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The Application of Time Series Forecasting Method to Estimate National Salt Demands

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***Abstract*— Salt is one of the most important commodities for domestic use and as a raw material for industry. It is essential to make an estimate salt requirement to meet them appropriately. The purpose of the study was to estimate salt needs using the time series forecasting method and to identify the most effective technique for salt needs forecasting. Forecasting analysis uses Naive, Moving Average, Weighted Moving Average, Exponential Smoothing, Exponential Smoothing with Trend, and Trend Projection methods. Forecasting accuracy is tested using MAD, MSE, and MAPE. Based on the results, the Trend Projection is the most effective time series forecasting technique for predicting salt requirements. This method was selected due to its lowest error rate value (MAD of 0.16, MSE of 0.04, and MAPE of 4.28%) compared to other methods. According to projected estimates, the amount of salt required in 2024 would be 4.86 million tons.**

***Keywords*: Forecasting, Time Series, Trend Projection, Exponential Smoothing, Moving Average, Weighted Moving Average.**

I. INTRODUCTION

Salt is a strategic and essential commodity as a staple for household consumption and as an industrial raw material. Salt functions as a preservative, flavor enhancer, as well as to improve the appearance and texture of food (Noviasari et al., 2023). According to Akbar et al. (2023), the national salt demand will reach more than 4 million tons in 2022. Based on the salt balance from the Coordinating Ministry for Economic Affairs processed by BPS, the total national salt demand in 2022 will reach 4.5 million tons. A total of 3.7 million tons of salt is used as raw materials and industrial auxiliary materials. Industrial sectors that use salt include: chlor-alkali plants (cap), various foods, fish salting, tanning, mining, animal feed, water treatment, soap and detergent, pharmaceuticals and cosmetics, as well as textiles and others.

The demand for salt in Indonesia has increased every year. According to Putri & Sugiarti (2021), As the population grows and industrialization advances, so does the demand for salt more increasing. Data from BPS, the Ministry of Industry, and PT Garam show that the national salt demand increased from 2011 to 2021, from 3.2 million tons in 2011 to 4.6 million tons in 2021. The demand for salt is generally rising, yet occasionally decrease from the previous year. For instance, the demand for salt fell by 0.9 million tons from 2021 to 4.51 million tons in 2022.

The national salt demand must be predicted so that the government can prepare production and reserves to meet these needs. Prediction of salt needs can be done by forecasting future needs based on data from previous years. Forecasting is essential to support decisions such as inventory management, production planning, procurement, and others (Pritularga et al., 2023). Meanwhile, according to Arnold et al. (2012), forecasting is used for business strategic plans, production plans, and production master schedules. And according to Puspita (2023), forecasting is one way to control production. Forecasting is a method of estimating the future using data from the past. Forecasting is both a science and an art of understanding the prediction of future events (Heizer et al., 2017). Forecasting is a computational analysis methodology that employs both qualitative and quantitative methodologies to predict future events utilizing future data references to reduce effect uncertainty. Forecasting can be used for short-, medium-, and long-term planning. (Maretania et al., 2021). According to Badi'ah & Handayani (2020), forecasting is used as a tool in effective and efficient planning, as well as to determine future resource needs and to make informed decisions.

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Hernadewita et al., (2020), forecasted generic drug sales using the time series forecasting method obtains the results of forecasting generic drug sales for the next period. Kusuma et al. (2020), said that the Linear Exponential Smoothing approach is a more accurate way to predict batik sales than the forecasting method used by batik managers. Nadhira et al. (2021), compared the demand forecasting of Softex 1400-M using the Single Exponential Smoothing and Single Moving Average methods. The findings demonstrate that the Single Moving Average approach is the most effective one with a MAPE of 12.82%. Demand forecasting can support to prevent excess or shortage of product stock. Meanwhile, Samosir et al. (2022) forecasted to determine the need for drugs to improve services using the Trend Projection method. Asyrof-H & Rahmawati (2023), used the Exponential Smoothing, Weighted Moving Average, and Single Moving Average methods to predict the demand for delivery services. According to the results, the Single Exponential Smoothing approach was the most effective since it produced the most accurate results with the smallest MAPE was 5.48. Meanwhile, Tamtama & Riantisari (2024) forecasted the demand for car washes using the Exponential Smoothing, Single Moving Average, and Weighted Moving Average methods, with the smallest MAPE result being the Weighted Moving Average method where the MAPE value is 21.41%. Several studies using forecasting methods show that the difference in forecasting objects and data influences the difference in the selection of the most appropriate method. Therefore, in conducting forecasting, it is necessary to test several forecasting methods to get the best results.

Previous research related to forecasting salt includes forecasting the price, production, demand, and sales of salt. The research was only conducted on micro sectors such as companies or certain regions. As well as Habibi & Riksakomara (2017), forecasted the price of salt for consumption at PT. Garam Mas uses Artificial Neural Network Feedforward-Backpropagation. Mahrus et al. (2021), forecasted the quantity of salt produced in Madura using the Double Moving Average and Exponential Smoothing methods. Badi'ah & Handayani (2020), analysed the forecast of demand for iodized consumption salt products in UD Garam Samudra using Linear Regression, Exponential Smoothing, Moving Averages, Weighted Moving Averages, and Naive Method. Sari et al. (2022), used the Least Squares approach to forecast salt sales in CV. Saltindo Megajaya. This study used time series forecasting methods (Naive Approach, Moving Averages, Weighted Moving Averages, Exponential Smoothing, Exponential Smoothing with Trend Adjustment and Trend Projections) to forecast the National salt demands. The purpose of this study is to find the most effective time series forecasting method for projecting future national salt demands.

II. RESEARCH METHOD

Forecasting is the beginning of a plan. Before planning, forecasting must be done to know what will happen over the next few periods (Arnold et al., 2012). According to Kusmindari et al (2019), forecasting is a process to predict several future needs. Forecasting uses historical data to project it into the future with mathematical models. Forecasting is carried out with two approaches, namely (1) quantitative forecasting uses a variety of mathematical models derived from associative variables or historical data, and (2) qualitative forecasting incorporates elements like value systems, emotions, personal experiences, and intuition in decision-making (Heizer et al., 2017).

This study employs a quantitative forecasting methodology based on time series. The time series forecasting method makes estimates based on past data. When there is little variation in the fundamental demand pattern from year to year, this approach is very suitable (Chopra & Meindl, 2016). According to, Luciano & Yuliarty (2020), the time series method is concerned with the value of a variable that is arranged periodically throughout the time in which demand forecasting is projected, for example weekly, monthly, quarterly and yearly. Time series quantitative forecasting method according to Heizer et al. (2017) includes:

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1. Naive Approach

The naive approach is the most straightforward forecasting method that assumes that demand will be the same in the future as it is now (Heizer et al., 2017). This approach is the most objective and cost-efficient forecasting method Hernadewita et al (2020).

Demand in the following period = Demand in the current period (1)

2. Moving Average (MA)

Moving averages is forecasting method that predict the upcoming period by averaging the values of previous data from multiple recent periods. If it is expected that market demand is constant over time, this strategy can be helpful. The following is the mathematical expression for a simple moving average (Hernadewita et al., 2020; Heizer et al., 2017):

$$\text{MA} = \frac{\Sigma \text{d} \quad \text{i} \; \text{p} \quad n \text{p}}{n} \quad (2)$$

Where *n* is the moving average's number of periods.

3. Weighted Moving Average (WMA)

Weighted moving average is a forecasting method used when a trend or pattern is identified; weighting allows the most recent number to be given greater weight. By giving greater weight to more recent periods, this strategy improves the forecasting technique's responsiveness to changes. A moving average with weighting can be mathematically represented as follows (Hernadewita et al., 2020; Heizer et al., 2017):

$$\text{WMA} = \frac{\Sigma (\text{W} \quad \text{i} \; \text{p} \quad n) \; \text{D} \quad \text{i} \; \text{p} \quad n)}{\Sigma \text{W}} \quad (3)$$

4. Exponential Smoothing

Exponential smoothing is a method that uses exponential functions to weight data to forecast moving averages with different weightings. This approach is very simple to use and requires very little historical data. The following is the basic exponential refinement formula (Hernadewita et al., 2020; Heizer et al., 2017; Chopra & Meindl, 2016):

$$F_t = F_{t-1} + \alpha (A_{t-1} - F_{t-1}) \quad (4)$$

o

$$F_t = \alpha (A_{t-1}) + (1 - \alpha) F_{t-1} \quad (5)$$

Where:

Ft = new forecasting
Ft_{-1} = previous forecasting
A = constant for smoothing ($0 \leq \alpha \leq 1$)
At_{-1} = the previous period's actual demand

5. Exponential Smoothing with Trend Adjustment

Exponential smoothing forecasting method that incorporates trend adjustment is called exponential smoothing with trend adjustment. This technique is applied when there is a trend in the forecasted data. The formula for exponential smoothing with trend correction is as follows: (Hernadewita et al., 2020; Heizer et al., 2017):

Forecasting by trend (*FITt*) = Exponential smoothing forecasting (*Ft*) + Exponential smoothing trend (*Tt*) (6)

The two smoothing constants needed for the exponential smoothing method with trend correction are α for the average and β for the trend. The following formula is used to determine averages and trends for each period:

$$F_t = \alpha (A_{t-1}) + (1 - \alpha)(F_{t-1} + T_{t-1}) \quad (7)$$

$$T_t = \beta (F_t - F_{t-1}) + (1 - \beta) T_{t-1} \quad (8)$$

Where:

Ft = forecasting using serialized data that has been

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exponentially smoothed out in the period *t*

Tt = trend with a smoothed exponential over period *t*

At_{-1} = previous period's actual demand

Ft_{-1} = previous forecasting

A = constant for smoothing ($0 \leq \alpha \leq 1$)

B = smoothing constant for trend ($0 \leq \beta \leq 1$)

6. Trend Projection

Trend projection is a forecasting method that projects trend lines into the future for medium- or long-term forecasting after modifying the lines on a collection of historical data. This approach examines trends as a linear, or straight, line. The following equation can be used to express the trend line in the trend projection approach (Puspita, 2023; Samosir et al., 2022; Hernadewita et al., 2020; Heizer et al., 2017):

$$\hat{y} = \boldsymbol{a} + \boldsymbol{b} \quad (9)$$

Regression line slope (*b*):

$$b = \frac{\sum x \; - n\bar{x}\bar{y}}{\sum x^{2} - n\bar{x}^{2}} \quad (10)$$

Y axis cut-off point (*a*):

$$a = y - b \quad (11)$$

Where:

$\hat{y}$ = the calculated value of the variable that needs to be forecasted (bound variable)

a = axis intersecting *y*

b = regression line slope

x = independent variable

y = bound variable

$\bar{x}$ = average value *x*

$\bar{y}$ = average *y*-value

n = quantity of data or observations

Measure of Forecasting Results' Accuracy

The measure of the forecasting accuracy is a measure of forecasting error, or the degree of discrepancy between the forecasted and actual demand (Kusmindari et al., 2019). The measures of forecasting results' accuracy of the used in this study include (Samosir et al., 2022; Hernadewita et al., 2020; Heizer et al., 2017):

1. MAD (Mean Absolute Deviation)
   The value is determined by summing the forecast error's (deviation) absolute values and dividing the outcome by the number of data periods (n), namely:
   $$M = \frac{\sum |A \quad - F_{t} \quad|}{n} \quad (12)$$
2. MSE (Mean Square Error)
   MSE is the mean squared difference among the actual and predicted values. The following is the formula:
   $$M = \frac{\sum (A \quad - F_{t} \quad)^{2}}{n} \quad (13)$$
3. MAPE (Mean Absolute Percent Error)
   MAPE is the mean absolute difference among the actual and predicted values, represented as a percentage of the actual values for *n* periods. MAPE's formula is:
   $$M = \frac{100}{n} \sum_{t=1}^{n} \frac{|\text{Actual}_{t} - \text{Forecast}_{t}|}{\text{Actual}_{t}} \quad (14)$$

III. RESULT AND DISCUSSION

The national salt demand from 2011-2023 has increased, where the demand for salt in 2011 was 3.2 million tons and in 2023 as much as 4.7 million tons. In general, the demand for salt is increasing, but sometimes there is a decrease from the previous year. Figure 1 illustrates the decline from 3.9 million tons in 2014 to 3.4 million tons in 2015, 4.2 million tons in 2018, 4 million tons in 2019, 4.6 million tons in 2021, and 4.5 million tons in 2022. Salt needs are always changing (not the same every year) so that good estimates are needed so that salt needs can be met properly.

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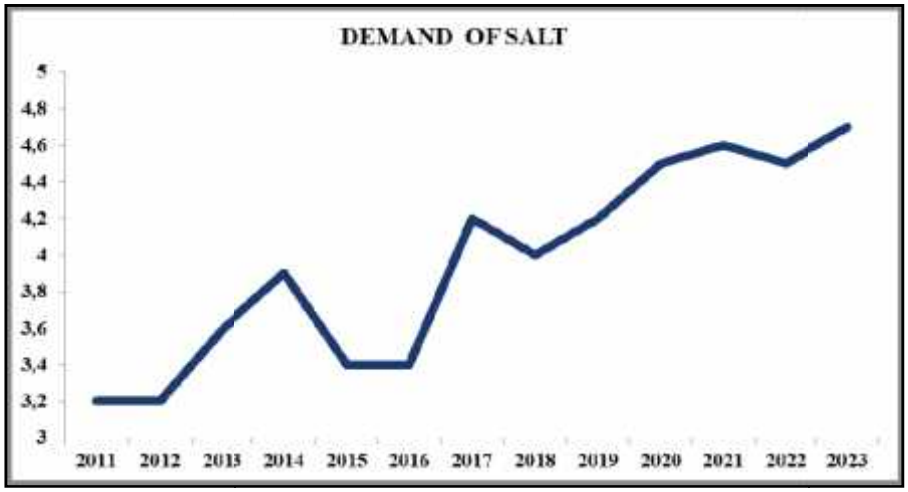

Figure 1: National Salt Demand Data 2011-2023
Source: PT. Garam, BPS, and the Ministry of Industry (2024)

