. Forecasting the number of containers was also carried out by Rashed *et al.* (2016) to estimate the number of port throughput.

The optimization of space and ship tonnage is very dependent on the number of container shipments provided by the Freight Forwarder. However, the Freight Forwarder is not transparent in providing the volume of its cargo. Freight Forwarders can pass their cargo volumes to competitors or other shipping carriers. Therefore, it is necessary to forecast the volume of cargo from the Freight Forwarder in order to monitor volume of cargo and make plans to optimize the volume of cargo. However, the number of Freight Forwarders are large and have different behaviour making it difficult to monitor the volume of cargo for each Freight Forwarder. So it is necessary to make segmentation of the Freight Forwarder to make it easier to monitor the volume of cargo from the Freight Forwarder (Murray, Agard and Barajas, 2015)

The segmentation is made based on the delivery behavior of the customer. These behaviour can be assessed using the Recency, Frequency, Monetary (RFM) model. by grouping customers based on the customer's last delivery time interval, delivery frequency, and total cargo volume (Aggelis and Christodoulakis, 2005; Cheng and Chen, 2009). Clustering is one way to determine the segmentation of customers. In several previous studies by Cheng and Chen (2009) and Angelie (2017), grouping with the K-means clustering method has also been carried out using RFM variables. According to Murray, Agard and Barajas (2015) if the customer segmentation is based on the behavior, it is allowed to use a simple forecasting method adapted to each segment

2. LITERATURE REVIEW

2.1 RFM Model

Cheng and Chen (2009) stated that customer behavior patterns are difficult to identify because they require a brute computing method, so the RFM model can simplify the process of identifying customer behavior. The RFM analytical model proposed by Hughes (1994) aims to distinguish and classify important customers from those that are not. This model is based on customer data to determine customer segmentation which consists of 3 variables, namely Recency of the last purchases, Frequency of the purchases, and Monetary value of the purchases (Cheng and Chen, 2009).

Recency is a variable to measure customer value based on the interval (date, month, year) from the customer's last transaction to the time the data is analyzed. The smaller the range, the larger the R value.

Frequency is a variable to measure customer value based on the total number of transactions in a certain period. For example, three transactions in one year, two transactions in one month. The more the frequency, the greater the F value.

Monetary is a variable to measure customer value based on the nominal amount of money spent in customer transactions in one period. The greater the amount of money spent by the customer in that period, the greater the M value.

2.2 Elbow Method

The Elbow method is one of the methods used in cluster analysis for interpretation and performance testing based on the consistency level of the right number of clusters by looking at the SSE (Sum Square of Error) value. At a certain point there will be a significant decrease from the graph so that it forms an indentation called the elbow criterion. The indentation then becomes the value of k or the best number of clusters (Bholowalia and Kumar, 2014).

2.3 K-Means Clustering

K-Means clustering algorithm is a non-hierarchical data clustering method that aims to group data in the form of one or more clusters. Data collections that have the same characteristics are grouped into one cluster. Data that has different characteristics are grouped with other clusters so that data in one cluster has a small level of variation. K-Means clustering has advantages, such

as relatively fast processing time, easy algorithm to implement, easy to interpret with interactive models, and dynamic on uneven data (Cheng and Chen, 2009). The following are the steps of K-Means clustering according to Aggelis and Christodoulakis (2005):

1. Determine the number of clusters k
2. Initialize k cluster centers in a random way
3. Allocate all data/objects to the nearest cluster. The proximity of two objects is determined based on the distance between the two objects.
4. Recalculate the cluster center with the current cluster membership.
5. Check again each object using the new cluster center. If the cluster center does not change again then the clustering process is complete. Or, go back to step (3) until the cluster center does not change anymore.

2.4 Clustering Validation

According to Brock *et al.* (2008) the results of clustering are validated using internal validation. This internal validation consists of silhouette width, connectivity, and dunn index. Silhoutte width is the average result of the silhoutte value of each observation. Silhoutte measures the degree of confidence of placement in clustering, if the value of silhoutte is close to 1 then the cluster placement is appropriate, but if the value is close to -1 then the placement is not appropriate and must be minimized (Brock *et al.*, 2008). Connectivity method is used to represent the strength of the relationship between cluster members. Connectivity values have a range between zero and infinity (∞). So the lower the connectivity value, the more optimal the number of clusters (Brock *et al.*, 2008). Dunn Index is a metric for validation of grouping results by measuring the cluster diameter and the distance between two clusters. By measuring the Dunn Index, the optimum number of clusters can be obtained (Khajvand and Tarokh, 2011).

2.5 Seasonal Naïve Forecast

The Naive method is a very simple forecasting method, where this method is often used as a comparison because of the ease of obtaining forecasting results (Hanke, 2003). Naive forecasting method is a forecasting method based on observations of previous data patterns, so this method assumes that past data is the best forecasting indicator in the future. If the data pattern is seasonal, the seasonal nave method models future data based on past seasonal data (Yudaruddin, 2019). For example, with monthly data, the forecast for all future February values is the same as the last observed February value. According to Murray, Agard and Barajas (2015) if the customer segmentation is based on the behavior, it is allowed to use a simple forecasting method adapted to each segment. Therefore, seasonal naïve method can be applied.

2.6 Customer Relationship Management

Relationship Marketing has developed in terms of the concept of becoming a Customer Relationship Management (CRM). CRM is a combination of process and technology that aims to understand customers in terms of the different products and services used. CRM supports the delivery of superior service to customers based on the effective use of customer information (Kotler and Keller, 2007). According to Kotler and Keller (2007), there are four CRM activities there are identify, acquire, maintain, develop.).

3. METHODS

Customer segmentation is conducted with the aim of obtaining transaction and delivery behavior from customers. The behavior is based on the RFM model. The results of the segmentation can identify customer behavior and to determine what strategy should be done. The results of the segmentation are forecasted for each segment. In the literature review, it is known that forecasting using segmentation results can increase accuracy compared to forecasting

compared to traditional methods. The methodology consists of 3 main stages, there are data preprocessing, clustering, and forecasting. For more details, the methodology is described in Figure 1.

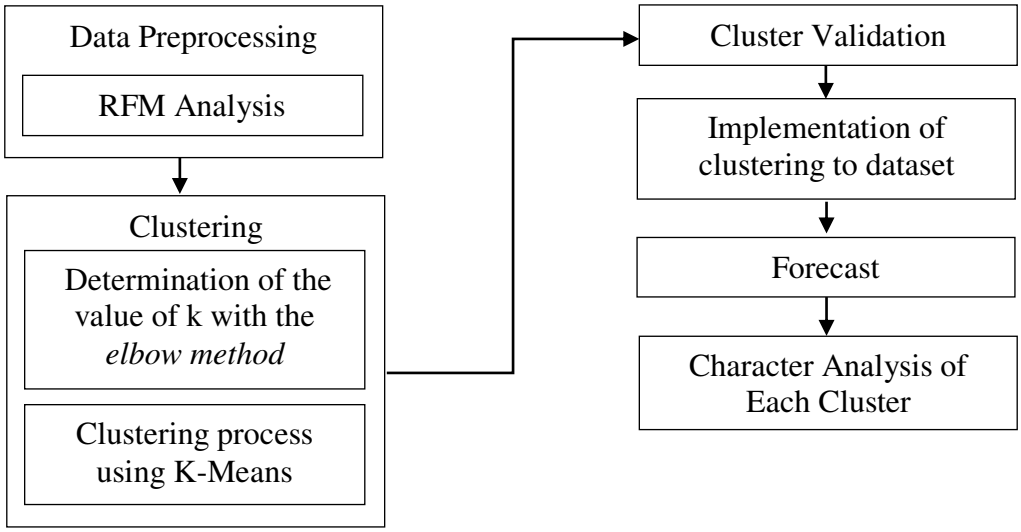


Figure 1. Methodology

3.1 Data Preprocessing

Raw data processing will be applied before the clustering process. Pre-processing data consists of attribute selection and create a data time series table using the pivot table in Microsoft Excel. The selection of attributes is adjusted to the required variables, such as are AccountID, week, total cargo volume (TEUs). The data used is only Surabaya to Samarinda cargo volume history in 2021. The RFM variables are obtained from these data.

In data transformation, there are several steps including changing the value into RFM form. Look for the value of the attribute recency, frequency and monetary. Then Min-Max normalization is performed, where the values of all variables are normalized to 0 to 1. Furthermore, the data is integrated into one table. The whole series of data preprocessing is done using Microsoft Excel.

3.2 Clustering

After the pre-processing of the data is completed then the data processed and grouped using the K-Means Clustering method. This data is the result of RFM analysis. The clustering process is applied using the RStudio. In the clustering process there are two steps, there are determining the value of k with the Elbow method and the clustering process.

Determination of the number of clusters in this study is conducted using the Elbow method. This step objective is to determine the value of k as input in K-Means clustering. The determination of the value of k is done by observing the decrease in the line on the graph. If the observed graph has decreased drastically and then followed by a steady decline, then this value becomes the reference as the value of k. Then the clustering process applied using the K-Means method.

K-Means clustering process is applied to determine the segmentation of freight forwarders. The data to be processed by K-Means is the result of normalized RFM analysis and based on the results of the k value obtained by the Elbow method. Then determine the centroid value and the distance of each data object to the centroid. So that the output of the K-Means clustering process is in the form of a cluster with a fixed or not moving centroid. This clustering process uses RStudio.

3.3. Cluster Validation

At this stage the cluster results will measure the performance level of the cluster model that has been formed in the previous stage. In this performance test, it will find out how well the clusters are separated and how closely related objects are in one cluster. This performance test is carried out internally using the ClValid() package in the Rstudio which contains three methods, there are the Dunn Index which describes that a cluster more different from other clusters, Silhoutte Width is used to determine the correct placement of a cluster, and Connectivity is used to measure the relationship between members in a cluster.

3.4 Implementation of Clustering to Dataset

After the clustering process is complete. The results of clustering are implemented into time series historical data according to AccountID. Historical data is combined according to each cluster. Each cluster is formed with a total volume of cargo which comes from the sum of shipment from each freight forwarder that corresponds to each cluster. Then a table is formed that can be used for time series forecasting. The data consists of AccountID, week, total cargo volume in TEUs units.

3.5 Forecast

Determine the model using the seasonal nave method. The forecasting model consists of the results of the segmentation process that has been implemented into the historical dataset of the volume of cargo for each customer in 2021.

Forecasting for each segmentation is made for the 1st week to the 12th week (3 months). Forecasting uses the seasonal nave method based on the 2021 cargo volume model. Forecasting is made using adjustments according to the needs of the Container Shipping Company.

3.6 Behavioral Analysis of Each Cluster

Behavior analysis is applied in each cluster. This stage objective is to obtain the identification of the behavior of each cluster. Identification determines the Customer Relationship Management (CRM) activities that will be implemented. These CRM activities become the basis for determining marketing strategies.

4. RESULTS

4.1 RFM Analysis

Process customer data based on three RFM variables per customer during 2021. Each customer accumulates each RFM value in a period of 1 year

Table 1. RFM model

Accountid	Recency	Frequency	Monetary
93	53	2	2
113	47	1	1
118	52	36	57
…	…	…	…
84300	50	3	9
84630	52	2	3

The data transformation uses the Min-Max method so that the data becomes the standard for each variable.

Table 2. RFM data normalization result

Accountid	Rnorm	Fnorm	Mnorm

93	1.00	0.02	0.00
113	0.88	0.00	0.00
118	0.98	0.67	0.02
…	…	…	…
84300	0.94	0.04	0.00
84630	0.98	0.02	0.00

4.2 Clustering

Determination of the value of k using the Elbow Method. In the plot, it is found that a square point is formed between points two and four, after point 3 there is no longer significant decrease, so it can be concluded that the number of clusters according to the Elbow method is 3 clusters.

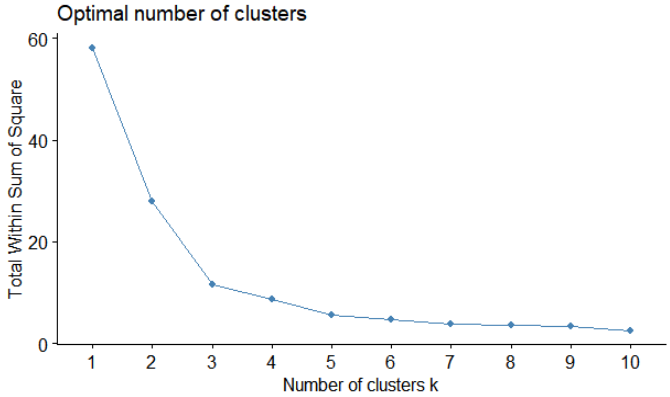


Figure 2. Elbow method result

The clustering process is carried out after getting the k value from the elbow method. This process starts by creating an initial name, this initiation contains a function to run K-Means on RStudio and enter the value of k as much as 3. The result of the K-Means process can be displayed by calling the initiation. There are a number of members in each cluster that has a different number of customers. For cluster 1 consists of 188 customers. In cluster 2 consists of 72 customers. And cluster 3 consists of 61 customers.

4.3 Clustering Validation

The clustering results were also tested using the Silhoutte Width, Connectivity and Dunn Index methods. The results of the Silhoutte Width method produce the optimum number of clusters of 3 clusters. Connectivity results produce an optimum number of clusters of 2 clusters because it has the lowest value, which is 14.5813. But the results with 3 segments have a slight difference compared to the number of other clusters. Therefor the number of 3 clusters can still be selected. The results of the Dunn Index produce the optimum number of clusters of 10 segments. From these results, it can be concluded that the number of clusters is optimal with 3 because it meets the elbow, silhouette width, and connectivity methods

Table 3. Clustering validation result

Number of Cluster	Connectivity	Dunn Index	Sihoutte Width
2	14.5813	0.0166	0.5342
3	15.9698	0.0168	0.5864
4	30.5476	0.0186	0.529
5	33.4766	0.0337	0.5308
6	47.9988	0.0372	0.5265
7	55.2722	0.0356	0.504
8	61.1175	0.0457	0.4881
9	59.7278	0.0431	0.5009
10	54.6345	0.0618	0.5016

4.4 Forecast

Determine the model using the seasonal nave method. The forecasting model consists of the results of the segmentation process that has been implemented into the historical dataset of the volume of cargo for each customer in 2021. After processing the forecasting model for each cluster using the seasonal nave method. Forecasting is made up to week 1 to week 12 (3 months). For forecasting 2022, it is necessary to increase the total cargo volume from the previous year with the objective of increasing the cargo volume and revenue. Also, vessels can depart optimally both from space and tonnage. In this study, the author discusses with container shipping companies regarding the plan to increase the volume of cargo in 2022. In the results of the discussion, the company makes plans to increase the volume of cargo by 5% in 2022 compared to the results achieved during 2021.

Table 4. Forecast Result

Cargo Volume each Week (Teus)	Cluster 1 2022	Cluster 2 2022	Cluster 3 2022
Week 1	76	40	453
Week 2	86	40	630
Week 3	51	49	591
Week 4	44	25	271
Week 5	60	41	618
Week 6	56	41	566
Week 7	56	63	812
Week 8	43	55	646
Week 9	64	50	648
Week 10	37	35	690
Week 11	66	56	529
Week 12	80	33	668

4.5 Behavioral Analysis of Each Cluster

The results of the clustering process in this study resulted in 3 clusters of Freight Forwarder customers. Each cluster has different shipment behavior. So, it is necessary to analyze each cluster. This analysis determines the strategic actions that will be applied to each cluster. so that the customer provides the volume of cargo as expected.

Cluster 1 is the customers who has lower rating than cluster 3. The majority of customers in this segment are still actively making deliveries until the end of the year. The majority have a recency value of 53. The average frequency value shows a value of 7 which indicates that the customer only made a few shipments in 2021. The average monetary value is 22 TEUs. It shows that the average customer sends 22 TEUs per week with a range of 1 to 340 in 1 year. In the theory of Customer Relationship Management (CRM) based on Kotler and Keller (2007) customers with these transaction behaviors need acquisition and maintenance activities. Because in this cluster is still needed to give more volume of cargo and maintain consistent delivery.

.

Table 5. Cluster 1 customer behavior summary

Attribute	Maximum	Minimum	Average	Mode
Recency	53	33	47	52
Frequency	23	1	7	1
Monetary	340	1	22	2

Cluster 2 is the customer who has the lowest rating compared to other clusters. Customers belonging to this segment have not made deliveries for a long time, so that the majority of customers in this segment only active in making deliveries until half of 2021 the range of recency values for container delivery in the 2nd week to the 32nd week only. The average frequency value shows a value of 3 which indicates that customers only make very few shipments in 2021. A monetary value indicating that the customer this cluster did not make many deliveries. Monetary value range only 1 to 119 TEUs in 2021. In the theory of Customer Relationship Management (CRM) based on Kotler and Keller (2007) customers with these transaction behaviors need acquisition activities to be able to get their cargo volume back. Whether seasonal cargo, owned by competitors or from new customers.

Table 5. Cluster 2 customer behavior summary

Attribute	Maximum	Minimum	Average	Mode
Recency	32	2	17	13
Frequency	12	1	3	1
Monetary	119	1	15	1

Cluster 3 is the customer who has the highest rating compared to other segments. Segment 3 is the main customer group in container shipping. This segment has an average and mode recency value of 53 indicating that customers were still active making shipments until the end of 2021. The mode value also shows that the majority of deliveries are made every week (53 shipments). The customer's monetary value shipments in the range from 29 to 3339 TEUs in 1 year. The Monetary value shows that the volume of cargo from cluster 3 customers is very vital. In the theory of Customer Relationship Management (CRM) based on Kotler and Keller (2007), customers with such shipment behavior are need maintain and develop activities.

Table 6. Cluster 3 customer behavior summary

Attribute	Maximum	Minimum	Average	Mode
Recency	53	31	52	53
Frequency	53	25	42	53
Monetary	3339	29	376	61

6. CONCLUSIONS

This research has shown a method to convert a large number of customers into a customer cluster that has similar shipments behavior. This makes it easier for shipping container companies to identify and monitor cargo volumes. Forecasting results from each segment also help container shipping companies to be able to estimate the volume of their cargo to determine the type of ship and space that will be needed by looking at the conditions in each segment. Forecasting results from the segmentation also help container companies in monitoring the volume of cargo and determining strategies to optimize the volume of their cargo. So that container companies have no difficulty in identifying customers who transfer their cargo volumes to competitors or when there is a specific drop in shipments. In this study, the customer segmentation formed is 3. Cluster 1 is a customer who is still active and routinely makes shipments but with a few volumes of cargo, therefor maintain activity is needed. For cluster 2, it is a customer who is no longer active in making shipments, so it is necessary to take back this potential with acquisition activity. And cluster 3 is the main customer who is still active and routine in making shipments with large volumes of cargo. It is the main customers for the company. Therefor maintain and developing activities is needed. With the customer clustering, marketing strategies can be applied to each cluster. With objective that each cluster customers to be able to meet the target volume of cargo from the company.

REFERENCES

Aggelis, V. and Christodoulakis, D. (2005) 'Customer Clustering using RFM analysis', *In Proceedings of the 9th WSEAS International Conference on Computers*, 1–5.

Angelie, anissa veronika. (2017). *Customer Segementation Using K-Means Clustering and RFM Model (Case Study: PT. Bina Adidaya Surabaya)*.

Bholowalia, P. and Kumar, A. (2014) 'EBK-Means: A Clustering Technique based on Elbow Method and K-Means in WSN', *International Journal of Computer Applications*, 105(9), 975–8887.

Brock, G. *et al.* (2008) 'ClValid: An R package for cluster validation', *Journal of Statistical Software*, 25(4), 1–22.

Cheng, C. H. and Chen, Y. S. (2009) 'Classifying the segmentation of customer value via RFM model and RS theory', *Expert Systems with Applications*. Elsevier Ltd, 36(3 PART 1), 4176–4184.

Fattah, J. *et al.* (2018) 'Forecasting of demand using ARIMA model', *International Journal of Engineering Business Management*, 10, 1–9.

Hanke, J. E. (2003). *Peramalan Bisnis*, 7th Edition, Pearson.

Hughes, A. M. (1994). *Strategic Database Marketing*. Chicago: Probus Publishing.

Khajvand, M. and Tarokh, M. J. (2011) 'Estimating customer future value of different customer segments based on adapted RFM model in retail banking context', *Procedia Computer Science*. Elsevier, 3, 1327–1332.

Kotler, P. and Keller, K. L. (2007). *Manajemen pemasaran Jilid 1*, 12th Edition, PT. Gelora Aksara Pratama, Jakarta.

Murray, P. W., Agard, B. and Barajas, M. A. (2015) 'Forecasting supply chain demand by clustering customers', *IFAC-PapersOnLine*, 28(3), 1834–1839.

Rashed, Y. *et al.* (2016) 'Short-term forecast of container throughout: An ARIMA-intervention model for the port of AntwerpNo Title', *Maritime economics & logistics*.

Yudaruddin, R. (2019). *Forecasting untuk Kegiatan Ekonomi dan Bisnis*, 1st Edition, RV Pustaka Horizon (Anggota IKAPI), Jakarta.

STRATEGY OF BUILDING THE JAKARTA - BANDUNG HIGH SPEED RAILWAY BRAND AWARENESS

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ABSTRACT

The construction of the Jakarta - Bandung high-speed railway project is under PT Kereta Cepat Indonesia Cina (KCIC) which was established in October 2015, and is the result of a joint venture between BUMN through PT Pilar Sinergi BUMN Indonesia (PSBI) and a consortium of Chinese railway companies through Beijing Yawan HSR Co.Ltd, with the main business in the public transportation sector with a business to business (B2B) scheme. PT KCIC is currently the owner of the Jakarta-Bandung High Speed Rail project (JBHSR), which is one of the Indonesian government's National Strategic Projects (PSN) in accordance with Presidential Regulation No. 3/2016. In addition to the development of public transportation infrastructure, PT KCIC also seeks to provide transportation services to support increasing community productivity along the high-speed railway route from Jakarta to Bandung with certain strategies.

The more choices of transportation modes, the competition in the transportation industry is getting tougher and require every transportation company to show strengths and advantages in taking advantage of existing opportunities, especially in building brand awareness, because it is undeniable that in every competition there must be a threat from every existing business actor, including the threat to the Jakarta - Bandung High-Speed Railway. The purpose of this research is to formulate the strategy of the Jakarta - Bandung High-Speed Railway in building its brand awareness. The analytical method used in this study is the PESTEL, SWOT analysis and Brand Equity methods. The data sources in this study are divided into primary data and secondary data, where primary data is obtained from interviews with stakeholers and secondary data is obtained from company documentation. The results obtained from this study indicate that the marketing communication mix and market penetration are the right strategies to be used by PT Kereta Cepat Indonesia China to increase sales and build its brand awareness.

Keywords : *Brand Equity, Brand Awareness, Jakarta – Bandung Highspeed Railway*

INTEGRATION OF LEAN AND TAGUCHI IN ELIMINATE WASTE AND INCREASE QUALITY IN BAGEA CAKE PRODUCTION PROCESS

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ABSTRACT

In Palopo City and its surroundinz, one of the food commodities that has been the mainstay of the community for a long time is sago (Metroxylon sp). Bagea is one of the traditional cakes made from sago flour that has high purchasing power. A bagea-producing SME often produces bagea that do not meet the desired specifications, especially bagea which often does not expand well. Sometimes rework cannot improve the quality of bagea so have to be rejected. This is an obstacle because they cannot optimize profits and often cannot meet consumer demands on time. This study integrates Lean and Taguchi in improving the quality of the bagea cake production process. Both methods will be applied through the DMAI (Define, Measure, Analyze, Control) stage. The results showed that the critical waste was the application of EHS, waiting, and defect. In this research the Taguchi experiment not only helps in identifying the factors that influence the quality characteristics of expansion bagea, but also helps in finding waste.

Keywords: Bagea cake, Lean, Taguchi, DMAI

1. INTRODUCTION

One of the features of Palopo City as an Eastern Indonesia Region is the abundance of sago plants. Bagea cake is one of the traditional cookies made from sago flour which is the flagship product of Palopo City. There is an SME that still often produces bagea cakes that do not meet the desired specifications, especially in bagea that often do not expand properly without knowing the exact cause. When there is a discrepancy in the specifications for the bagea cake, the UKM must rework the dough in order to get the desired results.

To remain competitive in the market, SMEs must constantly seek ways to create quality processes and products. This can be realized by implementing Lean (Antony et al., 2016). Lean implementation can help remove all types of waste from business processes (Corbett, 2011). Costa et al. (2020) in his research stated that Lean have been widely applied in various sectors, but applications and research in the food industry are still very few.

In the concept of Lean manufacturing Taichi Ohno (1988) introduced seven types of waste, namely defect, overproduction, waiting, inventory, motion, transportation and excess processing. Meanwhile, Gaspersz (2007) introduces nine wastes, which are abbreviated as E-DOWNTIME. The additional two wastes are EHS (environment, health, and safety) and not-utilizing employee skill. In the food sector, health and safe are seen as part of quality, which distinguishes it from other sectors (Costa et al., 2020).