Table 1. Results of Salt Demand Forecasting Calculation

Period	Demand	Forecast											
		Naive	MA (N=2)	MA (N=3)	MA (N=4)	WMA (N=2)	WMA (N=3)	WMA (N=4)	ES (α=0,2)	ES (α=0,5)	ES (α=0,8)	EST	TP
2011	3,2												3,2
2012	3,2	3,20							3,20	3,20	3,20	3,20	3,31
2013	3,6	3,20	3,20			3,2			3,20	3,20	3,20	3,20	3,44
2014	3,9	3,60	3,40	3,33		3,44	3,4		3,28	3,40	3,52	3,50	3,57
2015	3,4	3,90	3,75	3,57	3,48	3,78	3,67	3,6	3,40	3,65	3,82	3,83	3,70
2016	3,4	3,40	3,65	3,63	3,53	3,6	3,59	3,57	3,40	3,53	3,48	3,55	3,82
2017	4,2	3,40	3,40	3,57	3,58	3,4	3,5	3,52	3,40	3,46	3,42	3,44	3,95
2018	4	4,20	3,80	3,67	3,73	3,88	3,8	3,77	3,56	3,83	4,04	4,01	4,08
2019	4,2	4,00	4,10	3,87	3,75	4,08	3,94	3,88	3,65	3,92	4,01	4,05	4,21
2020	4,5	4,20	4,10	4,13	3,95	4,12	4,14	4,06	3,76	4,06	4,16	4,19	4,34
2021	4,6	4,50	4,35	4,23	4,23	4,38	4,31	4,28	3,91	4,28	4,43	4,46	4,47
2022	4,5	4,60	4,55	4,43	4,33	4,56	4,49	4,43	4,05	4,44	4,57	4,61	4,60
2023	4,7	4,50	4,55	4,53	4,45	4,54	4,53	4,5	4,14	4,47	4,51	4,57	4,73
2024		4,70	4,60	4,60	4,58	4,62	4,62	4,60	4,25	4,58	4,66	4,69	4,86

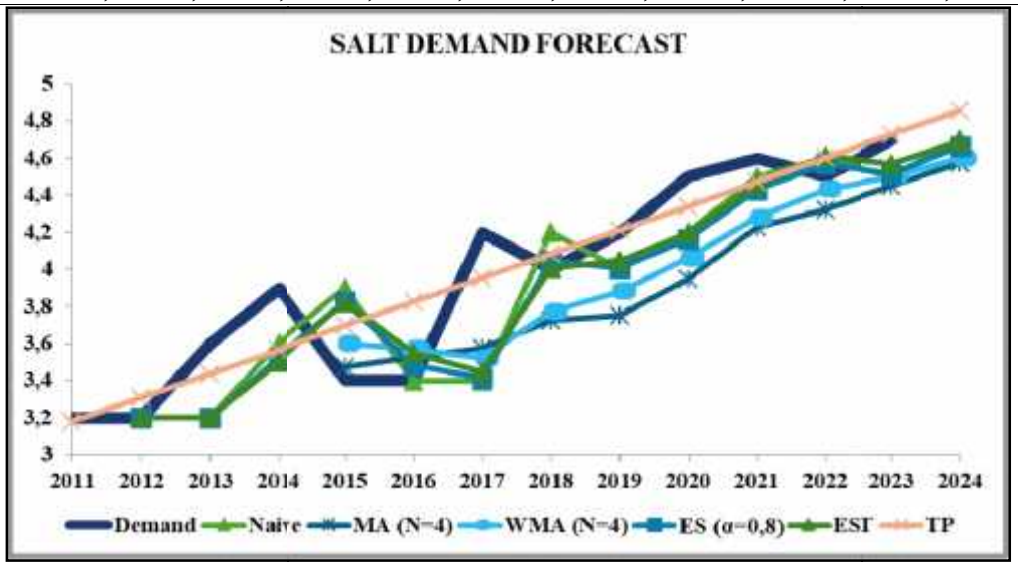

Figure 2: Comparison of Forecast Result with Salt Demand Data

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Table 2. Forecast Accuracy Measurement Results

Method	Forecast	MAD	MSE	MAPE
Naive	4,70	0,26	0,11	6,47%
Moving Average (N=2)	4,60	0,31	0,14	7,88%
Moving Average (N=3)	4,60	0,32	0,13	7,88%
Moving Average (N=4)	4,58	0,32	0,14	7,55%
Weighted Moving Average (N=2)	4,62	0,30	0,13	7,53%
Weighted Moving Average (N=3)	4,62	0,30	0,12	7,24%
Weighted Moving Average (N=4)	4,60	0,29	0,11	7,00%
Exponential Smoothing (α=0,2)	4,25	0,40	0,25	9,52%
Exponential Smoothing (α=0,5)	4,58	0,27	0,12	6,66%
Exponential Smoothing (α=0,8)	4,66	0,24	0,10	5,90%
Exponential Smoothing with Trend	4,69	0,25	0,11	6,27%
Trend Projection	4,86	0,16	0,04	4,28%

The results of the salt requirements calculation utilizing the time series forecasting approach, which includes *the Naive, Moving Average, Weighted Moving Average, Exponential Smoothing, Exponential Smoothing with Trend*, and *Trend Projection* methods are shown in Table 1. The results of the calculation show that in the Trend Projection method, there is an increase in salt demand in 2024 by 4.86 million tons, compared to the need in 2023 of 4.7 million tons. In the Naive method, the forecast results in 2024 are the same as the salt demand in 2023, because of this approach, the demand for the anticipated value for the upcoming period is the same as that for the prior period. Meanwhile, the forecast results of other methods will decrease in 2024. The forecast results on the Moving Average (MA) method with n = 2 and 3 of 4.6 million tons and n = 4 of 4.58 million tons. Meanwhile, in the Weighted Moving Average (WMA) method with n = 2 (weights 0.4 and 0.6) and n = 3 (weights 0.2, 0.3, and 0.5) as much as 4.62 million tons and n = 4 (weights 0.1, 0.2, 0.3, and 0.4) as much as 4.6 million tons, where n is the moving average's number of periods. Exponential Smoothing (ES) with α = 0.2 is 4.25 million tons, α = 0.5 is 4.58 million tons, and α = 4 is 4.66 million tons. Meanwhile, in Exponential Smoothing with Trend (EST) with, α = 0.5 and β = 0.5 as much as 4.69 million tons.

Measure of Forecasting Results' Accuracy

A measure forecasting results' accuracy is necessary to measure forecasting errors or the degree of discrepancy among predicted and actual demand. Table 2 displays the results of the forecasting error calculation for each time series approach utilized in the study. A comparison of the forecast results of the six methods with the actual salt requirement value can be seen in Figure 2. The demand for salt increases every year even though sometimes there is a decrease, but in general there is an increase in salt demand so that it is very consistent with forecasting methods that have a trend. Based on the analysis of the six methods, the most suitable method to forecast salt demand is the Trend Projection method because the forecast value every year increases, in contrast to other methods that decrease at the end of the period. According to outcomes of the forecasting error computation, this approach also possesses the lowest error value when compared to other approaches.

IV. CONCLUSIONS

Based on the study's findings, time series forecasting approach generates a forecast value of 4.86 million tons for salt demand in 2024. Salt demand increased by 0.16 million tons from salt demand in 2023. From the six time series forecasting techniques utilized in this study, namely Naive Approach, Moving Average, Weighted Moving Average, Exponential Smoothing, Exponential Smoothing with Trend, and Trend Projection. The most effective forecasting technique salt demands is the Trend Projection method. This approach has the lowest error rate value among the others, with a MAD of 0.16, MSE of 0.04 and MAPE of 4.28%.

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Implementation of Workplace Safety in the Welding Industry: Challenges and Solutions

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***Abstract*— Occupational safety and health (OSH) is critical for companies to minimize workplace accidents and health risks. However, many employees in the welding sector often neglect these aspects, leading to potential hazards. This study examines the implementation of OSH practices in the welding department of an iron manufacturing company in Surabaya using the Job Safety Analysis (JSA) method. Data were collected from 35 respondents through interviews, observations, and documentation of past incidents. The results highlight common hazards, including ultraviolet exposure damaging eyes and skin, welding fumes causing respiratory issues, electric shocks leading to injuries or fatalities, and physical impacts from sharp or heavy materials. To mitigate these risks, compliance with standard operating procedures (SOPs) and the use of complete personal protective equipment (PPE) are essential. This research emphasizes the importance of OSH awareness and adherence to safety protocols to enhance workplace safety and productivity.**

***Keywords*: Iron Manufacturing, Occupational Safety and Health, Job Safety Analysis.**

I. INTRODUCTION

The welding industry is a critical sector in manufacturing and construction, contributing significantly to economic development[1]–[3]. However, it is also one of the most hazardous fields, where workers face various occupational risks, including exposure to ultraviolet (UV) radiation, inhalation of toxic fumes, electric shocks, and physical injuries[4], [5]. Despite the availability of safety guidelines and protective measures, the implementation of occupational safety and health (OSH) standards remains inconsistent across industries[6]–[9]. This inconsistency results in workplace accidents, reduced productivity, and long-term health complications for workers.

One of the most pressing issues is the lack of awareness and understanding among workers and employers regarding the importance of OSH practices[8], [10]–[14]. Many welding departments fail to provide adequate training on safety protocols or enforce the consistent use of personal protective equipment (PPE)[15], [16]. For instance, UV radiation emitted during welding can cause severe damage to the eyes and skin, yet workers often neglect to wear appropriate face shields or protective clothing. Similarly, welding fumes, which contain hazardous substances such as manganese and hexavalent chromium, pose serious respiratory risks. Without proper ventilation systems and respiratory protection, workers are exposed to long-term health hazards, including chronic lung diseases and cancer[17]–[23].

Another critical challenge is the inadequate monitoring and evaluation of workplace safety practices. In many cases, accidents occur due to preventable factors, such as poorly maintained equipment, improper handling of materials, and insufficient risk assessments. For example, electric shocks resulting from faulty welding machines or exposed cables can lead to severe injuries or fatalities. Physical injuries, such as burns, cuts, and bruises, are also common, often caused by sharp materials or hot surfaces in the welding environment[24]. These incidents highlight the need for systematic hazard identification and risk management.

To address these challenges, the study focuses on implementing the Job Safety Analysis (JSA) method in the welding department of an iron manufacturing company in Surabaya. JSA is a structured approach that involves identifying potential hazards in each step of a work process, evaluating the associated risks, and developing

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effective control measures[25]–[29]. By breaking down tasks into smaller steps, JSA helps identify specific hazards that might otherwise be overlooked. This method not only enhances workplace safety but also improves operational efficiency and worker morale [30]–[33].

The research involves collecting data through interviews, observations, and documentation of past incidents. The findings reveal that UV radiation and welding fumes are the most significant hazards, followed by risks such as electric shocks, burns, and physical injuries. To mitigate these risks, the study recommends several measures, including enforcing the use of complete PPE, providing regular safety training, and installing advanced ventilation systems. For instance, face shields and gloves made of heat-resistant materials can protect workers from UV exposure and burns, while respirators can reduce the inhalation of toxic fumes. Additionally, implementing safety patrols and routine inspections can ensure compliance with safety protocols.

The study also emphasizes the importance of fostering a safety-oriented culture within the organization. Employers must prioritize worker safety by allocating sufficient resources for training programs and safety equipment. Workers, on the other hand, need to adopt a proactive approach by adhering to safety guidelines and reporting potential hazards. Collaboration between management and employees is essential for creating a safe and productive work environment.

In conclusion, the welding industry faces significant occupational safety challenges that require immediate attention. The implementation of the JSA method in the welding department of an iron manufacturing company demonstrates the effectiveness of structured risk management in reducing workplace hazards. By addressing critical issues such as UV radiation, toxic fumes, and physical injuries, the study provides valuable insights for improving safety standards in the industry[34], [35]. With consistent enforcement of OSH practices and a commitment to continuous improvement, organizations can protect their workers, enhance productivity, and achieve long-term sustainability.

II. METHOD

This study adopts the Job Safety Analysis (JSA) method, a systematic approach used to identify, assess, and control potential hazards in the workplace. The methodology involves breaking down specific tasks into detailed steps, identifying associated risks, and proposing mitigation strategies to enhance workplace safety[36]–[40].

a) Data Collection

The research was conducted in the welding department of an iron manufacturing company in Surabaya. Data collection involved three main methods:

- Observation

Direct observations were conducted to analyze the working environment and processes. Senior employees were asked to perform welding tasks to identify any variations in practices that could introduce new risks.

- Interviews and Discussions

Structured interviews and discussions were held with 35 employees, including technicians and supervisors, to gather insights into workplace practices and potential hazards.

- Documentation of Past Incidents

Historical data on workplace accidents were reviewed to identify patterns and understand the severity and frequency of hazards. Examples include incidents of burns from welding sparks, respiratory issues from fumes, and injuries due to material handling.

b) Data Analysis

The collected data were analyzed using a quantitative approach. Risks were categorized based on their likelihood and severity, ranging from low to extreme risk levels[36], [41]–[46]. The analysis was conducted in the following steps:

- Evaluating existing safety controls.
- Breaking down job tasks into sequential steps.
- Identifying potential hazards associated with each step.
- Proposing risk mitigation measures for each identified hazard.

c) Implementation of Controls

Risk controls were prioritized based on their significance. For example, hazards related to UV radiation exposure were addressed by mandating the use of complete personal protective equipment (PPE), such as welding helmets and gloves. Other measures included installing ventilation systems to mitigate the impact of welding fumes and organizing safety training sessions to enhance awareness among workers.

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This methodology ensured a comprehensive understanding of the risks in the welding department and provided actionable recommendations to improve occupational safety and health (OSH) practices.

III. ANALYSIS

This study employed the Job Safety Analysis (JSA) method to evaluate occupational hazards in the welding department of an iron manufacturing company in Surabaya. The analysis was conducted in three main stages: identifying potential hazards, categorizing the severity and frequency of these hazards, and proposing control measures to mitigate risks.

a) Identification of Hazards

Observations and interviews highlighted several critical hazards encountered during welding activities. Key risks included:

- Ultraviolet (UV) Radiation: Direct exposure to UV rays during welding causes significant harm to workers' eyes and skin. This hazard is particularly severe for employees without adequate protective equipment such as welding helmets.
- Toxic Fumes: Welding generates fumes that contain hazardous substances, including manganese and chromium, leading to respiratory issues. Poor ventilation exacerbates this risk.
- Electric Shock: Faulty or exposed wiring in welding machines increases the likelihood of electric shocks, which can cause severe injuries or even fatalities.
- Physical Injuries: Burns from welding sparks and cuts from handling sharp materials were frequently reported.

b) Risk Categorization

Each hazard was assessed based on its likelihood and severity to prioritize control measures. The categorization is as follows:

- Extreme Risk: Hazards such as prolonged UV exposure and toxic fume inhalation, pose serious long-term health risks.
- High Risk: Electric shocks and burns, which can lead to immediate and severe injuries.
- Moderate Risk: Physical injuries such as cuts and bruises, which are less severe but still disrupt workflow and productivity.
- Low Risk: Minor risks like equipment mishandling, which cause light injuries and are easier to control.

c) Proposed Controls

Based on the analysis, the study proposed several measures to improve safety:

- Personal Protective Equipment (PPE): The use of complete welding PPE, including UV-resistant helmets, gloves, and aprons, was emphasized to minimize physical injuries.
- Ventilation Systems: Installing advanced ventilation systems to extract welding fumes and prevent inhalation of hazardous gases.
- Electrical Safety: Regular maintenance and inspection of welding equipment to prevent electric shocks.
- Training Programs: Conduct safety training and awareness sessions to educate workers about potential hazards and safe practices.
- Safety Patrols and Monitoring: Establishing safety patrol teams to ensure compliance with protocols and identify new risks in real-time.

d) Outcomes and Implications

The findings of this study revealed that structured risk assessment through the JSA method significantly improves workplace safety by identifying and addressing critical hazards. The proposed measures not only mitigate risks but also enhance workers' confidence and productivity by ensuring a safer working environment. Organizations that adopt these strategies can expect a reduction in workplace accidents, improved compliance with safety regulations, and increased operational efficiency.