In the food sector, EHS should be a serious concern. Indifference to EHS principles can not only endanger the safety and health of workers but can also cause food contamination which can lead to a decline in the profitability and reputation of the company. Meanwhile, the type of waste in the form of not-utilizing employee skills also needs to be considered in SMEs. Workers in SMEs have a low level of knowledge and most of them do not undergo training. So this research will help SMEs in identifying workers who do not carry out their duties optimally.

Lean can be combined with other methods to assist in providing solutions that are possible to implement (Antony et al., 2016). To find out the main causes that affect the quality characteristics of bagea which often do not expand properly, it will be solved using a Taguchi experiment. Taguchi (1987) revealed that this method uses less running, is easy to analyze, obtains the best combination/formula, and has low application costs.

2. LITERATURE REVIEW

2.1 Bagea

Bagea is a traditional cake made from sago flour originating from Papua, Maluku, and Sulawesi. These areas are the Eastern Region of Indonesia which is overgrown with sago (Metroxylon sp) plants. This cake has a distinctive taste that comes from sago and cracks on the top surface. Basically this cake has a fairly hard texture because it comes from sago. Although the texture is quite hard, this cake has many fans, especially for visitors or tourists. The local community also makes bagea a dish when holding a party, celebrating a religious day, or as a relaxing meal served with coffee or tea.

2.2 Lean

According to Gaspersz (2007), Lean is a continuous improvement effort to eliminate activities that are not value added (waste) and increase product value (value added), so as to maximize value to customers (customer value). Wilson (2010) states that a process is said to be Lean if it can run using a minimum of raw materials, inventory, labour, and space. The main objective of Lean implementation is to increase company profitability by eliminating all forms of waste and maximizing customer value.

The first popularity of Lean was carried out in the US by the George Group. However, the term Lean and six sigma was first introduced into the literature in 2002 as part of the evolution of six sigma (Timans et al., 2012). Since then, there has been a marked increase in the popularity and spread of Lean and six sigma in the industrial world (Timans et al., 2012) and in some small and medium-sized manufacturing companies (Kumar et al., 2006).

2.3 DMAIC

Antony et al. (2016) mentions that DMAIC is used to improve existing business processes. These five stages can assist in covering the problem as a whole, measuring current performance, analyzing root causes of problems, testing and verifying improvement recommendations and implementing continuous improvement.

a. Define: the purpose of this stage is to collect information about the background of the problem, define the problem and related processes, define goals, and identify specific customer needs.
b. Measure: valid data collection and measurements are carried out on the baseline measurement.
c. Analyze: this stage aims to analyze the root cause of the variation in the process.
d. Improve: it is necessary to establish an action plan as the implementation of quality improvement.
e. Control: this stage focuses on continuous process monitoring by observing statistical results to ensure the process is running as expected.

2.4 Taguchi

The Taguchi method was coined by a Japanese quality management consultant named Dr. Genichi Taguchi in 1949. This method was developed using the DoE (Design of Experiment) technique to simultaneously evaluate the factors that influence product and process characteristics with varying levels. The results of the combination of levels were analyzed to find out how much the decrease or increase in the quality of the parameters used (Soejanto, 2009).

The purpose of the Taguchi method is to improve product and process quality and reduce resources and costs to a minimum. The goal of this method is to make the product or process insensitive or robust to uncontrollable environmental factors or noise, so this method is often referred to as robust design.

3. METHODS

This research uses the DMAI (Define, Measure, Analyze, Improve, Control) stage without control.

3.1 Define and Measure

a. SIPOC (Supplier, Input, Process, Output, and Customer)

SIPOC is a diagram that provides a summary overview of business processes from start to finish.

b. Waste assessment by adopting risk matrix

Risk matrix consists of two aspects, namely frequency and impact. The following is the frequency and impact scale used in this research.

Table 1. Frequency scale of waste

Rating	Criteria	Description
1	Improbable (IP)	Waste/defect improbable happens
2	Remote (RM)	Waste/defect remote happens
3	Occasional (OC)	Waste/defect occasional happens
4	Often (OF)	Waste/defect often happens
5	Always (AW)	Waste/defect always happens

Table 2. Impact scale of E-OWNTIME waste

Rating	Criteria	Description
1	*Negligible* (*N*)	No bad influence
2	*Low* (*L*)	low bad influence
3	*Moderate* (*M*)	Bad influence is still within tolerance
4	*High* (*H*)	High bad influence
5	*Very high* (*V*)	Very high influence

Table 3. Impact scale of defect

Rating	Criteria	Descriprion
1	*Negligible* (*N*)	No influence on costumer satisfaction
2	*Low* (*L*)	Low influence on customer satisfaction
3	*Moderate* (*M*)	Moderate influence on customer satisfaction
4	*High* (*H*)	High influence on customer satisfaction
5	*Very high* (*V*)	Very high influence on customer satisfaction

The following is the risk matrix adopted in this study to determine the level of waste.

Table 4. Risk matrix

Frequency		*Impact*				
		1	2	3	4	5
		N	*L*	*M*	*H*	*V*
5	*AW*					
4	*OF*					
3	*OC*					
2	*RM*					
1	*IP*					

The meaning of the colours in the matrix can be seen in the following table.

Table 5. Waste levels

Category	Description
	Waste is critical, it needs to be handled or find a solution immediately
	Waste is quite critical, it needs to be handled or find a solution after critical waste handled
	Waste could be neglected
	No waste

c. Taguchi experiment

The problem of bagea that often do not expand properly, will be solved using the Taguchi method.

3.3 Analyze dan Improve

a. Analyze using why-why

After obtaining the potential waste that causes critical waste, it will be continued with an analysis of the root causes of the potential waste that causes critical waste using why-why.

b. Improvement recommendations

Brainstorming is done to build the best fix for the existing problems.

4. RESULTS

4.1 Define and Measure

a. SIPOC

The flow of business processes starting from the supplier to being sent to the customer is presented in the form of the following SIPOC diagram.

S Supplier	I Input	P Process	O Output	C Costumer
Supplier 1: Supplier 2: Supplier 3: Supplier 4: Supplier 5: Supplier 6: Supplier 7: Supplier 8: 	Sago flour Grated coconut Brown sugar Tapioca flour Peanuts Walnut Cheese Sesame Sugar Margarine Vanilla milk Baking soda Food coloring Coconut oil Egg LPG Mica packaging Staples Duct tape Plastic bags Label sticker Ink stamp	Work in process: - Sago flour & tapioca flour are roasted together and sifted - Grated coconut roasted and mashed - Peanuts are roasted crushed and the shells are separated - Walnuts are roasted and crushed --- Mix-1: - Powdered sugar, eggs, margarine, vanilla milk, baking soda are mixed using a mixer, then the dough is given liquid brown sugar, food coloring and **roasted coconut** --- Mix-2: - Liquid dough mixed with roasted flour --- Mold: - The plastic base and baking sheet are smeared with coconut oil, then the dough is milled, molded, then sprinkled with peanut, sesame, cheese, or walnut toppings --- Roasting: Baked dough --- Packaging: - Cakes that are not hot are arranged in mica packaging - The packaging is stapled and duct tape - The label sticker is stamped with an expired date then pasted on the top surface of the packaging - Arrangement of products into jumbo plastic bags	- Roasted flour - Roasted coconut - Peanut topping - Walnut topping --- Liquid dough --- Solid dough --- Variants of nuts, sesame, cheese, walnuts --- Bagea cake --- Finished product	Retailer 1 Retailer 2 Retailer 3

Figure 1. SIPOC diagram

b. Waste assessment

Assessment of activities that cause waste seen from the aspect of events and impacts The following is the waste obtained and processed in the risk matrix

Table 7. E-OWNTIME waste assessment

Code	Waste	Frequency	Impact	Waste Level
	EHS			
A1	Workers do not wear PPE when roasting flour	5	4	
A2	Workers do not cover the roasted flour	4	3	
A1	Baker tired of standing	5	4	
A4	Store nuts and walnuts not black plastic bags	3	4	
A5	Workers do not wear heat caps	5	4	

Overproduction				
-	-			-
Waiting				
B1	Idle oven tray	4	5	
	Not-utilizing employee skill			
C1	Baker doing other activities and not focusing on the oven	3	5	
C2	Workers do not do packaging neatly	3	5	
C2	A lot of toppings are scattered in the pan	4	3	
C3	Dough hardens because not covered	3	5	
Transportation				
D1	Moving the pan to the oven causes the molded dough to shift	3	3	
Inventory				
-	-			-
Motion				
E1	Workers looking for tools	4	3	
Excess processing				
F1	Rework on dough	3	5	
F2	Rework on a pan that has sticky cake residue	4	3	
F3	Rework on packaging	3	3	

Table 8. Defect assessment

Code	Defect	Worker voice			Costumer Voice		
		Frequency	Impact	Waste Level	Frequency	Impact	Waste Level
G1	Cake does not expand	4	5		2	3	
G2	Holes at the bottom	3	3		2	4	
G3	Overcooked	3	5		1	5	
G4	The duct tape is not neat	3	5		3	5	
G5	The adhesiveness of the label sticker is not good	1	5		4	5	
G6	Opaque label ink	2	5		3	5	

The table above shows that there are differences in opinion between workers and consumers in terms of customer satisfaction.

c. Taguchi experiment

Factors that are not involved are considered as factors that have no effect on bagea expansion. The following are the factors and levels used in the Taguchi experiment.

Table 9. Factor and level

Characteristic	Factor	Level 1	Level 2
Flour roasting	Mixing	Without tapioca flour	Sago flour mixed with tapioca flour
	Timing	15 min (not bubbling)	30 min (bubbling)
	Storage period	3 days	7 days
Brown sugar	Viscosity	Not thick	Thick
Liquid dough	Mixing timing	10 minutes	20 minutes
Sugar	Texture	Coarse sugar	Powdered sugar
Baking Soda	Dose	2 tbsp	3,5 tbsp

Experiment were performed using OA L8 (2^7). The quality characteristic that is measured by the expansion of the bagea is the width of the cake. The factors that influence the expansion of bagea cakes are 30 minutes of flour roasting time, 3 days of storage of roasted flour, thick brown sugar, and 3,5 tbsp of baking soda. While other factors, either using level 1 or level 2, have no effect on the expansion of bagea. From this experiment, the bagea-making technique that has been carried out so far which is a waste can be seen in the following table.

Table 9. Waste obtained from the Taguchi experiment

Waste	Type
Roasting tapioca flour	Excess processing
Roasting sago flour for one week needs	Inventory
Mix the liquid dough for 20 minutes	Excess processing
Granulated sugar	Excess processing

The table above shows the activities that are standard in making bagea cakes, but they are not added value (waste) because they do not affect the quality of bagea expansion. These activities can be eliminated in order to reduce lead time, cost, and defect.

4.3 Analyze and Improve

At this stage, an analysis of the root causes of problems in critical waste is carried out and recommendations for improvement are provided. The following is a table of root causes of the problem and recommended fixes

Code	Waste	Root Cause	Improvement Recommendation
EHS			
A1	Workers do not wear PPE when roasting flour	Lack of awareness and knowledge of workers	Instilling awareness of HSE in workers and owners providing PPE for workers
A3	Baker tired of standing	Oven position	The oven does not need to be placed on the table so that the baker does not stand up while baking
A5	Workers do not wear heat cap	Lack of awareness and knowledge of workers	Instilling awareness of HSE in workers and owners providing PPE for workers
Waiting			
B1	Idle oven tray	There is a rework of the dough when the cake does not expand	Following the manufacturing technique based on the results of the Taguchi experiment
Defect			
G1	Cake does not expand (top surface does not crack)	Roasted flour does not bubbling	Roast flour until it bubbling (30 minutes)
		Using roasted flour that has been stored for a long time	Roasting flour for the purposes of two to three days of production
		Melted brown sugar is not thick	Do not add too much water
		Dosage of baking soda is less	Follow the dosage of baking soda based on the amount of flour used
G5	The adhesiveness of the label sticker is not good	The adhesiveness of the type of sticker paper used is not good	Use a type of sticker paper with good adhesion

6. CONCLUSIONS

So far, research on waste has only focused on 7 wastes. HSE should not be an integral part of the quality improvement process in the food sector. Failure to comply with the principles of health and safe environment (EHS) in food can have an impact on the creation of defective, unhygienic and nutritional products that are not good (unhealthy), resulting in a decrease in the profitability and reputation of the company. The results of the Taguchi experiment can be used as a reference in bagea making techniques. Besides, this research proves that Taguchi can be implemented with Lean to help identify waste in this research.