This analysis demonstrates that effective hazard management is a continuous process requiring the collaboration of all stakeholders, including management, supervisors, and employees. Through the consistent application of JSA, the welding department can set a benchmark for safety practices in the industry.

IV. DISCUSSION

The findings of this study underscore the critical importance of implementing comprehensive occupational safety and health (OSH) practices in the welding department. The use of the Job Safety Analysis (JSA) method has proven effective in identifying and addressing workplace hazards, providing a structured framework for risk management.

The analysis revealed that ultraviolet (UV) radiation and welding fumes are the most significant risks, posing severe health threats to workers. Prolonged exposure to UV radiation without adequate protection can result in

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permanent damage to the eyes and skin, while inhalation of toxic fumes contributes to chronic respiratory issues. These findings emphasize the need for complete personal protective equipment (PPE) and effective ventilation systems as primary mitigation measures.

Electric shocks and burns were categorized as high-risk hazards, often stemming from faulty equipment or improper handling. These risks highlight the necessity of regular equipment maintenance and worker training. The study demonstrated that consistent use of PPE, such as insulated gloves and fire-resistant clothing, significantly reduces the likelihood of such incidents.

Moreover, the study observed that a lack of awareness and compliance among workers remains a persistent challenge. Safety training and regular safety patrols were identified as effective strategies to address this issue. Educating employees about the potential hazards and encouraging adherence to safety protocols fosters a culture of safety within the organization.

Implementing the recommended control measures not only mitigates risks but also enhances productivity and worker morale. A safer working environment reduces absenteeism caused by injuries and promotes operational efficiency. The findings align with existing literature on the effectiveness of structured OSH frameworks in high-risk industries.

In conclusion, this study reinforces the necessity of a proactive approach to workplace safety. By integrating the JSA method and fostering a culture of safety, organizations can significantly reduce occupational hazards. Future research could explore the long-term impact of these interventions on worker health and organizational performance.

V. CONCLUSION

This study highlights the critical role of implementing comprehensive occupational safety and health (OSH) measures in the welding department of an iron manufacturing company. The application of the Job Safety Analysis (JSA) method has proven to be an effective framework for identifying, categorizing, and mitigating workplace hazards. Key risks, such as ultraviolet (UV) radiation exposure, toxic fume inhalation, electric shocks, and physical injuries, were identified and addressed through structured analysis.

The findings demonstrate that proper use of personal protective equipment (PPE), effective ventilation systems, regular equipment maintenance, and safety training significantly reduce the likelihood of accidents and long-term health complications. These measures not only ensure worker safety but also contribute to improved productivity and operational efficiency.

The study emphasizes the importance of fostering a safety-oriented culture within the organization. Compliance with safety protocols and proactive risk management must be prioritized at all organizational levels to sustain a safe and productive work environment.

In conclusion, adopting JSA as a systematic approach to hazard management enhances workplace safety and aligns with best practices in industrial operations. Future research could focus on evaluating the long-term benefits of these interventions and exploring their applicability in other high-risk sectors.

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Implementation of Critical Chain Project Management Method on Controlling the Pipeline Project

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***Abstract*— In the implementation of construction projects, the incompatibility between the plan and the actual schedule that causes additional time and cost is often occurring. The Pipeline Project started in July 2022 and is scheduled for completion in November 2022. However, in actuality, the project finished in July 2023. Based on this case, an acceleration method needs to be implemented so that the project can be completed quickly and efficiently. One of the methods applied is Critical Chain Project Management (CCPM). Scheduling is carried out using the actual duration of the project that is applied with CCPM. The actual duration of the project is 318 days. Furthermore, by using the CCPM, the duration has become 216 days. So, by using the CCPM, the project is completed 32.08% faster than the actual duration of the project. Based on the results of the analysis, applying the CCPM method can make an optimal duration of the project.**

***Keywords*; Critical Chain Project Management, Duration, Scheduling**

I. INTRODUCTION

In a project, the incompatibility between the plan and the actual schedule causes additional time and cost are often occurring (Ramadhan, A. R., 2021). Planning and scheduling in the execution of a project is an important part of determining the overall success of the project (Subakir, & Sugiyanto, 2022). As a project in general, some obstacles result in delays in the completion of this project. The lateness that occurred was caused by several factors such as the lateness of the material incoming, the bridge project by another contractor, some trees that affected the pipeline, the weather, and the lack of manpower and tools.

A common problem in the current construction segment is that there are frequent changes in the implementation phase that cause the completion of the
construction process to retreat from the initial schedule (Kim, S. H, 2012). As a result, the project is not running smoothly, resulting in an additional cost that exceeds the planned, causing the project process to be delayed even to the point of crashing. Good project control is an important thing to do to avoid additional work and costs incurred by the project (Suherman, 2016).

The pipeline project started in July 2022 and is scheduled for completion in November 2022. However, in actuality, the project finished in July 2023 with a total duration is 318 days. Based on this case, this research will be carried out to control the pipeline project using Critical Chain Project Management (CCPM).

Critical Chain is a project planning and processing model that focuses on the need for resources to implement a project because the Critical Chain differs in position from the Critical Path and PERT methods that emphasize working orders and strict planning settings (Arvianto et al., 2015). The use of CCPM methods in project execution scheduling can optimize the schedules that have already been created due to the possibility of multitasking, Parkinson's law, student's syndrome, and then safety time being removed subsequently into the form of a buffer (Wardana, R. A., 2020).

In this method, the safety time that is normally placed on each activity will be removed and replaced with the buffer time placed at the end of the critical chain as a backup time on the entire project. If

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uncertainty occurs during the project execution, it can be anticipated with the existence of buffer time to avoid delays (Nasution, 2014).

II. RESEARCH METHODOLOGY

The phase in this research began by making the Work Breakdown Structure of the project. After that, scheduling the actual duration to get the actual Schedule. Then, scheduling the project using the CCPM method to get the duration and the critical path of the project.

2.1 Work Breakdown Structure

The first step is to make a WBS. Work Breakdown Structure (WBS) is a grouping of work elements shown in graphic form to organize and divide the overall scope of a project (Rev, 2003). The functions of the WBS are to group the work and work details of a project to facilitate the process of making a schedule (Efendi, 2020). The WBS is a basic document in project management because it provides a basis for planning and setting project schedules, costs, and changes (Schwalbe, K., 2004).

2.2 Critical Chain Project Management (CCPM)

Critical Chain Project Management (CCPM) is a project planning and control method developed from a methodology called the Theory of Constraints (TOC) that is applied to projects to improve future project performance (Goldratt, E. M., 1997). In a variety of projects, Critical Chain Project Management is defined as the longest chain of interrelated events, where the interrelationship lies in the work or resources that interrelate (Sugiyanto, 2021).

A construction project needs to be scheduled in advance to allocate time, costs, and resources according to the company's budget (Larasati, D. A., & Sutopo, W., 2020). In each work, several obstacles result in low project planning performance. One of the main causes is the amount of safety time added to the project scheduling (Azis et al., 2017). This is due to consideration in preventing the risk of delayed completion in the time estimates of each work. The problem of changing the safety time because of too much, then with the CCPM method updated by replacing it with a buffer time that functions to avoid the uncertainty that will arise and cause a delay in the completion of the project (Azis et al., 2017). The CCPM method is also used to avoid human behavioral problems such as student's syndrome, Parkinson's law, multitasking, and overestimated activity durations (Santosa, 2009).

The CCPM is also suggested by the "Project Management Body of Knowledge" (PMBOK) as a breakthrough in a revolutionary way of thinking that can be used to determine how to accelerate project completion, improve scheduling capabilities, and reduce the budget that already set (Ramanda & Arvianto, 2015).

2.3 Decreasing the Work Duration

The first step in applying the CCPM method is to reduce the duration of each work by 50% of the actual duration or use cut and paste method (C&PM). This reduction aims to eliminate the safety time so that problems such as student's syndrome, Parkinson's law, multitasking, and over-estimated activity durations can be eliminated (Santosa, B., 2009).

2.4 Adding the Buffer Time

Buffer time management is the basis for managing activities in the critical chain of project scheduling. Buffer time management can provide insights into considerations about resource constraints and focus on the causes of uncertainty in project management. Scheduling without consideration of resource limitations should be done in a project because the time to start each activity is influenced by the availability of resources (Soeharto, 1999).

Reducing the duration of activity on this method leads to an increasing risk of delay. Therefore, it requires a buffer or retention time to be applied so that the activity is not late. In Critical Chain Project Management (CCPM) methods, the addition of buffer time is useful for protecting the critical chain in project scheduling (Siswanto, A. B., & Salim, M. A., 2015).

To obtain accurate buffer calculation, use the root square error method (RSEM). This method is the same as calculating two standard deviations by inserting durations of CPM (S) and CCPM (A) that are greater than 50% of the safe estimate. The buffer size is obtained by

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solving the equation (1) (Newbold, R. C., 1998).

$$2\sigma = 2 \times \sqrt{\left(\frac{S1-A1}{2}\right)^2 + \left(\frac{S2-A2}{2}\right)^2 + \cdots + \left(\frac{S_n - A_n}{2}\right)^2} \quad (1)$$

Description:
2σ = Buffer Time size
S = CPM Duration
A = CCPM Duration

2.5 Calculating the Feeding Buffer

The feeding buffer is useful to keep activity performance from project scheduling uncertainty that can change to activities in the non-critical path and does not affect the interrelated critical path. Furthermore, the feeding buffer also serves as a backup time that will protect and maintain the performance of critical path activity from changes due to scheduled uncertainties and if there is a delay in the nonspecific path activity. Feeding buffers are placed at the intersection between non-critical and critical chains (Malau, 2019).

2.6 Calculating the Project Buffer

After calculating the feeding buffer, the next phase is to calculate the project buffer. This buffer is added at the end of the project to protect the end time of its completion. Project buffers are placed in the end phase of a project after work on the last critical chain (Malau, A. Z., 2019).

III. RESULT AND DISCUSSION

3.1 *Define*

The pipeline project started in July 2022 and is scheduled for completion in November 2022. However, in actuality, the project finished in July 2023 with a total duration is 318 days. Based on this case, this research will be carried out to control the pipeline project using Critical Chain Project Management (CCPM).

3.2 *Work Breakdown Structure*

WBS on this Pipeline Project is divided into nine scopes including Preparation Work, Soil Work, Thrust Block Work, Box Service Connection Work, Road Crossing Protection Work, Support Work, Piping Work, Horizontal Directional Drilling Work, and Commissioning which can be seen in Figure 1.

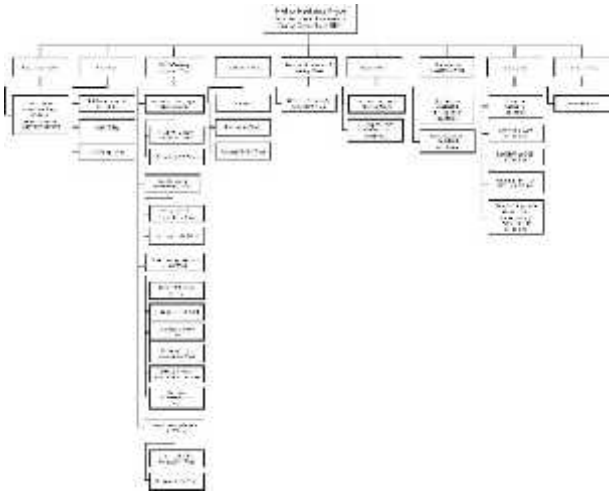

Figure 1. Work Breakdown Structure

3.3 *Scheduling the Actual Duration*

The actual duration schedule starts from July 2022 to July 2023, it's for about ±12 months or 318 days. All works must be scheduled according to the sequence of works. The current duration scheduling using Microsoft Project can be seen in Figure 2.

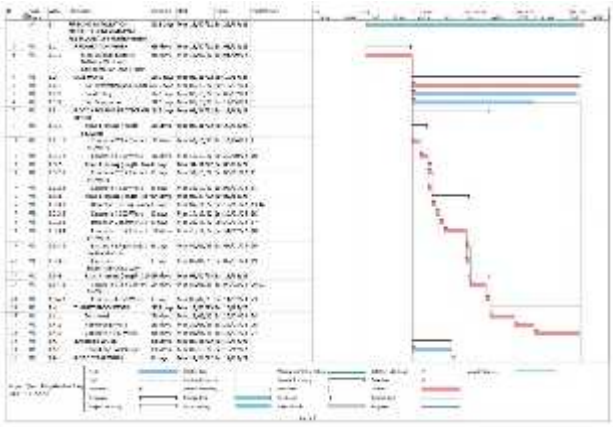

Figure 2. Actual Duration Scheduling

3.4 *CCPM Scheduling*

In CCPM scheduling, several stages need to be analysed including reducing the duration of the activity, calculating the feeding buffer and project buffer, and making network planning.

3.5 *Decrease the Work Duration*

The duration reduction is done on each work by 50% of the actual duration or using the cut and paste method (C&PM) that can be seen in Table 1.

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Table 1 Data of Decreasing the Work Duration

Activity	Duration (CPM)	Duration (CCPM)
Preparation Work		
Mob, Demob, Material Delivery, Workers' Compensation, and Project Management	66	33
Soil Work		
Soil Excavation and Backfilling	246	123
Sand Filling	240	120
Soil Compaction	180	90
Road Crossing Protection Work		
Road Crossing (length: 54,42 m)		
Concrete CTB + Cement 6% Work	12	6
Concrete K-350 Work	12	6
Road Crossing (length: 8 m)		
Concrete CTB + Cement 6% Work	6	3
Concrete K-350 Work	6	3
Road Crossing (length: 18 m)		
Demolish Existing Paving	6	3
Concrete K-350 Work	6	3
Demolish Concrete CTB	6	3
Concrete CTB + Cement 6% Work	30	15
Existing Paving + Sand 5 cm Installation	6	3
Kansteen Slipform/Precast Work	6	3
Road Crossing (length: 110 m)		
Concrete CTB + Cement 6% Work	24	12
Concrete K-350 Work	6	3
Thrust Block Work		
Formwork	36	18
Reinforcing Work	30	15
Concrete K-350 Work	66	33
Permit and Social Cost		
Permit and Social Cost	60	30
Road Stake Work		
Road Stake Work	6	3
Horizontal Directional Drilling Work		
HDD HDPE Pipe PN 12,5, Ø600 Work	72	36
Support Work		
Thick Plate 12 mm + Welding Work	6	3
U-Clamp Dia. 30 + Bolt per 5 m Installation	12	6
Box Service Connection Work		
Box Service Connection 1500x17000x2650 Installation	12	6
Cover Iron Cast 2000x1500 Installation	6	3
Piping Work		
Fitting and Accessories Installation	84	42
Gate Valve Ø24" Installation	162	81
Flexible Joint Ø24" Installation	162	81
HDPE Pipe PN 12,5, SDR 13,6, PE 100, Ø600 Installation	246	123
Black Steel Pipe Ø600 IDE SCH 20 + Cement Lining AWWA C205 Installation	246	123
Commissioning		
Hydrostatic Test	6	3

The critical path of CCPM activities on the Pipeline Project is A-B-AF, A-E-F-G-H-I-J-K-L-M-N-O-P-Q-R-S-AF with a total duration of 159 days.

3.6 *The Calculation of the Feeding Buffer*

Buffers are added to project time whose duration of activity is shortened to generate a safer schedule. To obtain accurate buffer calculation, use the root square error method (RSEM) which can be seen in the following example of buffer time calculation. This is the example of buffer time calculation on Sand Filling work:

$$2\sigma = 2 \times \sqrt{\left(\frac{S1 - A1}{2}\right)^2 + \left(\frac{S2 - A2}{2}\right)^2 + \cdots + \left(\frac{Sn - An}{2}\right)^2}$$

$$2\sigma = 2 \times \sqrt{\left(\frac{240 - 120}{2}\right)^2}$$

$$2\sigma = 2 \times 60$$

$$2\sigma = 120 \text{ hari}$$

Based on the calculation above, the total buffer time on the Sand Filling work is 120 days.

The following table 2, table 3, and table 4 are the results of the feeding buffer calculations.

Table 2 Feeding Buffer on Non-Critical Path C

Kode	Activity	Duration (CPM)	Duration (CCPM)	$((S-A)/2)^2$
	Soil Work			
C	Sand Filling	240	120	3600
	Total			**3600**
	***Feeding Buffer* (hair)**			**120**

Table 3 Feeding Buffer on Non-Critical Path D

Kode	Activity	Duration (CPM)	Duration (CCPM)	$((S-A)/2)^2$
	Soil Work			
D	Soil Compaction	180	90	2025
	Total			**2025**
	***Buffer Time* (hair)**			**90**

Table 4 Feeding Buffer on Non-Critical Path T-U-V-W-X-Y-Z

Kode	Activity	Duration (CPM)	Duration (CCPM)	$((S-A)/2)^2$
	Permit and Social Cost			
T	Permit and Social Cost	60	30	225
	Road Stake Work			
U	Road Stake Work	6	3	2,25
	Horizontal Directional Drilling Work			
V	HDD HDPE Pipe PN 12,5, Ø600 Work	72	36	324
	Support Work			
W	Thick Plate 12 mm + Welding Work	6	3	2,25
X	U-Clamp Dia. 30 + Bolt per 5 m Installation	12	6	9
	Box Service Connection Work			
Y	Box Service Connection 1500x17000x2650 Installation	12	6	9
Z	Cover Iron Cast 2000x1500 Installation	6	3	2,25
	Total			**573,75**
	***Buffer Time* (hair)**			**47,91**

3.7 *The Calculation of Project Buffer*

After calculating the feeding buffer, the next phase is to calculate the project buffer which can be seen in Table 5.

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Table 5 Project Buffer on Critical Path A-E-F-G-H-I-J-K-L-M-N-O-P-Q-R-S-AF

Kode	Activity	Duration (CPM)	Duration (CCPM)	$((S-A)/2)^2$
Preparation Work				
A	Mob, Demob, Material Delivery, Workers' Compensation, and Project Management	66	33	272,25
Road Crossing Protection Work				
	Road Crossing (length: 54,42 m)			
E	Concrete CTB + Cement 6% Work	12	3	9
F	Concrete K-350 Work	12	3	9
	Road Crossing (length: 8 m)			
G	Concrete CTB + Cement 6% Work	6	1,5	2,25
H	Concrete K-350 Work	6	1,5	2,25
	Road Crossing (length: 18 m)			
I	Demolish Existing Paving	6	1,5	2,25
J	Concrete K-350 Work	6	1,5	2,25
K	Demolish Concrete CTB	6	1,5	2,25
L	Concrete CTB + Cement 6% Work	30	7,5	56,25
M	Existing Paving + Sand 5 cm Installation	6	1,5	2,25
N	Kansteen Slipform/Precast Work	6	1,5	2,25
	Road Crossing (length: 110 m)			
O	Concrete CTB + Cement 6% Work	24	6	36
P	Concrete K-350 Work	6	1,5	2,25
Thrust Block Work				
Q	Formwork	36	18	81
R	Reinforcing Work	30	15	56,25
S	Concrete K-350 Work	66	33	272,25
Commissioning				
AF	Hydrostatic Test	6	3	2,25
	Total			**812,25**
	Buffer Time (hari)			**57**

From the calculations as shown in Table 5, the project buffer is 57 days which can be included in the schedule of the CCPM method (159 days) so that the total duration of the scheduling with the CCPM method is 216 days. The schedule of CCPM duration with the addition of buffer time can be seen in Figure 3.

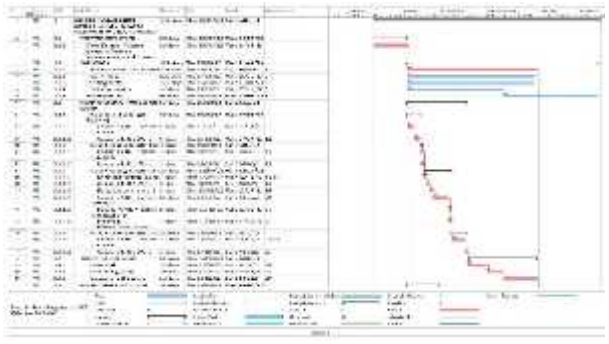

Figure 3. CCPM + Buffer Scheduling

From the advanced calculations, the reverse calculations, and the total float, the network diagram of CCPM is obtained with the addition of buffer time as in Figure 4.

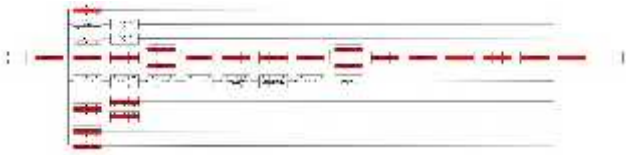

Figure 4. Network Diagram of CCPM + Buffer Time

Based on the results of the duration discussed earlier, it has been proven that scheduling using the Critical Chain Project Management (CCPM) method produces a shorter duration than the actual duration of the project. The following Table 6 represents a comparison of actual duration results with the duration of CCPM scheduling on the Pipeline Project.

Table 6 The Comparison between the Actual Duration and CCPM Result

Methods	Duration (day)
Actual Duration	318
CCPM	216

The calculation results from the actual duration are 318 days. Furthermore, using the CCPM, the duration is 216 days. So, by using the CCPM, the project is completed 32.08% faster than the actual duration.

IV. CONCLUSION

Based on the results of the analysis that has been carried out and discussed, the following conclusions are obtained:

1. Work Breakdown Structure on the Project Pipeline Installation from Sembayat Reservoir to Ground Water Tank JIIPE is divided into 9 scopes, at each scope has its respective stages of work. These nine scopes are Preparation Work, Soil Work, Road Crossing Protection Work, Thrust Block Work, Horizontal Directional Drilling Work, Support Work, Box Service Connection Work, Piping Work, and Commissioning.
2. The comparison of duration between the actual duration and the duration of CCPM

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is that the actual duration of the project is 318 days. While the CCPM method obtains a duration that is 216 days. So, with the CCPM method, the project is completed 32.08% faster than the actual duration. Based on the results of the analysis, applying the CCPM method can make an optimal duration of the project.

IV. ACKNOWLEDGMENT

The author would like to thank all those who have contributed and helped make this paper. Hopefully, this research can provide benefits and positives for many people.

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Clustering Capital and Business through the Implementation of Corporate Strategy in the Amanah Belimbing Wuluh SME Group

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Abstract **- Small and Medium Enterprises (SMEs) became a trend when the Indonesian economy experienced a downturn. SMEs of Amanah Belimbing Wuluh is a micro sector that is only able to produce products and is able to sell its production to cover the needs of the economic cycle. The aim of this research is to measure the feasibility of capital using the Net Present Value (NPV) concept. Measuring capital feasibility with the Average Rate of Return (ARR) concept. Looking for clustering of company strategies in business development through capital budgeting. The research sample was 30 SMEs. Data analysis using K-Means Cluster. The research results based on the feasibility of SME capital using the Net Present Value (NPV) concept produce a positive value (NPV) of IDR. 344,869,146 so it can be said to be feasible. The feasibility of SME capital with the Average Rate of Return (ARR) concept is 44.12% annually above a discount factor of 16% so it can be said to be feasible for the turnover of SMEs business capital Amanah Belimbing Wuluh Dukuh Menanggal. Cluster analysis divides two groups of company strategies. Cluster 1 contains investment strategies that have the attributes; final investment, total investment and average investment. Cluster 2 contains a capital turnover strategy that has the Average Rate of Return attribute.**

Keywords: **SMEs Clustering, NPV, ARR, Company Strategy**

I. INTRODUCTION

Small and Medium Enterprises (SMEs) became a trend when the Indonesian economy was experiencing a downturn. The micro sector that can only produce products and be able to sell their production to cover the needs of economic turnover. The business strategy applied by SMEs is very different, a simple concept, simple equipment with capital in the middle category, resulting in a lower risk of bankruptcy experienced by SMEs [1]. Regarding business strategy, SMEs are sometimes still at a less qualified level. The lack of innovation also has an impact on the weakness in facing competition. There is a need for knowledge that encourages SMEs to be more aggressive in facing future challenges, of course, more in-depth about financial reporting, financing strategies and even financial engineering. Back to macro and micro economic rules, SMEs must always be able to professionally recognize good financial management, especially also the lack of knowledge in making financial statements, SAK ETAP is sometimes not also applied to micro businesses. [2]

In reality, the strategies implemented by SMEs are more relevant in the face of prolonged Covid-19, the business world is on the verge of collapse. A report from the Organization for Economic Co-operation and Development (OECD), that the pandemic is indeed devastating the economy in the real sector, but this impact is also reflected in the decline or sluggishness of market demand. The cessation of bargaining circulation in the market results in a decrease in the production sector, a decrease in people's purchasing power, and a decrease in supply [3]. More broadly, the effect on the SME sector is that

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product distribution is hampered on the way, because big cities have also not fully recovered to accept non-consumptive products, products in the form of handicrafts, kraft and clothing products have somewhat stopped to rotate. People in the covid-19 pandemic era are still concentrating on food recovery and treatment, this is what encourages SMEs to experience very significant development problems [4].

Amanah Belimbing Wuluh Small and Medium Enterprises located in Dukuh Menanggal Village, has around 30 SME members in 2024. SMEs can be defined as businesses that have limited capital with a limited number of employees under 50 people, capital turnover is also limited, SMEs are independent businesses that are certainly not part of a large business or company. The capital of Small and Medium Enterprises is not more than 300 million in a year, so the orientation of SMEs is the fulfillment of a small scale economy [5].Micro Enterprises will turn into medium-sized businesses if in the course of their business they reach a turnover of 500 million to 10 billion, of course, when experiencing changes in financial structure, SMEs must always get guidance from the local Dinas [6].

The importance of handling SMEs for the academic community is part of environmental awareness. The assistance provided by Industrial Engineering lecturers has been relatively long. The assistance has been carried out in the form of making product catalogs for SMEs in Dukuh Menanggal since 2018, the business evaluation can achieve a PI of 4.072 in 2019 [7]. This is the background of this research so that it continues to be a sustainable activity. Then the concept of clustering capital and business to find out the mapping. Choosing how to cluster with cluster analysis techniques is an effort to find information on the capital owned by SMEs, of course, it will be grouped from heterogeneous or inequality in the ability to return capital (Capital Budgeting) into equal or homogeneous groups, of course, after becoming new clusters will be identified capital capabilities and types of businesses owned by SMEs [8].

Problems arising in SMEs Amanah Belimbing Wuluh, determination of capital, and it is very necessary to make clustering, even clustering SMEs become a source of data to see the development, professionalism is also required here [9]. Of course not limited to its financial performance, but also the performance of the ability to return on capital, many companies, medium industries and even cooperatives use the analysis of return on capital in the form of NPV [10]. The urgency of the research is focused on efforts to organize the capital and type of business. Previous research only covered marketing issues, the focal point was not broad in efforts to develop its corporate strategy [1]. This research will have an impact on sorting or clustering groups of small and medium enterprises (SMEs), efforts to separate from the ability to return capital Net Present Value (NPV) and efforts to cluster the profit Average Rate or Return (ARR). According to [11], the average return on capital associated with the cash flow of SME investment during the investment period will provide information that the SME is in a stable condition, in relation to the discount factor that is determined. The discount provides information to potential investors, that the lowest limit of return turnover by SMEs, after financial engineering, will be obtained that SMEs have a percentage return above the discount factor.

Many research interests have not been achieved, the role of SMEs is indeed classified as much in the marketing sector, especially in SMEs engaged in food processing [12]. The selection of clustering involving capital budgeting analysis methods, of course, illustrates that a number of businesses owned by Kelurahan Dukuh Menanggal, through the Amanah SME group, are able to make infographics, that the clustering of SME capital is divided into certain parts, with the assumption that in the first cluster with large capital, the next cluster will definitely be lower in value.

The objectives to be achieved from this research include; (1) Capital feasibility with the concept of Net Present Value (NPV). (2) Capital feasibility with the concept of Average Rate of Return (ARR). (3) Clustering corporate strategies in business development through capital budgeting. The results of this research greatly contribute to the progress of

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Small and Medium Enterprises in Dukuh Menanggal, Surabaya City.

II. MATERIALS AND METHODS

This research is quantitative, research that will conduct Cluster Analysis. Clustering analysis to group SMEs with capital and business rules. Capital clustering is more directed at Net Present Value (NPV), Average Rate of Return (ARR). The variable indicators of the NPV measurement are used as a corporate strategy to be developed, the clustering of these indicators will provide an overview of cluster 1 or cluster 2 that must be prioritized.

a. Capital Budgeting Variables

Net Present Value or often abbreviated as NPV is the difference between the present value of the incoming cash flow and the value of the outgoing cash flow at a certain period of time [10]. A positive NPV value (NPV> 0) is an illustration that the results of the analysis show a positive value, it can be described that the acquisition of profit can certainly exist, and vice versa if the NPV value is negative (NPV < 0) indicates the ability of SMEs to create profits is very difficult, even the process of returning capital is very unlikely, this is calculated after considering the Time Value of Money.