REFERENCES

Antony, J., Vinodh, S., & Gijo, E. V. (2016). *Lean Six Sigma for Small and Medium Sized Enterprises: A Practical Guide*. Taylor & Francis Group. CRC Press.

Corbett, L. M. (2011). Lean Six Sigma: The contribution to business excellence. *International Journal of Lean Six Sigma* 2, 118-131.

Costa, L. B. M., Godinho Filho, M., Fredendall, L. D., & Ganga, G. M. D. (2020). The effect of Lean Six Sigma practices on food industry performance: Implications of the Sector's experience and typical characteristics. *Food Control*, 112, 107-110.

Gaspersz, V. (2007). *Lean Six Sigma for Manufacturing and Services Industries*. PT Gramedia Pustaka Utama.

Kumar, M., Antony, J., Singh, R. K., Tiwari, M. K., & Perry, D. (2006). Implementing the Lean sigma framework in an Indian SME: A case study. *Production Planning and Control*, *17*(4), 407–423.

Ohno, T. (1988). *Toyota Production Systems: Beyond Large Scale Production.* Productivity Press, Cambridge.

Soejanto, I. (2009). *Desain Eksperimen Dengan Metode Taguchi.* Yogyakarta: Graha Ilmu.

Timans, W., Antony, J., Ahaus, K., & Van Solingen, R. (2012). Implementation of Lean Six Sigma in small- and medium-sized manufacturing enterprises in the Netherlands. *Journal of the Operational Research Society*, *63*(3), 339–353.

Taguchi, G. (1987). *The System of Experimental Design: Engineering Methods to Optimize Quality and Minimize Costs*. White Plains, New York

Wilson, L. (2010). *How to Implement Lean Manufacturing*. McGraw-Hill.

XYZ DIGITAL BANKING APPLICATION SERVICE QUALITY IMPROVEMENT STRATEGY BY IMPLEMENTING INTEGRATION OF E-SERVQUAL, KANO METHOD AND QUALITY FUNCTION DEPLOYMENT (QFD)

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ABSTRACT

Digital disruption has prompted Indonesian banks to consider digital platforms as part of their strategy. In this competitive context, the quality of Mobile Banking services is a very important benchmark to ensure the success of banks in digital competition. For this reason, the research focuses on the analysis of Quality Function Deployment (QFD) as an alternative to building a further development strategy on the XYZ Mobile Banking application service, through the integration of research instruments based on the E-ServQual concept as needs consisting of 8 dimensions and the development of the Kano model. (Kano Model Type IV) to classify these needs based on their effect on the level of customer satisfaction. The needs classification is combined with Quality Function Deployment (QFD) analysis to determine the required technical response as a necessary strategy to improve the service quality of the XYZ Mobile Banking application. The results of the validity and reliability tests on 100 sample respondents produced valid values on all 21 item needs (CICT > 0.1966) and reliable results on 20 item needs by annulling the 17th item (Cronbach Alpha = 0.6418). The analysis of the E-ServQual method shows the largest negative Gap Score on the attributes "chat chat feature", "Service options can be customized" and "The system will not experience errors/hangs". The classification of needs through the development of the Kano method shows that all needs are included in the one-dimensional category indicating the level of customer satisfaction is linear. Furthermore, the integration of the methods carried out resulted in 8 technical responses consisting of “System Stabilization”, “UI (User Interface) Review and Improvement”, “UX (User Experience) Review and Improvement”, “Procedure Review and Enhancement”, “Review and Enhancement”. Improvement of Security System”, “Comprehensive Application Testing is carried out”, “Improvement in terms of Education”, and “Improvement of SLA (Service Level Agreement) Complaint Handling”.

Keywords: E-SERVQUAL, Mobile Banking, Model Kano, Model Kano Type IV, Quality Function Deployment (QFD).

1. INTRODUCTION

The banking industry is required to accelerate the implementation of digital banking in order to be able to compete in order to provide services that are easier and faster and in accordance with customer needs. This is supported by a survey conducted by PricewaterHouseCoopers, through the PwC Survey: Digital Banking in Indonesia 2018 as a basis that shows the level of importance and urgency of Mobile Banking to the banking industry in Indonesia. One of the things that underlies this research is public acceptance of digital services. The survey shows that there is an increasing

trend in the number of smartphone users in Indonesia. The increasing trend in the number of smartphone users is shown in Figure 1. This opens up opportunities for increasing customers who can be utilized by the banking industry through the Mobile Banking application.

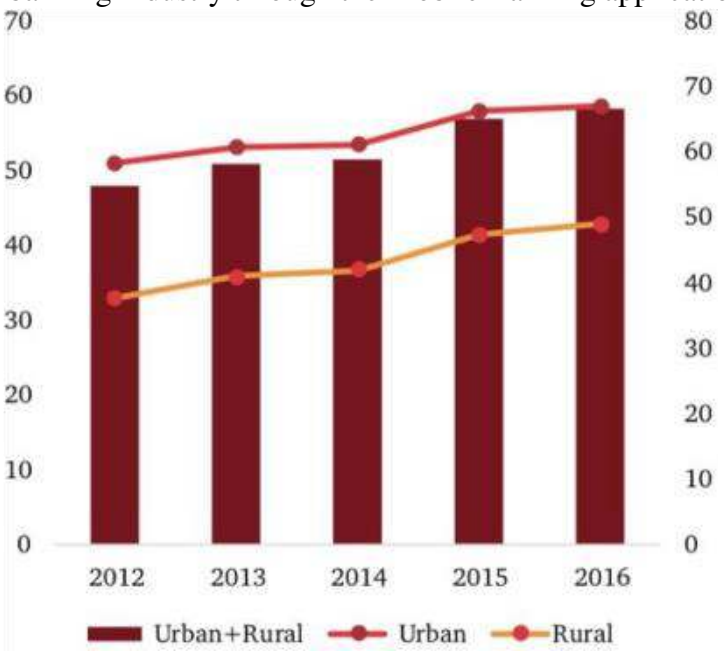


Figure 1. Smartphone users in Indonesia (PwC, 2018)

Regarding customer experience, this survey shows that as many as 72% of the total respondents believe that the value of customer satisfaction is the most important thing to measure customer experience which is shown in Figure 2. This shows that the value of customer satisfaction is the main measure of the quality of banking services.

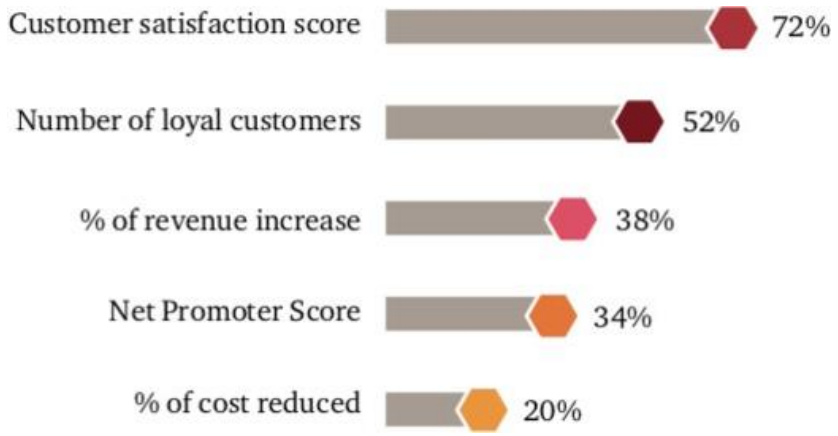


Figure 2. Methods for Measuring Customer Experience (PwC, 2018)

The researcher compares the Mobile Banking application at 10 banks from Indonesia that are included in it based on the number of downloads, the number of ratings, and the number of reviews through the Play Store which are shown in Table 1. The quality of service for the Mobile Banking application is very important because it affects customer satisfaction and loyalty.

Table 1. Mobile Banking Application Information on the 10 Best Banks in Indonesia Forbes Version (Source: Processed by the Author, January 2022)

No	Nama Bank	Nama Aplikasi	Android	IOS	Rata - Rata (c) (a+b)/2	Android	IOS	Total Reviewer(f) (d+e)	Total Nilai (c*80%)(f*20%
			Jumlah Rating (a)	Jumlah Rating (b)		Jumlah Rating (d)	Jumlah Reviewer '(e)		
1	Bank Central Asia	BCA Mobile	4,4	3,4	3,9	996.871	16.574	1.013.445	**5,15**
2	Bank Negara Indonesia	BNI Mobile Banking	4,6	4,7	4,7	490.407	104.934	595.341	**4,91**
3	**PT.XYZ**	**Mobile Banking XYZ**	**4**	**4,7**	**4,4**	**345.456**	**74.086**	**419.542**	**4,32**
4	Cimb Niaga	OCTO Mobile	4,5	4,8	4,7	218.460	67.404	285.864	**4,29**
5	Citibank	Citi Mobile	4,5	4,7	4,6	24.534	11.539	36.073	**3,75**
6	Jenius	Jenius	4	4,4	4,2	156.800	20.007	176.807	**3,71**
7	Bank Syariah Indonesia	BSI Mobile	4,1	3,9	4,0	70.183	4.781	74.964	**3,35**
8	DBS	Digibank	4,2	3,6	3,9	55.780	3.375	59.155	**3,24**
9	Bank Mandiri	Livin'	3,7	3,8	3,8	44.950	5.800	50.750	**3,10**
10	HSBC Holdings	HSBC Mobile Banking	3,5	2,8	3,2	81.047	96	81.143	**2,68**

based on Table 2, Mobile banking XYZ with a total rating of 4.32 applications in the order of 3 out of 10 became the object of research in this research.ai applications so it is very important to understand the criteria for a good application and then develop it accordingly.

Based on the importance and urgency of Mobile Banking to the banking industry in Indonesia and the level of quality of XYZ Mobile Banking services, a method is needed to help improve the quality of XYZ Mobile Banking services. This study uses the integration method of the Mobile Banking service quality instrument, the Kano model, and the Quality Function Deployment (QFD). In the context of Mobile Banking services, the Mobile Banking service quality instrument in the research conducted by Safi'i et al. (2019) and Tsai et al. (2018) which is the development of the E-S-QUAL and E-Recs-QUAL instruments. The Kano model is used to classify customer needs based on their effect on customer satisfaction levels. This improves the assumption that there is a linear relationship between the attributes of customer needs and the level of customer satisfaction. In addition, the Kano model used in this study is a type IV Kano model. The Kano Type IV model is a development of the Kano model, which explores the high attractive, less attractive, high must-be, and less must-be attributes of the Kano model and proposes a quality life cycle theory. Back Translation is used to translate research instruments from foreign languages (English). Back Translation aims to prevent bias in the meaning of the respondents. Quality Function Deployment (QFD) is used to translate the attributes of customer needs into the technical response of the organization or company (technical response) needed to improve the quality of XYZ Mobile Banking services.

2. LITERATURE REVIEW

2.1 E-SERVICE QUALITY

Basically, e-Service Quality is the development of service quality which is applied to an electronic media. E-Service Quality or also known as E-ServQual, is a new version of Service Quality (ServQual). E-ServQual was developed to evaluate a service provided on the Internet network. E-service Quality is defined as an extension of the ability of a site to facilitate shopping, purchasing and distribution activities effectively and efficiently (Chase, et al., 2006:337). According to Zeithaml et. Al in Hongxiu Li (2009), e-Service Quality has 5 important components including:

1. Security is the perceived security of the company's service system. Includes personal data security and transaction security that has been carried out.
2. Communication is the smooth communication between the company and its customers from an electronic communication media including information on customer data and the amount of noise that may occur from using the system.
3. Reliability is the reliability of the information provided by the company including the truth of the information and the accuracy of the information provided in accordance with the promise or previous information.
4. Responsiveness is the speed of service through electronic media implemented by the company including the working time of customer service and the speed of response from customer service.
5. Delivery is a way of conveying information to customers, including the courtesy of employees and the friendliness of employees in solving consumer problems.

2.2 KANO MODEL

The model developed by Dr.Noriaki Kano (Chen, 2006) is a model that aims to categorize the attributes of the product based on how well it is able to satisfy customer needs. In the model, it is distinguished three types of desired product that can affect customer satisfaction namely:

- Attractive : The fulfillment of this category would lead to increased customer satisfaction but if not met will not cause the decrease in consumer satisfaction.
- One dimensional : If this attributes is given then the customer satisfaction will increase and so does the opposite.
- Must be : In many ways, must-be requirements is a factor that must be competitive and if not met, customers would not be interested in the products offered.
- Indifferent : An attribute whose presence or absence does not cause any satisfaction of dissatisfaction to customers; and
- Reverse : An attribute whose presence causes customer dissatisfaction and whose absence results in customer satisfaction

Kano questionnaires on customer demand are designed in positive and negative questions for each aspect of customer demands. Every answer has five options then classified into six categories in the Kano evaluation table status according to the Table 2 The Kano Evaluation Table.