Average Rate of Return (ARR) is an assumption about the company's ability to return the average investment. Of course, this relates to the value of the company's profitability recorded in the financial statements each year. ARR is always associated with discounting or also called a discount factor, meaning that the ARR should not be lower than the promised discount value, of course it will change the stigma of investors if the value is below that. The simple rule is to divide the average profit by the investment time or number of years. ARR must be very easy to understand, especially investors will always ask what percentage of ARR the company records [13].

The variable indicators set as the focal point of this study, based on research [14] that the indicators can include: Initial investment (X1), Profit (X2), Final Investment (X3), Total Investment (X4), Average investment (X5), Cashflow (X6) and Average rate of Return (X7).

b. Research Sample and Data Collection Technique

The sample was selected based on certain objectives, namely, SMEs that have received capital from related agencies. So that the sample of this study amounted to 30 SMEs. The sampling technique, used Purposive Sampling, with certain criteria or objectives, so that the sample is very representative to be the object of research. Certain criteria are based on SME members who from 2019 to 2023 are active in financial reporting.

Data collection techniques using documentation, which is taking the financial statement data members of SMEs Amanah Belimbing Wuluh Dukuh Menanggal for 5 years, starting from 2019 to 2023.

c. Data Analysis Technique

Cluster analysis is a grouping analysis, of course this analysis is chosen so that there is a unification of several components that are considered the same or homogeneous into different groups, so that the grubs or clusters can be identified [11]. K-Means Cluster Analysis is a Non-Hierarchical Cluster analysis with SPSS, so the next step is to interpret the results. Let's learn together the tutorial on interpretation of non-hierarchical cluster analysis with SPSS. The main results that will be read from the analysis output are; Iteration History, Final Cluster Centers, Anova.

III. RESULTS AND DISCUSSIONS

Results

The results of this study will be sorted from the beginning of the data that will be the source of processing. Data such as assets owned by all members of the SME group, liabilities and profits, to the stages of analyzing the research data.

a. Research Data

This research data contains data relating to the source of SME wealth, cooperative operating expenses and cooperative profits obtained from financial statement data during 2019-2023. Associated with the calculation of Net Present Value (NPV), associated with cooperative financial statements, then divided into two parts cash inflow and cash outflow.

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Based on the financial statements recorded in the balance sheet of Amanah Belimbing Wuluh SMEs Dukuh Menanggal in 2019-2023, in relation to current assets and the number of borrowers can be tabulated as follows:

Table 1. SME Assets for the 2019-2023 Period

Year Period	Number of Members SMES	Current Asset (Rp.)	Current Liabilites (Rp.)	Final Receivables (Rp.)
2019 (1th Year)	21	89.925.600	20.706.900	78.684.850
2020 (2nd Year)	18	91.629.700	22.561.950	104.740.000
2021 (3th Year)	18	100.265.800	55.824.750	104.740.000
2022 (4th Year)	24	176.402.700	93.275.300	167.310.000
2023 (5th Year)	30	292.055.500	145.998.650	246.325.000
Total	111	750.279.300	338.367.550	701.799.850

Source: SME Financial Report for Financial Year 2023

Based on these data for five years in the sampling research data, that the total members of productive SMEs based on financial reporting in the association group as many as 111 borrowers and the total current assets of the cooperative as an NPV analysis material as a Future Value group, the total current assets for 5 years amounted to Rp. 750,279,300. Based on the above data also for five years in the research data that became sampling, that the total current liabilities as much as Rp. 338,367,550 and the total final receivables of SMEs as NPV analysis material as group C0 (Initial Investment) which became the burden of Amanah Belimbing Wuluh SMEs for 5 years amounted to Rp. 701,799,850.

b. Data Analysis

Analysis of this research data contains analysis related to this research question. In relation to the answer to the research that leads to the analysis of the feasibility of granting credit in determining loans in SMEs Amanah Belimbing Wuluh Dukuh Menanggal, the form of analysis there are 3 parts as follows:

1) Analysis of Net Present Value (NPV)

Net Present Value is measuring the financing spent so far as an investment with cash inflows from income per period, associated with cash inflows now. Mem-present value-kan (assess the present cash flow) is done by discounting the net cash inflow to be received with a discount rate (discount factor) for SMEs Amanah Belimbing Wuluh Dukuh Menanggal set at 16%.

a) Analyzing Initial Financing (Co)

Initial financing in the NPV analysis process is the costs charged to the company each year plus the prediction of the final cost of the specified time. This initial investment is the burden of SMEs receivables on the cooperative, which will be used as a source of funding for lending to customers / members. Analysis of initial financing in SMEs Amanah Belimbing Wuluh Dukuh Menanggal, can be obtained from the final accounts receivable data for five years, as follows:

Table 2. Set Initial Financing (Co)

Years	**Periode Analyst**	**Final Receivable**
2019	(1th Year)	Rp. 78.684.850
2020	(2nd Year)	Rp. 104.740.000
2021	(3th Year)	Rp. 104.740.000
2022	(4th Year)	Rp. 167.310.000
2023	(5th Year)	Rp. 246.325.000
Initial Financing/Initial Investment (Co)		Rp. 701.799.850
Year-end Economic Financing (Ct)		Rp. 246.325.000

Source: Data processed

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Based on the processed data that the initial investment (Co) which will be used for NPV analysis, from UKM Amanah Belimbing Wuluh Dukuh Menanggal obtained a value of Rp. 701,799,850 while the economic value or economic financing at the end of the observation year or the fifth year is Rp. 246,325,000.

b) Analyzing Net Cashflow (C)

Net Cashflow or net cash flow is the difference between the total money in (cash inflow) and money out (cash outflow) from the business in a certain period. Net Cashflow (C) for companies in the SME class can be taken from all incoming income minus financing / expenses. Then also deduct the tax burden that must be borne by the cooperative. The tax burden is set at 10%. The results of the calculation of Net Cashflow (C) each year can be shown as follows:

Table 3. *Net Cashflow* (C) UKM

Description	*Cash Inflow*	*Cash Outflow*	Saldo
Current Assets	Rp. 750.279.300		Rp. 750.279.300
Current Liabilities		Rp. 338.367.550	
Profit Per Year		Rp. 96.528.900	Rp. 434.896.450
Operating Profit/Gross			Rp. 315.382.850
Tax Set at 10%			Rp. 31.538.285
Profit After Tax			**Rp. 283.844.565**

Source: Data processed

Based on the analysis above, the Net Cashflow value is profit after tax, so the Net Cashflow (C) value is Rp. 283,844,565.

c) Calculating Net Present Value (NPV)

Based on the previous data processing that with a discount factor of 16%. The results of the analysis of the initial investment calculation (Co) obtained a value of Rp. 701,799,850 while the Net Cashflow (C) value throughout the year for 5 years is Rp. 283,844,565, then the economic value or economic financing at the end of the fifth year is Rp. 246,325,000, so the NPV formula can already be used to calculate the value of creditworthiness.

Before all initial investment financing, net income and year-end economic value are included in the NPV formula, it is necessary to analyze the value of income every year by considering the discount factor, the results can be described in the table below:

Table 4. Setting the *Discount Factor* Value Every Year

Years	Periode Analyst	Net Cashflow/C
2019 $C/(1+0{,}16)^1$	Rp. 283.844.565/1,16	Rp. 244.693.591
2020 $C/(1+0{,}16)^2$	Rp. 283.844.565/1,35	Rp. 210.942.750
2021 $C/(1+0{,}16)^3$	Rp. 283.844.565/1,56	Rp. 181.847.199
2022 $C/(1+0{,}16)^4$	Rp. 283.844.565/1,81	Rp. 156.764.826
2023 $C/(1+0{,}16)^5$	Rp. 283.844.565/2,10	Rp. 135.142.092
Total Nilai C 1-5 tahun		Rp. 929.390.458

Source: Data processed

Retrieved
Co = Rp. 701.799.850
Ct = Rp. 283.844.565
C = Rp. 246.325.000
r = 0,16 (16%)

Based on the NPV Analysis formula, the calculation results are:

$$N = -C + \frac{C_t}{(1+r)^t}$$

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$$N = -C + \frac{C_1}{(1+r)^1} + \frac{C_2}{(1+r)^2} + \frac{C_3}{(1+r)^3} \frac{C_4}{(1+r)^4} + \frac{C_5}{(1+r)^5} + \frac{C_t}{(1+r)^t}$$

NPV = - Rp. 701.799.850 + $\frac{R\ .2\ \ .8\ \ .5}{(1+0,1\ )^t}$ + $\frac{R\ .2\ \ .3\ \ .0}{(1+0,1\ )^5}$

NPV = - Rp. 701.799.850 + Rp. 929.390.458 + Rp.117.278.539

NPV = - Rp. 701.799.850 + Rp. 1.046.668.996

NPV = Rp. 344.869.146

The calculation results show that the value of Net Present Value (NPV) is positive, namely Rp. 344,869,146 so that it can be said to be feasible for investment in business capital SMEs Amanah Belimbing Wuluh Dukuh Menanggal.

The decision of the Net Present Value (NPV) analysis to provide the feasibility of determining the business capital owned by SMEs Amanah Belimbing Wuluh Dukuh Menanggal can be said to be accepted because the positive NPV value is above 0 or the NPV value> 0 (Positive) then the feasibility analysis is accepted.

1) Average Rate of Return (ARR)

Average Rate of Return (AAR) is the average amount of cash flow received in one year during the investment period. The way to calculate AAR is to combine all the estimated cash flows from the investment and divide them by the estimated total investment year. In this cooperative ARR considers the discount factor of 16%.

Table 5. Establish a Final Investment Value Each Year

No.	Year	Initial Invest (Co) (a)	Profit (b)	Finals Invest (c = a-b)
1	2019 (0)	701.799.850		
2	2019 (1th Year)	701.799.850	37.662.800	664.137.050
3	2020 (2nd Year)	664.137.050	11.859.800	652.277.250
4	2021 (3th Year)	652.277.250	10.358.800	641.918.450
5	2022 (4th Year)	641.918.450	21.167.600	620.750.850
6	2023 (5th Year)	620.750.850	36.186.800	584.564.050

No.	Total Invest (d=a+c)	Average Invest (CI)	Cashflow (ANP)	ARR
1				
2	1.365.936.900	682.968.450	283.844.565	41,56 %
3	1.316.414.300	658.207.150	283.844.565	43,12 %
4	1.294.195.700	647.097.850	283.844.565	43,86 %
5	1.262.669.300	631.334.650	283.844.565	44,96 %
6	1.205.314.900	602.657.450	283.844.565	47,10 %
	∑ARR			220,61 %
	Average ARR			44,12 %

Source: Data processed

Based on the table above, calculating the ARR for each year can be formulated as follows:

$$A = \frac{A}{C} x\ 100\%$$

$$A\ (2019) = \frac{R\ .283.844.565}{R\ .682.968.450} x\ 100\%$$

$$A\ (2019) = 0{,}4156 x\ 100\%$$

$$A\ (2019) = 41{,}56\%$$

So that the Average Rate of Return (ARR) value in 2019 is 41.56%. ARR in 2020 amounted to 43.12% then ARR in 2021 amounted to 43.86% then ARR in 2022 amounted to 44.96% and ARR in 2023

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amounted to 47.10%. The total value of the Average Rate of Return (ARR) for 5 years is 220.61% so that the average ARR per year is 44.12% above the discount factor of 16%.

Analysis of Average Rate of Return (ARR) decision to provide a feasible value of lending in the determination of loans to SMEs Amanah Belimbing Wuluh Dukuh Menanggal can be said to be accepted because the ARR value of 44.12% above the discount factor of 16%. This means that the provision of credit that has been done by SMEs Amanah Belimbing Wuluh Dukuh Menanggal can be said to be feasible.

2) K-Means Cluster Analysis

Non Hierarchical Cluster Analysis with SPSS, part of the attributes of capital budgeting, whose elements we will do Kluster K-Means analysis. From this attribute or also called a variable, it will be seen into the cluster group. In SPSS, it is divided into case labels and variables, the details of the attributes to be clustered are as follows:

a) Case label: Year of Observation (2019-2023)

b) Variable : - Initial Investment/Co (X1)
- Profit/P (X2)
- Final Investment/Ca (X3)
- Total Investment/I (X4)
- Average Investment/CI (X5)
- Cashflow/ANP (X6)
- Average Rate of Return/ARR (X7)

a) Final Cluster Results

Interation results are used to detect how many times the iteration process is carried out in the clustering process of the 6 objects studied, it can be seen from the following output display:

Tabel 6. Iterasi History

Iteration	Iteration History[a] Change in Cluster Centers 1	2
1	5.770E7	3.904E7
2	.000	.000

a. Convergence achieved due to no or small change in cluster centers. The maximum absolute coordinate change for any center is ,000. The current iteration is 2. The minimum distance between initial centers is 212490623,113.

Table 7. Final cluster

Final Cluster Centers	Cluster 1	2
Initial Investment (Co)	672738050	631334650
Profit (P)	19960467	28677200
Final Investment (Ca)	652777583	602657450
Investment Amount (I)	1325515633	1233992100
Average Investment (Ci)	662757817	616996050
Cashflow (ANP)	283844565	283844565
ARR	42.85	46.03

It turns out that the clustering process is carried out through 2 iteration stages to get the right cluster. From the table above, it is stated that the minimum distance between cluster centers that occurs from the iteration results is Rp. 212,490,623, 113. The final results of the clustering process are described below:

1) Initial investment (X1) is in cluster 1 because the value is higher with an average value of IDR 67,273,805 for observations from 2019 to 2023.
2) Profit (X2) is in cluster 2 because the value is higher with an average value of Rp. 28,677,200 for observations from 2019 to 2023
3) Final investment (X3) is in cluster 1 because the value is higher with an average value of Rp. 652,777,583 for observations from 2019 to 2023
4) Total investment (X4) is in cluster 1 because the value is higher with an average value of Rp. 1,325,515,633 for observations from 2019 to 2023
5) Average investment (X5) is in cluster 1 because the value is higher with an average value of Rp. 662,757,565 for observations from 2019 to 2023
6) Cashflow (X6) is in cluster 2 because the value is higher with an average value of Rp. 283,844,755 for observations from 2019 to 2023
7) Average Rate of Return (X7) is in cluster 2 because the value is higher with an average value of 46.03% for observations from 2019 to 2023.

The Anova test will provide information that each clusterization has no difference, considering the significance value is above 5% (sig. > 0.05). Based on this decision, Table 8 will provide a description.