Table 2. The Kano Evaluation Table

Positive Questions	Reverse Questions				
	Happy	Must be	Indif ferent	Accep table	Un happy
Happy	Q	A	A	A	O
Must be	R	I	I	I	M
Indifferent	R	I	I	I	M
Acceptable	R	I	I	I	M
Unhappy	R	R	R	R	Q

The steps of data processing with the Kano model are as follows:

1. The answers to functional and dysfunctional statements are classified into six categories in the Kano evaluation table statu according to the Table 2 the Kano Evaluation Table
2. The answers from each respondent for each questionnaire that has been classified are then tabulated. Using Blauth's formula, grade coloumn can be obtained for each customer requirement as follows :
   - If (one dimensional+attractive+must be) > (indifferent+ reserve+questionable) then grade could be obtained from the biggest value of (one dimensional, attractive, must be)
   - If (one dimensional+attractive+must be) < (indifferent+ reserve+questionable) then grade could be obtained from the biggest value of (indifferent+ reserve+questionable)

Kano's weight line then determined numerically as follows: Attractive = 3; One Dimensional = 2; Must be = 1

2.3 Quality Function Deployment (QFD)

Quality Function Deployment (QFD) was first introduced by Yoji Akao in Japan (Akao, 1994). QFD is a concept for translating customer requirements (customer requirements) into technical requirements (Pentelescu, 2008). In general, the House of Quality (HoQ) involves the following seven stages (Baki et al., 2009):

1. Voice of customer or customer need (what's)
2. Level of Importance
3. Competitive Assessment
4. Technical Requirement (how's)
5. Relationship matrix
6. Correlation matrix
7. Target Value

3. METHODS

In general, there are four stages carried out in the research methodology, namely the problem identification stage, the data collection and processing stage, the analysis and improvement stage, and the conclusion and suggestion stage. The following is the flow chart used in the study as described in Figure 3. This research was conducted to solve the customer needs. The object of study in this case is Digital Banking XYZ. In the process, this research uses three theoretical concepts, namely e-Servqual, Kano, and Quality Function Deployment (QFD).

This research instrument was obtained and designed through a literature study on the previous research by Tsai et al. (2018) and Safi'i et al. (2019). Instruments for measuring the quality of Mobile Banking services, which consist of dimensions and their definitions are shown in Table 3.

Table 3. Dimensions of Mobile Banking Service Quality Measurement Instruments

Dimensions	*Definition*	*Number of items*
Efficiency	1. Achieve the extent of fast and easy use of the system	6
Fulfilment	2. Achieve the extent of living up to the service promises	6
System availability	3. Achieve the extent of effective and correct operation of the system	2
Privacy and assurance	4. Achieve the extent of system safety and protection customer information	3
Responsiveness	5. Achieve the extent of handling customer demand in a timely manner	4
Compensation	6. Achieve the extent of compensating customer losses	2
Contact	7. Achieve the extent of obtaining services through the system	3
Personalisation	8. Achieve the extent of providing exclusive personal services by the system	3

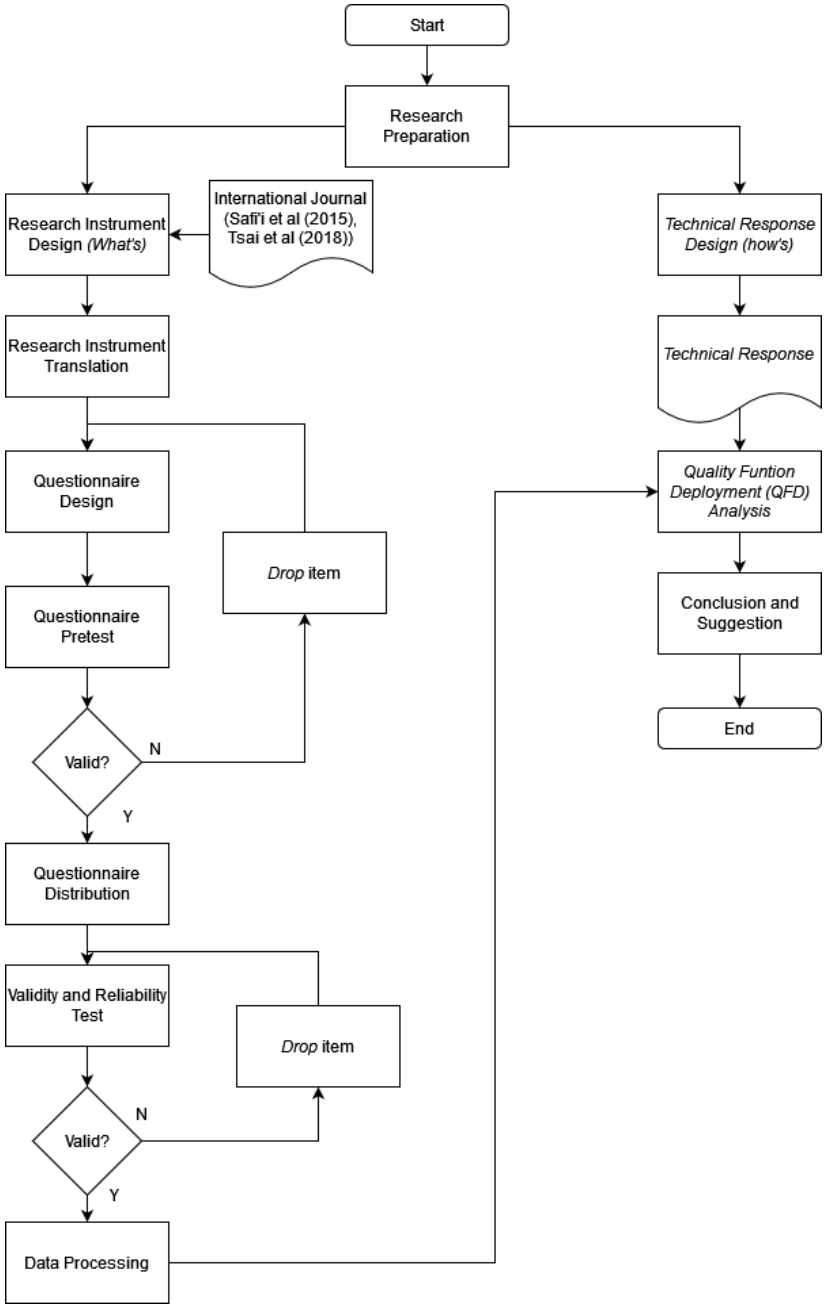


Figure 3. Research Methodology

The determination of the population in this study is based on the average number of transactions carried out every month, namely 125 active customer transactions. So that the selected sample can represent the population, the number of samples is determined according to the slovin formula (Rusadi, 2008: 150). From the population data, the number of samples can be calculated to be 100 customers.

3.1 DATA PROCESSING

The object of this research is the management of Digital Banking PT. XYZ and customers of PT. XYZ which is classified as an active digital consumer on the XYZ Mobile Banking application. The determination of the population in this study is based on the average number of

transactions carried out every month, namely 125 active customer transactions. So that the selected sample can represent the population, the number of samples is determined according to the slovin formula (Rusadi, 2008: 150) so that it is found the need for 100 samples of customers. Furthermore, there are 4 stages in data processing as follows:

- The first stage is processing the E-ServQual data, which is getting the customer's perception and expectation value by averaging the perception value and expectation value of all customer responses. The average of the perceived value and the average of the subtracted expectation values will produce a gap score on each attribute of customer needs. The level of importance data processing is done by averaging the value of the level of importance of each attribute of customer needs. The data will be used as a component in calculating the importance of the "what's" value in the House of Quality analysis.
- The next stage is the Kano model data processing. Kano model data processing is carried out to determine the Kano category for each attribute of customer needs. The determination of the Kano category is based on the evaluation table. The evaluation table will map Kano's categories based on the results of customer responses to functional statements and customer responses to dysfunctional statements that have been filled out in the Kano questionnaire. Blauth's formula will recapitulate the results of different Kano categories from as many as 100 respondents who filled out, so that one Kano category can be determined for each attribute of customer needs.
- The third stage, the design of the organization's or company's technical response (technical response) is carried out through discussions with the management of PT. XYZ to map strategies in responding to weak customer needs attributes, namely customer needs attributes that have a negative gap score and are included in the attractive, one-dimensional, or must-be categories, which are assessed as critical factors in efforts to improve service quality.
- The last stage is the making of the House of Quality through the calculation of the components of the House of Quality.

At the conclusion and suggestion stage is the final result of the research that has been done. Where the researchers provide conclusions on the results of the study based on the objectives and suggestions to the PT. XYZ, in order to improve services to customers.

4. RESULTS

From the calculation of the GAP Score, it can be seen that all attributes of customer needs have a negative gap score. This indicates that the average customer has greater expectations on all attributes of customer needs, thus requiring improvement efforts. banking XYZ this feature is still not available. while the attribute of customer needs with the smallest gap score is owned by the attribute of customer needs "Personal information will not be disseminated".

The determination of the Kano category is done by mapping between the functional statement responses and the statement responses. The results of the functional statement that the majority of respondents chose the Like (S) answer and the dysfunctional statement showed the majority of the responses chose the TS (Dislike) answer on the dysfunctional statement. These attributes of customer needs have a strong tendency towards the one-dimensional (O) canoe category. The one-dimensional Kano category shows that an increase or decrease in the performance of the attributes of customer needs has a linear influence on the level of customer satisfaction.

QFD is used in this study to translate the attributes of customer needs into the company's technical response objectives in the context of improvement efforts. In this study, the translation of the attributes of customer needs resulted in eight company technical responses and the importance rating Technical Response (How's). The design of this technical response involves respondents from the management of XYZ Mobile Banking. The discussion is carried out by discussing the attributes

of customer needs and their level of importance (adjusted importance) in an effort to meet the needs of the attributes of customer needs. Based on the discussions that have been carried out, the following is a technical response that has been made based on the weighting of the relationship between customer needs and technical response:

1. System Stabilization.
2. Review and Improvement of UI (User Interface)
3. Review and Improve UX (User Experience)
4. Review and Enhancement Procedure
5. Review and Improvement of Security System
6. Perform Comprehensive Application Testing
7. Improvement in terms of Education
8. Improve SLA Complaint Handling

The Pareto Principle (80-20 Rule) can be used to help determine and identify priority technical responses that are considered vital. The Pareto diagram of technical response based on the importance of the "how's" is shown in Figure 4.

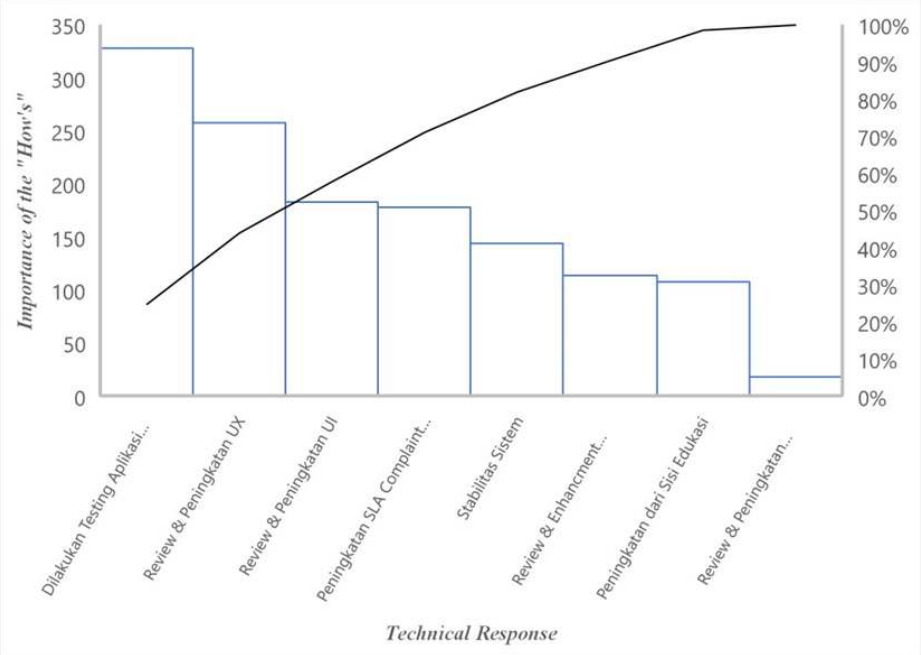


Figure 4. Pareto Chart: Importance Rating

The results of the Pareto calculation explain that 80% of the overall importance of the "how's" comes from "Complete Application Testing", "UX Review & Improvement", "UI Review & Improvement", and "Improved SLA Complaint Handling" as a technical response which is considered vital according to the Pareto principle.

House of Quality (HoQ) is the final result of the implementation based on the integration of the components that have been obtained previously which were implemented in this study shown in Figure 5.

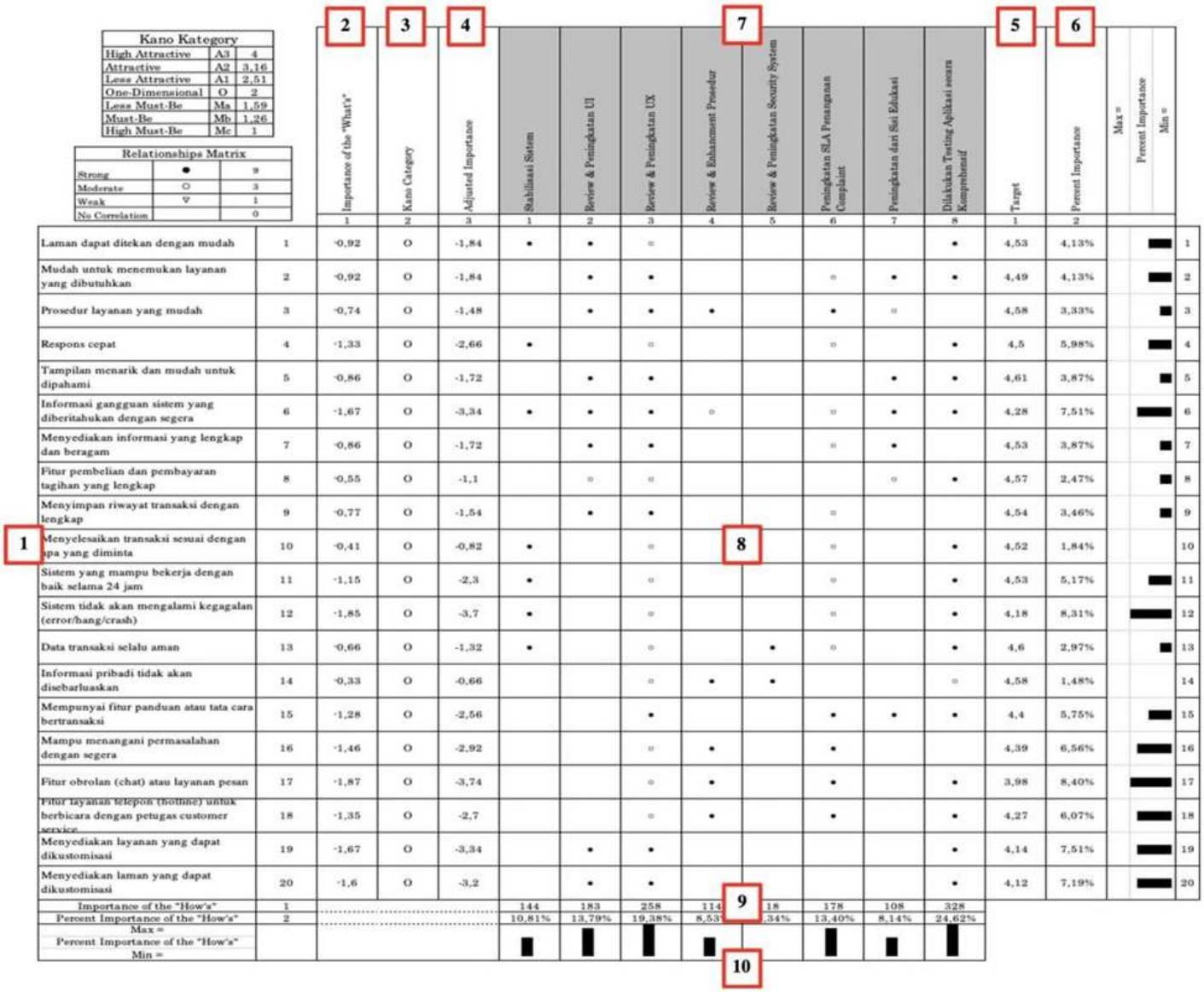


Figure 5. The incorporation of an integrated House of Quality (HoQ) to improve the quality of XYZ Mobile Banking services.

The explanation of each integrated House of Quality (HoQ) component in Figure 5 is as follows:

1. The What's (customer needs) section
2. Importance of The What's . Section
3. The Kano Category section is a column that contains the canoe category of the Type IV Kano model
4. Adjusted Importance Section
5. Target Section
6. Percent Importance Section
7. The How's . Part
8. Relationship Matrix Section
9. Importance of The How's . Section
10. The Percent Importance of The How's . Section

PT. XYZ can use research results as a reference in making strategies as a basis for improvement and development of XYZ Mobile Banking. Description of research results that can be used by PT. XYZ as follows:

- The results of the analysis of the level of customer satisfaction evaluated based on the SERVQUAL concept through the gap score theory showed that all attributes of customer needs had negative values, which indicated that all attributes of customer needs still needed improvement.
- The results of Kano's category analysis show that all attributes of customer needs belong to the one-dimensional Kano category. This indicates that the level of customer satisfaction is linear or directly proportional to the performance of fulfilling the attributes of customer needs that can be used as a reference for further development.
- The results of the QFD analysis of the translation of the attributes of customer needs resulted in eight company technical responses and an importance rating that can be used as a reference to build a strategy for improving the quality of mobile banking services.

5. CONCLUSIONS

Based on the research objectives that have been carried out, the following are the conclusions obtained.

1. Based on the analysis of the servqual method, it shows a value that maps the level of customer satisfaction on all attributes of customer needs that all attributes of customer needs have a negative Gap Score value, which means there is a difference between expectations and perceptions of trust. The result of the Gap value is used to find the Importance of the “what's” value.
2. The level of user satisfaction on the attributes of customer needs requires special improvement efforts on the attributes that have the lowest GAP Score and need to be improved, as follows:
    - Chat feature / Direct Message Service with BOT Mobile Banking XYZ
    - Customizable Services available with more options
    - The system will not experience errors/hangs
3. Analysis of the Kano method states that all attributes of customer needs belong to the one-dimensional Kano category. This indicates that the level of customer satisfaction is linear so that the Kano category in this case does not bring a significant difference to the adjusted importance value.
4. To achieve better service quality, the management of PT. XYZ must improve several aspects in technical response as a solution to improve the quality of XYZ Mobile Banking services which is carried out through Quality Function Deployment (QFD) analysis, as follows:

    - System Stabilization.
    - Review and Improvement of UI (User Interface)
    - UX (User Experience) Review and Improvement
    - Review and Enhancement Procedure
    - Review and Improvement of Security System
    - Perform Comprehensive Application Testing
    - Improvement in terms of Education
    - Improve SLA Complaint Handling

REFERENCES

Arikunto, S, 2001, Prosedur Penelitian Suatu Pendekatan Praktek, Rineka Cipta, Jakarta.

Badan Pusat Statistik, 2018, Statistik Gender Tematik: Profil Generasi Milenial Indonesia, Kementerian Pemberdayaan Perempuan dan Perlindungan Anak, Jakarta.

Barnes, S.J. and Corbitt, B., 2003, Mobile Banking: Concept and Potential,

International Journal of Mobile Communications, 1, 273-288.

Caruana, A., 2002, Service loyalty: The Effects of Service Quality and the Mediating Role of Customer Satisfaction, European Journal of Marketing, 36(7/8), 811–828.

Dabholkar, P.A., Thorpe, D.I., and Rentz, J. O., 1996, A Measure of Service Quality for Retail Stores: Scale Development and Validation, Journal of the Academy of Marketing Science, 24, 3-16.

Drucker, P.F., 1954, The Practice of Management, Harper & Row, New York. Ekinci, Y., 2003, An Investigation of the Determinants of Customer Satisfaction,

Tourism Analysis, 8(2), 193-196.

Ghotbabadi, A.R. and Baharun, R., 2015, Service Quality Measurement: A Review, International Journal of Academic Research in Business and Social Sciences, 5(2), 267-286.

Hair, J. F. Jr., Babin, B., Money, A. H., and Samouel, P., 2003. Essential of Business Research Methods, John Wiley & Sons, United States of America.

Hasan, Mia, and Rahman, 2017, Mobile Banking Service Quality and Customer Satisfaction in Bangladesh: An Analysis, The Cost and Management, 45(2), 25-32.

Huang, E.Y., Fan, Y.C., and Lin, S.W., 2015, M-S-QUAL: Mobile Service Quality measurement, Electronic Commerce Research and Applications, 14(2), 126- 142.

Inukollu, V.N, Keshamoni, D.D., Kang, T., and Inukollu, M., 2014, Factors Influencing Quality of Mobile Apps: Role of Mobile App Development Life Cycle, International Journal of Software Engineering & Applications, 5(5), 15-34.

Jun, M. and Palacios, S., 2015, Examining the Key Dimensions of Mobile Banking Service Quality: An Exploratory Study, International Journal of Bank Marketing, 34(3), 307-326.

Kano, N., Seraku, N., Takahashi, F., and Tsuji, S. 1984, Attractive Quality and Must-Be Quality. Journal of the Japanese Society for Quality Control, 41, 39-48.

Kesuma, D.P., 2013, Penerapan Quality Function Deployment dengan Mengadopsi Penggabungan Metode SERVQUAL dan Model Kano dalam Upaya Meningkatkan Kualitas Layanan Web Perguruan Tinggi: Studi Kasus Web STMIK MDP, Universitas Indonesia.

Kontan, 2019, Transaksi Mobile Banking Perbankan

Kusuma, N., 2016, Strategi Peningkatan Kualitas Layanan Enterprise Portal Dengan Integrasi Metode Servqual, Kano Model dan QFD: Studi Kasus PT. Maskapai Reasuransi Indonesia, Tbk., Universitas Indonesia, Jakarta.

Lin, C.Y. and Shih, K.H., 2013, Service Quality of Mobile Banking Systems, Management, Knowledge and Learning International Conference 2013, 515- 521.

Matzler, K. and Hinterhuber, H.H., 1998, How to Make Product Development Projects More Successful by Integrating Kano's Model of Customer Satisfaction into Quality Function Deployment, Technovation, 18, 25-38.

McKinsey&Company, 2018, Asia's Digital Banking Race: Giving Customers What They Want.

Mikulić, J. and Prebežac, D., 2011. What Drives Passenger Loyalty to Traditional and Low-Cost Airlines? A Formative Partial Least Squares Approach. Journal of Air Transport Management, 17(4), 237-240.

Mizuno, S., Akao, Y., and Ishihara, K., 1994, QFD: Customer-Driven Approach, Taylor & Francis, Portland.

Mohammadi, H., 2015, A Study of Mobile Banking Loyalty in Iran. Computers in Human Behavior, 44, 35-47.

Parasuraman, A., Parsu, and Zeithaml, Valarie and Malhotra, Arvind, 2005, E-S- Qual: A Multiple-Item Scale for Assessing Electronic Service Quality, Journal of Service Research, 7, 213-233.

Patel, N.V. and Bhatt, N.K., 2017, An Empirical Study on Integration of Servqual and Kano Model for Measuring Service Quality of Hospitals in Ahmedabad, Indian Journal of Commerce & Management Studies, 8(3), 77-95.

Pentelescu, O., 2008, Using Quality Function Deployment in Food Industry, Bulletin of University of Agricultural Sciences and Veterinary Medicine Cluj- Napoca, Agriculture, 65, 479.

Pouliot, F., 1993, Kano's Methods for Understanding Customer-defined Quality,

Centre for Quality of Management Journal, 2(4), 1-36.

PricewaterhouseCoopers, 2018, PwC's 2018 Digital Banking Consumer Survey: Mobile Users Set the Agenda.

PricewaterhouseCoopers Indonesia, 2018, PWC Survey: Digital Banking in Indonesia 2018.

Russel, R. and Taylor, B., 1998, Operation Management: Focusing on Quality and Competitiveness, Prentice Hall, New Jersey.

Safi'i, I., Putra Y.P., and Vitasmoro P., 2019, Priority for Improvement of Mobile Banking Services Using Kano model and QFD, AIP Conference Proceedings, 2114, 060002-1 – 060002-5.

Sekaran, U., 2008, Metodologi Penelitian Untuk Bisnis, Salemba Empat, Jakarta. Shih, K.H., Hung, H.F., and Lin, B., 2010, Assessing User Experiences and Usage

Intentions of M-Banking Service, International Journal of Mobile Communications, 8(3), 257–277.