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Table 8. Anova Analyst

ANOVA						
	Cluster		Error			
	Mean Square	df	Mean Square	df	F	Sig.
Initial Investment (Co)	2.057E15	1	5.204E14	3	3.953	.141
Profit (P)	9.118E13	1	1.947E14	3	.468	.045
Final Investment (Ca)	3.014E15	1	3.007E14	3	10.026	.005
Investment Amount (I)	1.005E16	1	1.447E15	3	6.944	.008
Average Investment (Ci)	2.513E15	1	3.619E14	3	6.932	.007
Cashflow (ANP)	.000	1	11.667	3	.002	1.000
ARR	12.160	1	1.682	3	7.228	.006

The F tests should be used only for descriptive purposes because the clusters have been chosen to maximize the differences among cases in different clusters. The observed significance levels are not corrected for this and thus cannot be interpreted as tests of the hypothesis that the cluster means are equal.

1) Initial investment (X1) has an F value = 3.953 with a sig value. = 0.141 because the sig. > 0.05, the initial investment is excluded from cluster 1 because there is no significant difference.
2) Profit (X2) has an F value = 0.468 with a sig value. = 0.543 because the sig value. > 0.05 then profit is excluded from cluster 2 because there is no significant difference.
3) Final investment (X3) has an F value = 10.026 with a sig value. = 0.005 because the sig. <0.05, the final investment is included in cluster 1 because there is a significant difference.
4) Total Investment (X4) has an F value = 6.944 with a sig value. = 0.008 because the sig. <0.05, total investment is included in cluster 1 because there is a significant difference.
5) Average investment (X5) has an F value = 6.932 with a sig value. = 0.007 because the sig value. <0.05, the average investment is included in cluster 1 because there is a significant difference.
6) Cashflow (X6) has an F value = 0.000 with a sig value. = 1.000 because the sig value. > 0.05 then cashflow is excluded from cluster 2 because there is no significant difference.
7) Average Rate of Return (X7) has an F value = 7.288 with a sig value. = 0.006 because the sig. <0.05, Average Rate of Return is included in cluster 2 because there is a significant difference.

Discussions

The objectives to be achieved from this research include; (1) Clustering using capital with the concept of Net Present Value (NPV). (2) Clustering using capital with the concept of Average Rate of Return (ARR). (3) Clustering using the concept of business type and grouping. The research results provide the following conclusions:

1. The results of the NPV analysis is a study of the feasibility of SME capital Amanah Belimbing Wuluh. The concept of Net Present Value (NPV) generated (NPV) is positive, namely Rp. 344,869,146 so that it can be said to be feasible for business capital investment of UKM Amanah Belimbing Wuluh Dukuh Menanggal.
2. The results of the ARR analysis is also a study of the feasibility of SME capital with the concept of Average Rate of Return (ARR) is worth every year 44.12% above the discount factor of 16% so it can be said to be feasible for the turnover of SME capital Amanah Belimbing Wuluh Dukuh Menanggal.

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3. Clustering corporate strategy with capital budgeting. Cluster analysis divides two groups of strategies. Cluster 1 contains investment strategies that have attributes; final investment, total investment and average investment. Cluster 2 contains a capital turnover strategy that has the attribute Average Rate of Return. ARR becomes cluster 2, this is in line with research [15].

IV. CONCLUSION

Providing answers to the research questions through a brief review, namely the conclusion, will provide information on the proper study of this research. Conclusions from the results of the analysis and discussion can be described as follows:

1. Feasibility of SME capital with the concept of Net Present Value (NPV) resulting (NPV) is positive value of Rp. 344,869,146 so that it can be said to be feasible for business capital investment SME Amanah Belimbing Wuluh Dukuh Menanggal.
2. Feasibility of SME capital with the concept of Average Rate of Return (ARR) is worth every year 44.12% above the discount factor of 16% so that it can be said to be feasible for the turnover of SME capital Amanah Belimbing Wuluh Dukuh Menanggal.
3. Cluster analysis divides two groups of corporate strategies. Cluster 1 contains investment strategies that have attributes; final investment, total investment and average investment. Cluster 2 contains a capital turnover strategy that has the attribute Average Rate of Return.

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Customer Loyalty Analysis on Valuation of Price, Location, Facilities, and Service Standards with the Structural Equation Modeling Method - Partial Least Squares (SEM-PLS)

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Abstract **- The world of business and industry, including the culinary industry, is rapidly developing in this modern era. Business owners have to compete in an increasingly tight situation. Compared to previous studies, this study is newer because it uses more variables. This quantitative study used 60 samples. SmartPLS software version 3.0 is used to perform the analysis with SEM. Outer model, inner model, mediation, and hypothesis tests are carried out. The results of the validity test show that the data is valid. The filling factor value is more than 0.7 and the AVE value is more than 0.5. In contrast, reliability tests show the reliability values of composites and Cronbach's alpha, which are also greater than 0.7 and are considered reliable. From the hypothesis analysis carried out, it can be concluded that; The consumer choice variable has a significant positive impact on customer loyalty, the facility and infrastructure variable has a significant positive impact on consumer choice, the facility and infrastructure variable has a significant positive impact on customer loyalty, the business location variable has a significant positive impact on consumer choice, the business location variable harms customer loyalty, the price assessment variable has an impact negative on consumer choice, the price assessment variable has a significant positive impact on customer loyalty, the service standard variable has a significant negative impact on customer choice and customer loyalty. These results show the importance of paying attention to these variables in business strategy.**

Keywords**; Culinary Industry, SmartPLS, Loyalty, Consumer**

1. Introduction

In this era marked by progress, the economic and industrial sectors have developed rapidly. Businesses face increasingly fierce competition as a result of this. Many Indonesians love to travel and check out typical foods from different regions, making the food industry one of the promising fields[1], [2]. This phenomenon opens up many opportunities for entrepreneurs who can create high-quality culinary products with attractive tastes, compositions, and presentations [3].

Kalitengah Canditunggal Culinary Station or better known as SKCK. SKCK is a culinary tourism destination located in Canditunggal Village, Kalitengah District, Lamongan Regency, just east of the entrance to the village. In running a business, marketing is a very important aspect, because the success of a business can be judged from the effectiveness of its marketing strategy[4]. Marketing is an activity that aims to achieve the company's goals. This activity is carried out by anticipating the needs of customers or clients and directing the flow of goods and services that meet their needs[5].

In the increasingly sharp competition among companies today, customer loyalty is the top priority where the level of customer interests and expectations as well as the implementation or performance carried out by the company must be appropriate. Companies must pay attention to the things that customers consider important so that they feel satisfied[6]. Purchase decision is the process of choosing from various alternatives according to the needs of the consumer by choosing [4].

Kalitengah Canditunggal Culinary Station, also known as SKCK, you will find a variety of appetizing menu options. In

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addition to the variety of dishes offered, the price is also very affordable. As consumers, the first thing we usually pay attention to before making a purchase is the price. Price perception is a way for consumers to understand and assess the price information they receive related to a product or service. It includes consumer judgments about how much sacrifice they have made (in terms of money) compared to the benefits or value they have gained from the product or service[7]

In addition to cost, the location factor is also very important to consider when setting up a business, because a strategic location can attract more customers [8]. After considering the location, the quality of service is also an important factor to consider. Location relates to the area where a company must have an office to run its operations [8]. When a site is easily accessible, customers are more likely to make repeat purchases. This statement is supported by the availability of adequate facilities. Facilities can be described as physical and affordable resources, which are meant to offer convenience to customers during the shopping experience. In addition to facilities, service quality is another important aspect that must be considered when promoting products[9], [10]. Service quality is an effort to meet the needs and desires of consumers, as well as the accuracy of service delivery in balancing consumer expectations [11]. If the service provided is satisfactory, there is a high possibility that the consumer will make a purchase again [12].

According to evaluations from various published journals, there are three factors: price perception, quality of service, and location that significantly influence the purchase choice at TB Rajawali Demak, with findings showing that favorable location and excellent quality of service improve purchasing decisions[13]. Furthermore, the influence of location, facilities, and purchase decisions, found that these three variables have a positive impact on customer loyalty in the context of MSMEs [14]. There are two important variables: service quality and customer loyalty, indicating that quality improvement. Service contributes to customer loyalty [15]. This novel research aims to understand the influence of independent variables on dependent variables by using the SEM-PLS approach as an analysis tool [16]

Price perception refers to the consumer's view of the price offered by the seller, as well as its comparison with the price perceived by the buyer [13]. In this context, there are three indicators of price perception (PA) on price conformity with product quality, price conformity with the benefits provided, and the level of price competition in the market. Business location refers to the area where the operational activities of a business are carried out[8]. Location indicators (LB): Location affordability, smooth access to the location, proximity to the location, and a safe and spacious atmosphere [17]. Facilities and Infrastructure are defined as the provision of equipment that looks real to provide comfort to consumers in making purchases, Facility Indicators (FI) are: Special planning, Room Planning, Equipment, and furniture[18]

Service standards (SS) are a crucial concept in management that reflects consumer expectations before they make a purchase. The quality of service reflects the efforts made to effectively meet the [19][20] Consumer Choice is an election process that is carried out according to certain needs, where a person chooses the option that is considered the most appropriate and profitable. Some indicators that can be used to evaluate purchase choices (CC) include the product's suitability to consumer preferences, the level of satisfaction after purchase, and the condition of the item being sold[21] [22] [23].

Customer loyalty is not only reflected in the act of buying our products repeatedly, but also through the commitment and positive attitude shown towards the company [24]. Several indicators can be used as a benchmark in measuring customer loyalty (CL), including frequency of repeat purchases, habits in brand consumers, consistent interest in the brand, a belief that the products offered are of high quality, and the tendency to recommend products to other people.n[24] [25]

2. Methods

This study uses a quantitative approach by distributing questionnaires and using the Likert Scale [26]. The research

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sample is 60 respondents, to measure the relationship between assumed variables. The research variables are price assessment variables, business location, infrastructure, consumer choice service standards, and customer loyalty. There are 19 indicators measured. The method used to process data in this study is Partial Least Square (PLS). PLS is a Structural Equation Modeling (SEM) equation model with a variance-based approach or component-based structural equation modeling [27].

PLS is used to explain the existence or absence of relationships between latent variables (prediction). PLS is a powerful analysis method because it does not assume current data with a specific scale measurement, and the number of samples is small[28]

Outer Model or Measurement Model

To assess the outer model in the data analysis technique with SmartPLS, three criteria were used, namely Convergent Validity, Discriminant Validity, and Composite Reliability. The convergent validity of the measurement model with reflective indicators is assessed based on the correlation between the estimated score/component score items with SmartPLS Software. If it correlates more than 0.70 with the measured construct, then the individual reflexive measure is said to be high[26]. In the initial stage of the research, the measurement scale of loading values of 0.5 to 0.6 was considered quite adequate. Based on this, this study will use a loading factor limit of 0.50.[29]. The results of the validity test were carried out in several stages, for 60 questionnaires, namely by eliminating invalid indicators, the following results were obtained:

3. Results and Discussion

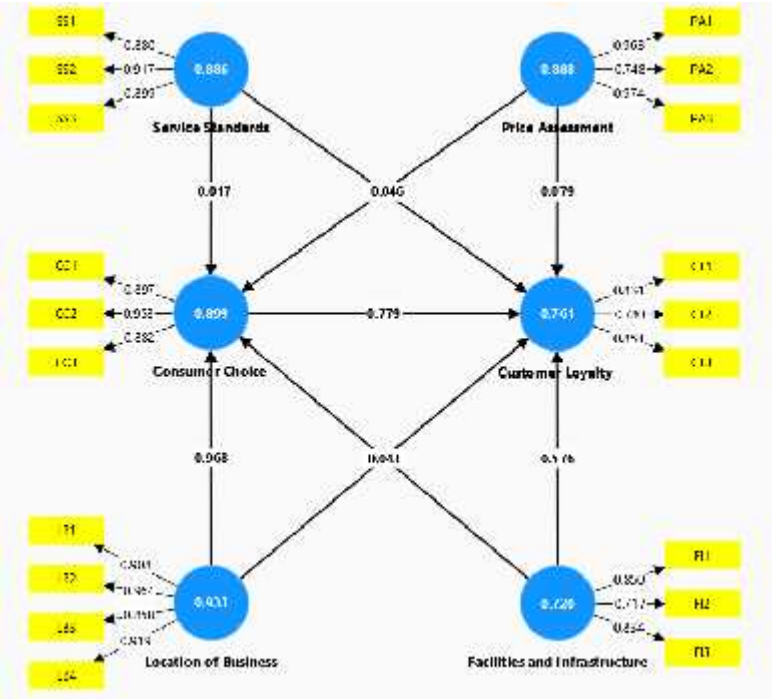

Figure 1. Final Stage Validity Test
Source: SmartPls Algorithm Results (2024)

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Table 1 Outer Loading, Composite Reliability, and Average Variance Extracted

Variable	Cronbach's alpha	Composite reliability (rho_a)	Composite reliability (rho_c)	Average variance extracted (AVE)
Consumer Choice	0.899	0.901	0.937	0.833
Customer Loyalty	0.761	0.766	0.863	0.677
Facilities and Infrastructure	0.720	0.724	0.844	0.645
Location of Business	0.933	0.936	0.953	0.834
Price Assessment	0.888	0.994	0.927	0.812
Service Standards	0.886	0.959	0.926	0.808

Source; Data processed in 2024

The results of the reliability test in Table 1 show that the variables of service quality, customer satisfaction, and consumer loyalty have a composite reliability number above 0.8 and have a Cronbach's alpha number of 0.7. Thus, it can be concluded that the remaining indicators in each variable have good reliability and can measure their construct.

Testing Inner Model or Structural Model

To obtain the relationship of constructs, significance values and R-squares of the research model can be done by testing the inner model or structural model. In evaluating the structural model, R-square was used for the dependent construct of the t-test and the significance of the structural path parameter coefficient. In PLS, the structural model uses R^2 to evaluate the dependent variable and for the independent variable uses the value of the path coefficient. Meanwhile, the significance value is seen based on the t-statistic value of each path.

Table 2. R Square

Variable	*R-square*	*R-square adjusted*
Consumer Choice	***0.979***	***0.978***
Customer Loyalty	***0.782***	***0.762***

Source: Data processed (2020)

From Table 2 above, the R Square (R^2) value of the Consumer Choice variable is 0.979 which indicates that 97.9% of service standards can explain the diversity of Consumer Choice. The remaining 2.1% was influenced by other variables that were not in the study. The Consumer Loyalty variable of 0.782 indicates that the diversity of consumer loyalty can be explained by the service standard variable and Consumer Choice of 78.2% and the remaining 21.8% is influenced by other variables that are not in the research model.