Shahin, A., Pourhamidi, Masoud, Antony, Jiju, Park, and Sung, 2013, Typology of Kano Models: A Critical Review of Literature and Proposition of a Revised Model, International Journal of Quality & Reliability Management, 30, 341- 358.

Shaikh, A.A. and Karjaluoto, H., 2015, Mobile Banking Adoption: A Literature Review, Telematics and Informatics, 32, 129-142.

Shankar, A., and Kumari, P., 2016, Factors Affecting Mobile Banking Adoption Behavior in India, The Journal of Internet Banking and Commerce, 21(1), 1– 24.

Shankar, A. and Jebarajakirthy, C., 2019, The Influence of E-Banking Service Quality on Customer Loyalty: A Moderated Mediation Approach, International Journal of Bank Marketing, 37(5), 1119-1142.

Stephanie, E., 2003, Slovin's Formula Sampling Techniques, Houghton-Mifflin, New York, USA.

Tan, K.C. and Pawitra, T.A., 2001, Integrating SERVQUAL and Kano's Model into QFD for Service Excellence Development, Managing Service Quality, 11, 418–430.

RISK'S CONTRIBUTION TO IMPACT ANALYSIS ON DRAINAGE CHANNEL CONSTRUCTION PROJECTS IN SURABAYA

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ABSTRACT

In year 2016-2019, 96% of the 147 Surabaya City Drainage Channel Construction Project for the stated fiscal year required addendum that caused by either additional work, delay or deductional work or by the combination of those three. Only 4% could be carried out accordingly to the plan. The purpose of this study is to identify the risks that occur in the contracts, analyze risk's contribution weight and their impact on the financial aspect and delay aspect to obtain major risks.

There were 48 risk variables obtained from previous research. Risk's occurance and magnitude of their impact on project's budget and scheduled time were obtained from calculations which datas were taken from the performance of 147 previous project. Furthermore, weighted scores were obtained in the FGD (Focused Group Discussion) of experts. When risk ranks were obtained, the major risks could be determinded. Impact for each project along with 14 risk variables had been occurred. From the weighting of the risk contribution to the impact of each project, we got R38 (Changes in work items or variations (additions, deductions, and/or modifications)) and R5 (Inadequate data collection and survey before design) as major risks.

Keywords : weighted score, drainage construction project, major risks

1. INTRODUCTION

Based on datas of 147 contracts of drainage channel works in 2016 – 2019 at the Water Resources and Highways Office of Surabaya City, there were contract addendums from their implementation as follows:

Table 1. Addendum of Drainage Channel Construction Contracts

No	Addendum Reason	Number of Projects	Percentage to Total Projects
1	delay overbudget	41	27,89
2	delay underbudget	20	13,61
3	no addendum	6	4,08
4	delay	3	2,04
5	overbudget	43	29,25
6	underbudget	34	23,13
total projects		147	100,00

Based on Table 1 above, it can be concluded that:

1. A total of 95.92% of 147 work contract packages for the 2016-2019 fiscal years required additional work completion time, additional work and/or less combined work.
2. Only 4.08% of all work contracts for the fiscal year went according to plan.

From the addendum percentage datas mentioned above, it can be said that deviations often occured related to job specifications and delays in submitting work from contractors. According to Assaf and Al Hejji (2006), a project considered to be successful if it is able to achieve its objectives, namely the quality or specifications of the work in accordance with the price paid by the owner to the contractor and the time according to the agreement in the contract or there is no delay in completion. At the initial stage of a project, an agreement or contract will be made between the owner, consultant and contractor containing costs or budgets, job specifications and agreed time in completing a construction project, which means that the construction project should be completed before or on time as specified in the contract (Rosdianto, 2014). There are 4 risk variables from the contractor's perspective that have the most significant influence on the delay in the Box Culvert Construction Project, namely flooding, cost estimation errors, congestion and errors in determining elevation (Dewi, 2011).

In order to improve future contract's performance, researcher proposed the idea of analyzing risk's contribution to impact by evaluating 147 projects historical data to determine major risks that do necessary to mitigate. To solve this problem, researcher used previous researches to obtain risk's variables, 147 projects historical datas to obtain risk occurrence and risk impact and conducted FGD in order to obtain risk's contribution to impact weighted score, calculating total score of risk impact to rank risks and determine the major risks.

2. LITERATURE REVIEW

To get a comprehensive picture of the research to be carried out, it is necessary to make a comparison of the similarities and differences between previous researches and what the researcher would have done, here are some previous studies that according to the researcher need to be reviewed:

1. Dewi, ES (2011) by using qualitative risk analysis in her research had obtained 4 risk variables in contractor's perspective that had significant effect or impact to the delay of box culvert construction project delay in Surabaya, they were : flood, cost budgeting error, congestion and elevation error.
2. Kurniawan, BY (2011) also by using qualitative risk analysis in his research had obtained 9 risk variables (owner payment delay, design modification, lack in material inventory warehousing facility, low workers productivity, owner's approval delay, main contractor payment delay to sub-contractor, schedule revision, environmental issues on affected areas and traffic congestion) that impacted financial aspect and 5 risk variables (design modification, lack in material inventory warehousing facility, low workers productivity, schedule revision, owner payment delay) that impacted delay aspects on Petra Square Apartment Construction Project, Surabaya.

In accordance with Dewi ES (2011) and Kayode and Adedokun (2019) that said drainage channel construction project had given positive socio-economic impact to society in education, health and hygiene and economic aspects, researcher had an urgency to determine major risks in

drainage channel construction projects in Surabaya in order to retain and give positive socio-economic impact to Surabaya society.

3. METHODS

The methods of this research can be described like figure 1 as follows :

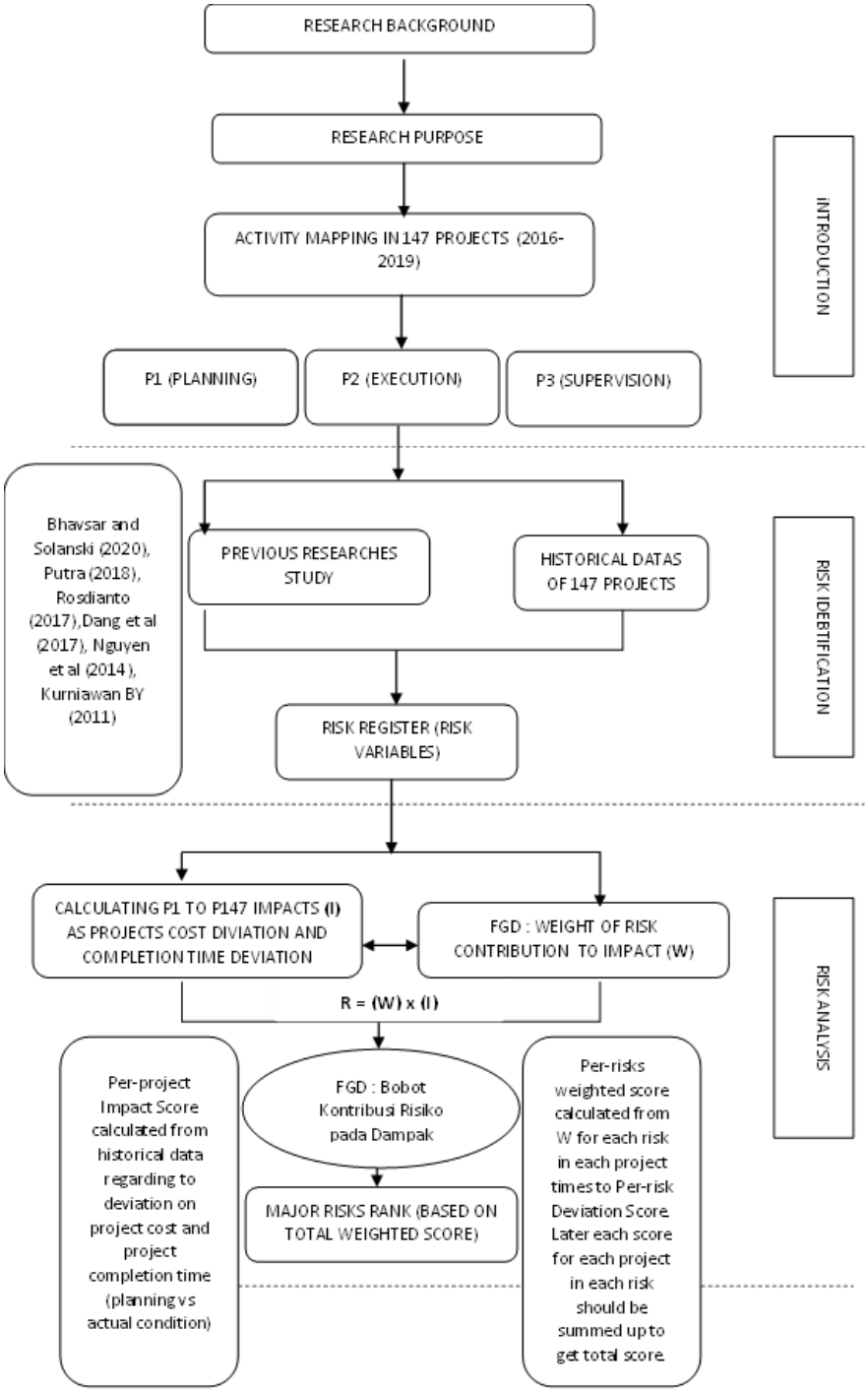


Figure 1. Research Method Flowchart

From Figure 1, this is the steps for this research. Frst step is the formulation of the existing problem and then sets the objectives and benefits of this research. The initial step of this research is to data collection on project documents for the drainage channel of Surabaya in 2016-2019, based on the results of data collection during that time span there are as many as 147 projects. The data analyzed such as contract documents, work handover reports, warning letters and job reports so that researchers will get data on risk events. The next step is risk identification by conducting a literature study in the form of journals and theories on risk management, especially the risk of drainage channel construction projects so that research risk variables are obtained. After that the next step is to carry out a Risk Analysis by calculating the contribution of each project in terms of project cost deviation (RAB) and completion time deviation by studying the contract documents of 147 projects to calculate the magnitude or risk ranking. The last step is Focus Group Disscusion to determine the weight of the contribution of each risk on the impact of each project in terms of cost deviation and completion time deviation Furthermore, Major Risks can be determined based on risk ranking of total score risk contribution to impacts.

4. RESULTS

The risk identification process in this study started from a study of previous research literature from similar studies. Then the researcher will match whether the risk variables listed really occur in risk events that have occurred in the implementation of Surabaya city drainage channel construction projects in 2016-2019 by using data from existing risk event reports:

1) R1 was Design modification
2) R2 was Delay in solving design problems
3) R3 was Improper project budgeting planning and calculation
4) R4 was Insufficient and/or unclear image details
5) R5 was Inadequate survey and data collection before design
6) R6 was Unavailability of qualified project manager and engineer
7) R7 was Unavailability of qualified and certified project's workers
8) R8 was Low worker's productivity
9) R9 was Worker's strikes and protests
10) R10 was Lack of main contractor's competency
11) R11 was Unavailability of common workers
12) R12 was Late response for worker's strikes and protests
13) R13 was Project Manager leave or abandon project
14) R14 was Lack of sub-contractor's competencies.
15) R15 was Lack of project management consultan's competencies
16) R16 was. Unavailability of equipments and qualified operator of the equipments
17) R17 was Unavailability of experts and special tools
18) R18 was Unhealthy cashflow of main contractor
19) R19 was Unpaid/Low Down Payment
20) R20 was Inflation effect on material price
21) R21 was Instable national economic condition
22) R22 was Shortage and/or material delay
23) R23 was Unavailability of access to materials and equipment

24) R24 was Tools and equipment damage
25) R25 was Insufficient of material volume and specification
26) R26 was Work accident/casualty
27) R27 was Poor time management of main contractor
28) R28 was Insufficient material warehouse capacity
29) R29 was Poor coordination in between planner-executor-supervisor
30) R30 was Delay of personnel mobilization
31) R31 was Inappropriate/fallacious working method
32) R32 was Dysfunctional of evaluation and supervision process
33) R33 was Outer and bigger party intervention
34) R34 was Low productivity of equipment and worker
35) R35 was Delay of sub-contractor work
36) R36 was Finding on working site that different from initial design
37) R37 was Owner change main contractor too frequently
38) R38 was Changes in work items or variations (additions, deductions, and modifications).
39) R39 was Bad political issues
40) R40 was Affected local people protest
41) R41 was Land ownership status dispute
42) R42 was Relocation of affected infrastructure, cultural heritage and/or cemetery
43) R43 was Environment pollution (air, water and soil)
44) R44 was Working permit arrangements difficulties
45) R45 was Land compensation protests from local people
46) R46 was Affected areas facilities (mosque, house, etc) rebuilding
47) R47 was Bad weather (high rainy season, flood, heat wave, etc)
48) R48 was Force majeur