Goodness of fit

The Q-Square value is the basis for assessing goodness of fit. The model is better or fits the data if the higher the Q-Square or the same as the coefficient determination (R-Square) in the regression analysis. The results of the calculation of the Q-Square value are as follows:

Q-Square $= 1 – [(1 – R^2 1) \text{ x } (1 – R^2 2)]$
$= 1 – [(1 – 0{,}979) \text{ x } (1 – 0{,}782)]$
$= 1 – (0{,}0210 \text{ x } 0{,}2180)$
$= 1 – 0{,}004578$
$= 0{,}995422$

A value of 0.995 or 99.5% is the predictive relevance value of the structural model in this study. The use of Consumer Choice as an intervening variable in the prediction model can explain the influence of service standards on consumer loyalty by 99.5%. Thus the model has good predictability so that it can be used for hypothesis testing.

Hypothesis Test

The t-statistic value between the independent variable and the dependent variable in the Path Coefficient table in the Smart PLS output is the basis for the significance value of the prediction model in structural model testing as described in the following table:

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Table 3. Path Coefficient

Hypothesis	Original sample (O)	T statistics (|O/STDEV|)	P values
Consumer Choice -> Customer Loyalty	0.779	1.293	0.196
Facilities and Infrastructure -> Consumer Choice	0.043	0.948	0.343
Facilities and Infrastructure -> Customer Loyalty	0.576	2.808	0.005
Location of Business -> Consumer Choice	0.968	32.253	0.000
Location of Business -> Customer Loyalty	-0.433	0.762	0.446
Price Assessment -> Consumer Choice	-0.018	0.769	0.442
Price Assessment -> Customer Loyalty	0.079	1.455	0.146
Service Standards -> Consumer Choice	-0.017	0.838	0.402
Service Standards -> Customer Loyalty	-0.046	0.891	0.373

Source; Data processed in 2024

H_1 Hypothesis Testing; From table 4, it can be seen that the original sample estimate value is 0.779 with a significance below 5% which is shown by a t-statistical value of 1.293 greater than the t-statistical value of 1.67. A positive original sample estimate value indicates that consumer choice has a positive and significant effect on consumer loyalty or H_1 is accepted. H_2 Hypothesis Testing; The second test was carried out to see if the facilities and infrastructure had a positive effect on consumer choices. The test results can be seen in Table 4., the quality of service obtained an original sample estimate value of 0.043 with a statistical value of 0.948 >1.67 which means that facilities and infrastructure have a positive and significant effect on consumer choices with a significance level below 5%. Thus H_2 is accepted.

H_3 Hypothesis Testing; The third test was carried out to see if the facilities and facilities had a positive effect on customer loyalty. The test results can be seen in Table 4., the quality of service obtained an original sample estimate value of 0.576 with a statistical value of 2.808 >1.67 which means that facilities and facilities have a positive and significant effect on customer loyalty with a significant level below 5%. Thus H_2 is accepted. H_4 Hypothesis Testing; The fourth test was carried out to see if the location of the business had a positive effect on the choice of the community. The test results can be seen in Table 4., the quality of service obtained an original sample estimate value of 0.968 with a statistical value of 32,253 >1.67 which means that the location of the business has a positive and significant effect on consumer choices with a significance level below 5%. Thus H_4 is accepted.

H_5 Hypothesis Testing; The fifth test was carried out to see if the location of the business harmed customer loyalty. The test results can be seen from Table 4., the quality of service obtained an original sample estimate value of -0.433 with a statistical value of 0.762 >1.67 which means that the business location has a negative and significant effect on customer loyalty with a significance level below 5%. Thus H_5 is rejected. H_6 Hypothesis Testing; The sixth test was conducted to see if price appraisal harmed consumer satisfaction. The test results can be seen from table 4., the quality of service obtained an original sample estimate value of -0.018 with a statistical value of 0.769>1.67 which means that the price assessment has a positive and significant effect on consumer choices with a significance level below 5%. Thus H_6 is rejected.

H_7 Hypothesis Testing**;** The seventh test was carried out to see if price appraisal had a positive effect on consumer satisfaction. The test results can be seen in Table 4., the quality of service obtained an original sample estimate value of 0.079 with a statistical value of 2.1,455 >1.67 which means that the Price Assessment has a positive and significant

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effect on consumer loyalty with a significance level below 5%. Thus H_7 is accepted. H_8 Hypothesis Testing; The eighth test was carried out to see if service standards harmed consumer choices. The test results can be seen from table 4., the quality of service obtained an original sample estimate value of -0.017 with a statistical value of 0.838 >1.67 which the service standard has a negative and significant effect on consumer choices with a significance level below 5%. Thus H_8 is rejected.

H_9 Hypothesis Testing; The ninth test was carried out to see if service standards harmed customer loyalty. The test results can be seen from table 4., the quality of service obtained an original sample estimate value of -0.046 with a statistical value of 0.891 >1.67 which means that the service standard has a negative and significant effect on consumer loyalty with a significance level below 5%. Thus H_9 was rejected.

4. DISCUSSION

The effect of consumer choice on consumer loyalty, The results of the hypothesis test show that the quality of service has a positive and significant effect on consumer loyalty. Consumer choice with the highest achievement. This can explain that loyalty from consumers can be formed from consumer choices that are always consistent with good service standards. Companies that can consistently and continuously increase consumer choices will gain a positive perception of their customers, thus encouraging these customers to repurchase or reuse the products offered by the company. The influence of facilities and infrastructure on consumer choices Based on the test, the results were obtained that facilities and infrastructure have a positive and significant effect on consumer choices. This shows that various efforts to improve facilities and infrastructure are carried out by the company. These results show that facilities and infrastructure have a very important influence on consumers because complete facilities will affect consumers' choice to use products or services from the company.

The effect of facilities and infrastructure on consumer loyalty, the results of testing facilities and facilities have a positive effect on customer loyalty. . Companies that can consistently and continuously improve facilities and infrastructure will obtain a positive perception of their customers to encourage these customers to repurchase or reuse the products offered by the company. The Influence of Business Location on Consumer Choice, Based on the results of the test of business location on consumer choice has a positive and significant value where that business location greatly affects consumer choice, strategic business location also determines consumer choice to use products or services from the company. The effect of business location on consumer loyalty, the results of testing business location and consumer loyalty have a negative value on loyalty, this shows that business location does not affect consumers to use the services or products offered by the company.

The effect of business location on consumer loyalty. The results of the price assessment test have a positive effect on consumer loyalty. This shows that the location of the business affects consumers to buy or use products or services from the company. The effect of service standards on consumer choice The results of the service standard test have a negative value on the choice of customers, this shows that service standards have no effect on the choice of consumers to use the services or products offered by the company and the effect of service standards on consumer loyalty The results of the service standard test have a negative value on customer choice, this shows that service standards do not affect consumer loyalty to repurchase or use the services or products offered by the company.

5. Conclusion

Based on the results of the study, it can be concluded that customer loyalty is influenced by consumer choices, facilities, and infrastructure, price assessments that have a positive impact both directly and indirectly on the company. However, there is a negative influence on the business location variable that harms customer loyalty, the price assessment variable harms consumer choice, and the service standard variable has a significant negative impact on customer choice and customer loyalty. As a result, the company is expected to continue to make improvements. The results of this study are beneficial for consumers and companies. Consumers will get

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the best service standards and companies will be able to maintain and increase consumer loyalty if they can provide services that meet or exceed their customer expectations. This needs to be done because it is proven based on the results of research that service has a positive impact on consumer loyalty. In addition, the advantage obtained by the company is that if consumers are satisfied with the company's services, in addition to being loyal, they will also refer to new consumers.

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Application of Statistical Tests in Measuring the Influence of Product Quality and Brand Image

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***Abstract*—The purpose of this study is to investigate how brand image and product quality have an impact on the interest in buying precious metals at the Sleman Branch Pawnshop. The study found that product quality, which includes purity, authenticity, and attractive design, significantly affects consumer buying interest. The quantitative methods used include survey methods and multiple regression analysis. In addition, Pegadaian's reputation as a safe and reliable financial institution greatly influences customers' desire to buy precious metals. The results of the regression analysis show that product quality has a regression coefficient of 0.543 with a p-value < 0.001, while brand images have a regression coefficient of 0.479 with a p-value < 0.001. The synergy between brand image and product quality shows an increase in customer buying interest. These two factors influence each other's purchase decisions. The implications of this study show that to maintain and increase consumer buying interest, Pegadaian must continue to maintain and improve the quality of its products and brand image. This research provides valuable insights for pawnshops on how to optimize marketing strategies and product quality management.**

***Index Terms*—About; Brand Image, Precious Metal, Product Quality, Purchase Interest**

I. INTRODUCTION

With global economic growth and public awareness of the importance of investment, interest in buying precious metals has increased in recent years [1]. As a financial institution offering precious metal products such as gold, Pegadaian faces the challenge of continuously attracting and maintaining consumer interest. This research aims to analyze how product reputation and brand image influence consumer interest in purchasing precious metals at Pegadaian Sleman Branch. Product quality and brand reputation are two important factors that influence consumer decisions in purchasing metals.

Product quality is defined as a product's ability to meet or exceed customer expectations [2]. A product is not only evaluated based on its physical attributes but also in terms of reliability, durability, and uniqueness. Consumer satisfaction and loyalty can be enhanced with high-quality products [3], [4]. The purity of gold, design, and certification of precious metal products determine product quality. Recognized certification, issued by Pegadaian, provides consumers with assurance about the authenticity and investment value of precious metals [5]. Conversely, brand image refers to how customers perceive a brand based on the information and experiences they receive and possess [6]. A positive brand image can foster trust and encourage consumer purchasing interest. A strong brand image can enhance the added value of a product in the eyes of consumers [7]. At Pegadaian, brand image is built through various marketing strategies, good service, and the company's reputation as a trusted financial institution. Consumers are more likely to choose products from brands with a positive image because they are considered safer and more reliable [8].

Empirical observations indicate that the interest in purchasing precious metals at Pegadaian Sleman Branch has experienced significant fluctuations. In recent years, the increase in global gold prices and national economic

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conditions have influenced public buying interest. However macroeconomic factors such as inflation and exchange rates play a crucial role in determining the interest in buying precious metals [9]. However, product quality and brand image remain the primary factors influencing consumer purchasing decisions [10].

This research aim is to discover and analyze the relationship between product quality and brand image on the interest in purchasing precious metals at Pegadaian Sleman Branch. It is hoped that this research can provide insights for Pegadaian management in improving marketing strategies and services to attract more consumers. Additionally, the purpose of this research is to contribute to the literature on the components that influence the interest in purchasing precious metals in Indonesia.

This research will focus on analyzing product quality and brand image and their relationship with purchasing interest. The limitation of this study lies in its scope, which is restricted to the Pegadaian Sleman Branch, so the results may not be generalizable to other Pegadaian branches in Indonesia. Quotations from relevant journals and books will be used to support the arguments and framework in this article. For instance, a study by [11] shows that product quality has a significant influence on consumer purchasing decisions, while research by [12] indicates that a positive brand image can enhance consumer loyalty and purchasing interest. Thus, this research is expected to make a meaningful contribution to understanding the dynamics of precious metal purchasing interest at Pegadaian and help Pegadaian improve its business strategies to achieve competitive advantage.

II. METHOD

This research employs a quantitative approach to determine the influence of product quality and brand image on the interest in purchasing precious metals at the Pegadaian Sleman Branch. This approach is chosen because it allows for objective measurement and statistical analysis, which can provide results that are more generalizable to a broader population. Data in this study is collected through a survey using a questionnaire distributed to consumers who have purchased precious metals at the Pegadaian Sleman Branch. The questionnaire is designed to evaluate three main variables: product quality, brand image, and purchasing interest. To facilitate analysis, the questionnaire uses a 5-point Likert scale.

The main instrument in this study is a closed-ended questionnaire consisting of several sections. The first section includes questions about the demographic characteristics of the respondents, such as age, gender, education, and income. The second section measures consumer perceptions of the quality of precious metals sold at Pegadaian. The third section assesses consumer perceptions of Pegadaian's brand image. The final section evaluates the level of consumer interest in purchasing precious metals at Pegadaian.

The data collection procedure begins with the identification and selection of participants using the purposive sampling method. Participants are selected based on certain criteria, such as having previously purchased precious metals at the Pegadaian Sleman Branch. The questionnaire is then distributed both directly and through online platforms to participants who meet these criteria. Once the questionnaires are completed, the data is collected and verified to ensure completeness and consistency.

Data analysis is conducted using descriptive and inferential statistical methods. Descriptive statistics are used to describe the demographic characteristics of the respondents and the distribution of their answers. To ensure the validity and reliability of the questionnaire, confirmatory factor analysis (CFA) and Cronbach's Alpha coefficient tests are performed. CFA is used to ensure that the items in the questionnaire measure the intended constructs, while Cronbach's Alpha is used to test the internal consistency of the questionnaire.

Multiple regression analysis is used to test the influence of product quality and brand image on purchasing interest. The multiple regression model allows researchers to see the extent to which each independent variable (product quality and brand image) affects the dependent variable (purchasing interest). The data analysis procedure includes data coding and cleaning, regression assumption tests, conducting regression analysis, and interpreting the results. Data coding and cleaning are performed to eliminate incomplete or invalid data. Regression assumption tests are conducted to check for normality, multicollinearity, homoscedasticity, and linearity of the data. Regression analysis is performed

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using statistical software such as SPSS or AMOS, and the analysis results are interpreted to answer the research questions and test the proposed hypotheses.

III. RESULT AND DISCUSSION

A. Descriptive statistics

Descriptive statistics provide an overview of the demographic characteristics of the respondents involved in this study. A total of 200 consumers who have purchased precious metals at Pegadaian Sleman Branch participated in this research. The demographic characteristics include the respondents' age, gender, education level, and monthly income.

The following table summarizes the demographic characteristics of the respondents :

Table 1. Characteristics of the Respondents

Char.	Cat.	No of Resp.	%
Age	20-29 Years	40	20
	30-39 Years	90	45
	40-49 Years	50	25
	50-55 Years	20	10
Gender	Male	80	40
	Female	120	60
Educ Level.	High School/Vocational School	30	15
	Diploma	30	15
	Bachelor's Degree	110	55
	Master's Degree	30	15
Mo inc	< IDR.5.000.000	50	25
	IDR.5.000.000 - IDR.10.000.000	100	50
	IDR.10.000.000 - IDR.15.000.000	30	15
	> IDR.15.000.000	20	10

Source: field data

From the table, it can be seen that the majority of respondents are in the productive age range (30-39 years) and most have at least a bachelor's degree. This indicates that the consumers of precious metals at Pegadaian Sleman Branch tend to come from an age group that is actively working and has a good educational background, which may influence their interest in investing in precious metals. Most respondents also have a relatively high monthly income, indicating that they have the financial capacity to invest in precious metal products.