By using historical data of 147 previous projects, researcher could determine 14 risks that happened, they were : R1,R2,R4,R5,R7,R10,R11, R16, R22, R23, R30, R31, R38, R42.Researcher also could determine deviation of project costs and completion time in each project like shows as follows :

Table 2. Each Project Impact to Financial and Time Deviation

Project Code	TOTAL FINANCIAL DEVIATION (%)	TOTAL COMPLETION TIME DEVIATION (%)	Project Code	TOTAL FINANCIAL DEVIATION (%)	TOTAL COMPLETION TIME DEVIATION (%)	Project Code	TOTAL FINANCIAL DEVIATION (%)	TOTAL COMPLETION TIME DEVIATION (%)	Project Code	TOTAL FINANCIAL DEVIATION (%)	TOTAL COMPLETION TIME DEVIATION (%)
P1	10%	20%	P38	-1%	0%	P75	-3%	0%	P111	2%	0%
P2	10%	33%	P39	4%	33%	P76	-5%	0%	P112	6%	0%
P3	7%	0%	P40	3%	0%	P77	-9%	21%	P113	5%	0%
P4	0%	0%	P41	10%	33%	P78	-9%	21%	P114	-4%	0%
P5	0%	0%	P42	10%	25%	P79	8%	38%	P115	4%	23%
P6	10%	26%	P43	1%	0%	P80	4%	0%	P116	-8%	0%
P7	9%	0%	P44	-2%	27%	P81	-2%	0%	P117	-4%	0%
P8	-1%	0%	P45	4%	39%	P82	10%	0%	P118	-3%	0%
P9	9%	17%	P46	8%	12%	P83	-3%	12%	P119	-78%	0%
P10	10%	17%	P47	5%	0%	P84	-3%	0%	P120	-7%	25%
P11	10%	0%	P48	2%	0%	P85	-4%	0%	P121	-1%	0%
P12	10%	0%	P49	7%	33%	P86	5%	0%	P122	1%	0%
P13	6%	28%	P50	9%	0%	P87	6%	0%	P123	-3%	0%
P14	-22%	0%	P51	8%	0%	P88	-1%	0%	P124	-4%	0%
P15	4%	0%	P52	4%	33%	P89	6%	50%	P125	-10%	0%
P16	7%	14%	P53	3%	0%	P90	-5%	21%	P126	-1%	0%
P17	-4%	25%	P54	7%	29%	P91	-1%	21%	P127	-9%	18%
P18	-11%	18%	P55	3%	17%	P92	-10%	14%	P128	5%	0%
P19	0%	0%	P56	1%	0%	P93	-26%	20%	P129	0%	0%
P20	10%	25%	P57	10%	0%	P94	-4%	21%	P130	5%	10%
P21	2%	23%	P58	-8%	0%	P95	-8%	0%	P131	-3%	0%
P22	-4%	0%	P59	-3%	50%	P96	3%	0%	P132	5%	17%
P23	1%	13%	P60	-6%	29%	P97	-2%	0%	P133	1%	0%
P24	3%	33%	P61	10%	0%	P98	5%	38%	P134	-3%	0%
P25	4%	0%	P62	10%	25%	P99	5%	0%	P135	-1%	0%
P26	4%	0%	P63	1%	30%	P100	7%	0%	P136	1%	0%
P27	9%	14%	P64	0%	0%	P101	-9%	33%	P137	3%	0%
P28	4%	25%	P65	0%	0%	P102	-3%	0%	P138	-29%	17%
P29	-15%	15%	P66	0%	44%	P103	-11%	0%	P139	-10%	0%
P30	6%	33%	P67	10%	0%	P104	10%	0%	P140	10%	0%
P31	-29%	21%	P68	5%	33%	P105	6%	67%	P141	2%	0%
P32	3%	33%	P69	9%	50%	P106	-8%	0%	P142	-3%	0%
P33	5%	0%	P70	10%	13%	P107	9%	23%	P143	-2%	28%
P34	7%	0%	P71	1%	42%	P108	-2%	0%	P144	-10%	31%
P35	2%	0%	P72	1%	0%	P109	1%	28%	P145	1%	0%
P36	3%	25%	P73	9%	0%	P110	0%	0%	P146	2%	17%
P37	9%	31%	P74	10%	20%	P111	2%	0%	P147	-10%	33%

By utilizing that deviation above as impact score for each project and using risk contribution to impact weight for each Risk in each project that researcher had gained in FGD, researcher found out following rank of risks :

Table 3. Major Risks Rank

Major Risks				
No	Risk Code	Financial Deviation Score	Financial Deviation Score	Total Score
1	R38	350,75	304,00	654,75
2	R5	340,25	203,00	543,25
3	R42	121,75	320,00	320,00
4	R1	102,25	226,00	328,25
5	R31	0	189,00	189,00
6	R10	0	138,00	138,00
7	R23	0	87,00	87,00

Then researcher define R38 and R5 as major risks due to the top 2 scores for total impact score that happened from year 2016 to 2019 for 147 projects. This major risks need to be mitigated later.

6. CONCLUSIONS

Based on the identification of 147 drainage channel construction project documents in the City of Surabaya in 2016-2019, from 48 risk variables that obtained from the literature there were 14 risks that occured in the project, as follows:

a) R1 was Design modification
b) R2 was Delay in solving design problems
c) R4 was Insufficient and/or unclear image details
d) R5 was Inadequate survey and data collection before design
e) R7 was Unavailability of qualified and certified project's workers
f) R10 was Lack of main contractor's competency
g) R11 was Unavailability of common workers
h) R16 was Unavailability of equipments and qualified operator of the equipments
i) R22 was Shortage and/or material delay
j) R23 was Unavailability of access to materials and equipment
k) R30 was Delay of personnel mobilization
l) R31 was Inappropriate/fallacious working method
m) R38 was Changes in work items or variations (additions, deductions, and modifications)
n) R42 was Relocation of affected infrastructure, cultural heritage and/or cemetery

The combined risk impact of each project was expressed as a percentage deviation where the impact can be classified into 2, namely the percentage deviation to the project's cost (financial aspect) and the percentage deviation to the time of execution of the work (delay aspect).

According to the conducted FGD, to weigh the contribution of the risk impact on each project, both in terms of cost and time percentages with experts of Surabaya Water Resources and Highways Service, PT. Sarana Marga Perkasa (Contractor), CV. Idea Karya Nusa (Planning Consultant) and CV. Putra Singaraja (Supervising consultant), after ranked the combined risk impact to financial and delay apects, there were 2 major risks that need to be mitigated, namely R38 (Changes in work items or variations (additions, deletions, and modifications)) with a value of 654.75 and R5 (Inadequate survey and data collection before design) with a score of 543.25.

REFERENCES

Alijoyo,A.(2006).Enterprise Risk Management, Jakarta:Ray Indonesia.

Amalia, Ridhati. (2012) "Sidoarjo Town Square Construction Project Delay Risk Analysis Using Fault Tree Analysis (FTA)". Thesis. ITS.

Association for Project Management (1997). Project Risk Analysts and Management, Norwich Norfolk : The APM Group Ltd.

Australian and New Zaeland Standards (1999). Risk Management, Standards Association of Australia.

Bhavsar, UM dan Solanki, JV I. (2020). "Identification of Constraints in Construction Projects", International Research Journal of Engineering and Technology, Vol.07, hal 6302-6307.

Chapman,C. (1997). Project Risk Analysis and Management – PRAM the Generic Process . International Journal of Project Magement, Vol.15. No. 5.

Cooper, D. Grey, S. Raymond,G. dan Walker,P. (2005). Project Risk Management Guidelines. John Wiley & Sons Ltd., England.

Cooper, D. dan Chapman, C. (1993). Risk Analysis For Large Project. First Edition. John Wiley & Sons Ltd., Norwich.

Dang, C.N., Le-Hoai, L., Kim, S.Y., Nguyen, C., Van Lee,Y.D., & Lee, S.H (2017). Identification of Risk Patterns in Vietnamesse Road and Bridge Construction : Contractor's Perspective. Built Environment Project and Asset Management, 7 (1), 59-72.

Dewi, E.S. (2011). Box Culvert Drainage Channel Construction Project in Surabaya Delay Risk Analysis. Thesis, Institut Teknologi Sepuluh Nopember, Surabaya.

Ervianto,W.I, (2002), Construction Project Management, Andi Yogyakarta Publisher, Yogyakarta

Dipohusodo, I. (1995). Project and Construction Management 1st edition. Kanisius Publisher, Yogyakarta..

Heldman, K.(2005). Project Manager's Spotlight on Risk Management. Alameda: Harbor Light Press.

ISO 31000:2018 (2018). BSI Standards Publication Risk management Guidelines, 2nd Edition.

Kartam, N., & Kartam, S. (2001). "Risk and Its Management in The Kuwaiti Construction Industry: A Contractors' Perspective." International Journal of Project Management, 19(6), 325-335.

Kayode, G.M, Adedokun, O.M (2019). The Impact of Construction of Drainage and Culvert Project on the Rural Dwellers of Irasa Community of Ado-Ekiti, Nigeria, International Journal of Research and Innovation in Social Science (IJRISS) |Volume III, Issue II, February 2019|ISSN 2454-6186.

Kerzner, Harold, (2006), Project Management: A system approach to planning, scheduling, and controlling, 9th edition, John Wiley & Sons, Inc., New Jersey .

Kocecioglu, D. (1991). Reliability Engineering Handbook, Volume 2. Englewood Cliffs: Prentice-Hall.

Koentjoro, N (2005). Society Research Method, Gramedia Pustaka Utama Publisher, Jakarta.

Krueger & Casey (2000). A Practical Guide For Applied Research, California : Sagepub.

Kurniawan (2015). Cargo Ship Project Delay Study, Thesis, Surabaya.

Kurniawan, B.Y (2011), Petra Square Apartment Surabaya Construction Project Delay Risk Analysis, Thesis, Institut Teknologi Sepuluh Nopember, Surabaya.

Marakas, George M. Decision Support Systems in the 21st Century Second Edition. New Jersey. Prentice Hall, 2003.

Mustika., A.F. (2014). Project Delay Analysis Using Fault Tree Analysis (FTA) Industrial Faculty Stage II Brawijaya University. Thesis, Universitas Brawijaya, Malang.

Nawawi, I (2021). Risk Analysis of Frontage Bridge Construction Project of Waru-Buduran Kabupaten Sidoarjo, Thesis, Magister Manajemen Teknik, Institut Teknologi Sepuluh Nopember, Surabaya.

Nguyen, T.H., Bhagavatulya, G.,& Jacobs, F. (2014). Risk Assessment : A Case Study for Transportation Projects in India. 3 (9), 1-14.

PMI (Project Management Institute, Inc). 2017. A Guide To The Project Management Body Of Knowledge (PMBOK), 2nd edition, Newtown Square, Pennsylvania, USA

Pourrostam, T dan Ismail A (2012). Causes and Effects of Delay in Iranian Construction Projects, IACSIT International Journal of Engineering and Technology, Vol. 4, No. 5, October 2012.

Perera, B. A. K. S, Dhanasingh,I.& Rameesdeen, R (2009). Rizikos Valdymastisiesient Kelius : Sri Lankos Atvejiz. International Journal of Strategic Property Management,J3 (2), 87-102.

Putra, A.T., (2014). Jacket Structure Construction Project Delay Evaluation : Case Study of EPCC Project Bukit Tua PT PAL Indonesia, Undergraduate Thesis, Institut Teknologi Sepuluh Nopember, Surabaya.

Rosdianto, A.M (2017). Taman Melati Surabaya Construction Project Delay Risk Analysis, Tesis Magister Manajemen Teknik, Institut Teknologi Sepuluh Nopember, Surabaya.

Satria, B (2012). Formal Safety Assessment Application on Risk Assessment on Helipad FSO: Case Study of FSO Kakap Natuna, Jurnal Teknik ITS Vol. 1, No. 1 (Sept. 2012) ISSN: 2301-9271.

Soemarno,M.S(2007), Land Utilization Risk and Analysis, PPJB Labaratory, FPUB Soil Science Universitas Brawijaya, Malang.

Szymański, P (2017), Risk Management in Construction Project, Procedia Engineering, 208, 174-182.