B. Validity and Reliability Testing

Construct validity testing was conducted using Confirmatory Factor Analysis (CFA). CFA is used to test whether the collected data fit the hypothesized model. This process involves several steps, including item selection, factor loading testing, and model evaluation.

Factor Loading: Factor loading is a coefficient that indicates how much an observed variable (item) correlates with the factor being measured. In this study, all questionnaire items showed factor loadings above 0.6, which is the minimum threshold for indicating good validity [13]. High factor loadings indicate that the items consistently measure the same construct. The following table shows the factor loadings for each item in the variables of product quality, brand image, and purchasing interest:

Table 2. Factor Loadings the Variable

Variable	Item	Factor Loading
Product Quality	PQ 1	0.72
	PQ 2	0.75
	PQ 3	0.80
	PQ 4	0.77
	PQ 5	0.74
Brand Image	BI 1	0.79
	BI 2	0.82
	BI 3	0.84
	BI 4	0.78
	BI 5	0.81
Purchase Interest	PI 1	0.85
	PI 2	0.88
	PI 3	0.90
	PI 4	0.86
	PI 5	0.87

Source: data processed

Reliability refers to the internal consistency of the research instrument. Reliability testing in this study was conducted using Cronbach's Alpha coefficient. Cronbach's Alpha measures the extent to which items within a scale correlate with each other, with values above 0.7 considered to indicate good reliability [14]. After testing, the Cronbach's Alpha coefficients for the variables of product quality, brand image, and purchasing interest, each with 5 items, are as follows: a) Product Quality: 0.88, b) Brand Image: 0.85, and c) Purchasing Interest: 0.90.

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This indicates that the Cronbach's Alpha values used in this study demonstrate that the instrument has high internal consistency.

The results of the validity and reliability tests indicate that the instrument used in this study is both valid and reliable. All questionnaire items show factor loadings above 0.6, indicating that these items consistently measure the intended constructs. Additionally, the high Cronbach's Alpha values for all variables demonstrate that the instrument has good internal consistency. Therefore, it can be concluded that the data collected from this questionnaire is trustworthy and suitable for further analysis. High validity and reliability are crucial in research as they ensure that the results genuinely reflect the measured constructs and are not due to measurement errors or inconsistencies in the instrument. Thus, the steps taken to ensure validity and reliability provide a solid foundation for the subsequent analysis and interpretation of the data.

C. Multiple Regression Analysis

Multiple regression analysis was used to test the influence of product quality and brand image on consumer interest in purchasing precious metals at the Pegadaian Sleman Branch. This analysis helps determine the extent to which each independent variable (product quality and brand image) affects the dependent variable (purchasing interest). According to the results of the multiple regression analysis, both independent variables, product quality, and brand image, have a significant influence on consumer purchasing interest. The following table shows the results of the multiple regression analysis:

Table 3. Multiple Regression

Var	Reg. Coef	Std Err	t-value	p-value
Const	1.523	0.467	3.26	0.001
Prod. Qual	0.543	0.089	6.10	0.000
Brand Img	0.479	0.076	6.30	0.000
Adk. R^2	**0.672**			
F-stat	**204.55**			0.000

Source: data processed

1) Constant (β_0) = 1.523: This indicates that if product quality and brand image are considered zero, consumer purchasing interest will still be at a level of 1.523, suggesting that other factors may also be influential.
2) Product Quality (β_1) = 0.543: This coefficient indicates that each one-unit increase in product quality will increase consumer purchasing interest by 0.543 units, assuming other factors remain constant. This coefficient is significant with a p-value < 0.001.
3) Brand Image (β_2) = 0.479: This coefficient indicates that consumer purchasing interest will increase by 0.479 units for each one-unit increase in brand image, assuming other factors remain constant. This coefficient is also significant with a p-value < 0.001.

The Influence of Product Quality on Purchasing Interest

Adjusted R^2 = 0.672: This value indicates that the regression model used has good explanatory power, as it shows that product quality and brand image variables can explain 67.2% of the variation in purchasing interest. F-statistic = 204.55, p < 0.001: The high and significant F-statistic value indicates that the regression model overall is good at explaining the variation in consumer purchasing interest.

The regression analysis results show a regression coefficient of 0.543 with a p-value < 0.001. This indicates that product quality has a positive and significant influence on consumer purchasing interest. In other words, the higher the perceived product quality by consumers, the higher their interest in purchasing precious metals at Pegadaian. In this context, product quality includes several important aspects such as gold purity, product authenticity, and attractive design. Since the purity of gold is closely related to the investment value they expect, consumers pay great attention to gold purity when purchasing precious metals. Product authenticity is also crucial to ensure that consumers receive legitimate and quality-assured products, avoiding the risk of fraud or buying counterfeit products. An attractive design can enhance the product's appeal, especially for consumers who buy precious metals not only as an investment but also as collectibles or jewelry.

The study found that good product quality can increase customer satisfaction and loyalty [15]. High customer satisfaction often results in loyalty, which in turn can increase the likelihood

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of repeat purchases and word-of-mouth recommendations. Therefore, Pegadaian should continue to focus on improving its product quality to maintain and enhance consumer purchasing interest.

The Influence of Brand Image on Purchasing Interest

Brand image also has a significant influence on purchasing interest with a regression coefficient of 0.479 and a p-value < 0.001. This indicates that a positive brand image can increase consumer purchasing interest. Pegadaian's reputation as a safe and trustworthy financial institution gives consumers confidence in investing in precious metals. A strong brand image creates a positive perception in the minds of consumers, making them feel assured that they are transacting with a reliable company with a good track record. This is crucial in the precious metals industry because consumer trust in the security and reliability of the product is vital in determining their purchasing decisions.

These results are consistent with studies by [16] [17], which show that a strong brand image can enhance the perceived value of a product in the eyes of consumers and build sustainable trust. A positive brand image not only increases consumer interest in making a purchase but can also create long-term loyalty, where consumers are likely to repeatedly choose products from a brand they trust.

The Interaction between Product Quality and Brand Image in Influencing Purchasing Interest

The interaction between product quality and brand image shows a synergistic effect in influencing consumer purchasing interest. These two variables mutually reinforce their impact on purchasing decisions. Consumers tend to have higher purchasing interest when the quality of the product offered is supported by a strong brand image. In the case of Pegadaian, high-quality precious metals will be more attractive if backed by Pegadaian's trusted brand image. Consumer trust in the brand enhances their perception of product quality, and conversely, high product quality strengthens the positive brand image.

Support these findings, indicating that a positive brand image can amplify the impact of product quality on consumer purchasing decisions [18], [19]. In this context, Pegadaian needs to continuously maintain and enhance both aspects simultaneously to maximize consumer purchasing interest. In addition to ensuring product quality [18] [20], Pegadaian should actively engage in marketing and branding activities that emphasize its product's strengths and its reputation as a trustworthy financial institution. An effective marketing strategy can involve various media, both traditional and digital, to deliver consistent messages about product quality and brand image. Additionally, Pegadaian could host special events or promotions that showcase their product's excellence, such as precious metal exhibitions or investment seminars, which not only increase consumer knowledge but also strengthen their brand image. By understanding the importance of these two factors and how they interact, Pegadaian can develop more effective strategies to increase consumer purchasing interest and strengthen its position in the precious metals market.

IV. CONCLUSION

Based on the results of the research conducted, the following conclusions can be drawn:

1. Product Quality and Purchase Interest: Product quality has a positive and significant impact on consumer purchase interest in precious metals at Pegadaian Cabang Sleman. Product quality, which includes purity, authenticity, and attractive design, can increase consumer purchase interest. This finding indicates that consumers are more likely to buy products they consider high quality, ultimately enhancing their satisfaction and loyalty.
2. Brand Image and Purchase Interest: Brand image also has a significant impact on consumer purchase interest. Pegadaian's reputation as a trusted and secure financial institution encourages consumers to invest in precious metals. A positive brand image strengthens consumer trust in the products offered and increases their perceived value.
3. Interaction of Product Quality and Brand Image: The interaction between product quality and brand image shows a synergistic effect in influencing consumer purchase interest. These two variables mutually reinforce their impact on purchasing decisions. Consumers are more likely to have high purchase interest when the quality of the

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product offered is supported by a strong brand image.

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Determining Key Performance Indicators at PT Cahaya Utama Branch Sidoarjo using Integrated Performance Measurement System (IPMS) and Balanced Scorecard Methods

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***Abstract*— This study aims to determine the appropriate Key Performance Indicators (KPIs) for PT Cahaya Utama Branch Sidoarjo using the Integrated Performance Measurement System (IPMS) and Balanced Scorecard (BSC) methods. The research employs a descriptive design, integrating qualitative and quantitative data. Key stakeholder needs were identified, and business objectives were set accordingly. KPIs were determined and validated through stakeholder feedback, comparative analysis, and expert judgment. The hierarchical weighting system prioritized the KPIs, highlighting critical areas for performance improvement. Results indicate a strong alignment between stakeholder needs and business objectives, with comprehensive and balanced performance metrics. The study concludes with recommendations for continuous KPI monitoring, employee development, customer-centric culture, and regular process audits to sustain and enhance organizational performance.**

***Keywords*: Key Performance Indicators, Integrated Performance Measurement System, Balanced Scorecard, Organizational Performance, Stakeholder Needs**

I. INTRODUCTION

Established in 2004, PT Cahaya Utama has rapidly expanded its operations throughout Indonesia, offering comprehensive outsourcing services. The Sidoarjo branch, being one of its significant operational units, has been pivotal in maintaining the company's reputation for quality service delivery. However, internal inefficiencies and resource limitations have posed significant challenges to sustained performance and customer satisfaction.

The primary issue faced by PT Cahaya Utama Sidoarjo Branch is the lack of a robust performance measurement system. This deficiency has led to difficulties in tracking progress, identifying areas for improvement, and aligning organizational activities with strategic goals. As a result, there is a pressing need to develop a comprehensive performance measurement framework that can address these challenges.

This study aims to develop a performance measurement system for the PT Cahaya Utama Sidoarjo Branch using the IPMS and BSC methods. The specific objectives are:

- To identify key performance indicators (KPIs) relevant to the organization's strategic goals.
- To categorize these KPIs into the four perspectives of the Balanced Scorecard.
- To prioritize the identified KPIs based on their importance and impact on organizational performance.

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II. LITERATURE REVIEW

1. Performance Measurement Systems

Performance measurement systems (PMS) are critical tools for organizations to monitor and evaluate their performance. Effective PMS helps organizations to understand their current performance, identify areas for improvement, and make informed decisions to achieve strategic objectives. Two widely recognized PMSs are the Integrated Performance Measurement System (IPMS) and the Balanced Scorecard (BSC).

2. Integrated Performance Measurement System (IPMS)

IPMS integrates various performance dimensions, offering a holistic view of organizational performance. It emphasizes the

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alignment of performance measures with business processes and stakeholder requirements. The key components of IPMS include defining business objectives, identifying stakeholder requirements, and developing performance measures that reflect these requirements.

3. Balanced Scorecard (BSC)

Developed by Kaplan and Norton in the 1990s, the Balanced Scorecard (BSC) is a strategic planning and management system used extensively in business and industry, government, and nonprofit organizations. BSC transforms an organization's strategic objectives into a coherent set of performance measures. It categorizes performance measures into four perspectives:

1. Financial Perspective
2. Customer Perspective
3. Internal Processes Perspective
4. Learning and Growth Perspective

Each perspective provides a different view of organizational performance, ensuring a balanced approach to performance measurement.

III. METHODOLOGY

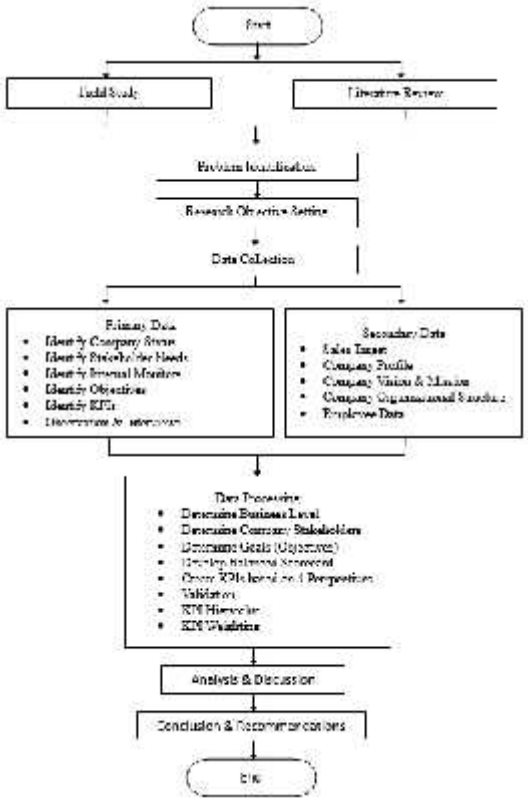

Figure 1 Flowchart

1. Research Design

This study employs a descriptive research design to analyze the performance measurement systems at PT Cahaya Utama Branch Sidoarjo. The research integrates both qualitative and quantitative data to provide a comprehensive understanding of the company's performance metrics.

2. Data Collection

Data collection involved both primary and secondary sources. Primary data were obtained through observations, interviews, and questionnaires distributed to employees and management. Secondary data were gathered from company records, industry reports, and relevant literature.

3. Data Analysis

The data were analyzed using the IPMS and BSC frameworks. The analysis involved identifying stakeholder needs, setting business objectives, determining KPIs, and validating these indicators through a systematic process.

IV. DATA PROCESSING AND ANALYSIS

1. Identifying Stakeholder Needs

The first step in the IPMS process is identifying the needs and expectations of key stakeholders, including employees, customers, and management. Each group has unique requirements that influence the company's performance metrics.

Table 1 Stakeholder Requirements for PT Cahaya Utama Cabang Sidoarjo

No	Stakeholder	Requirement
1	Management	Minimize Company Operating Costs
2		Increase Company Sales
3		Increase Company Productivity
4	Employees	Improve Facilities Supporting Work
5		Enhance Employee Skills
6		Receive Competitive Salaries and Benefits
7		Career Opportunities within the Company
8	Customers	Provide Optimal Customer Service Quality
9		Offer Competitive Pricing
10		Ensure Services Are Always Available and Accessible
11		Build Strong Relationships with Customers

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2. Setting Business Objectives

Based on the stakeholder needs, the company set nine business objectives categorized by stakeholder alignment. These objectives provide a clear direction for performance measurement and improvement.

Table 2 Requirements and Corresponding Business Objectives

Requirement	Business Objective
Minimize Company Operating Costs	Increase Company Profitability
Increase Company Sales	Increase Customer Quantity
Increase Company Productivity	Increase Company Revenue
Improve Facilities Supporting Work	Increase Employee Satisfaction
Enhance Employee Skills	Increase Employee Skills
Receive Competitive Salaries and Benefits	Increase Employee Satisfaction
Career Opportunities within the Company	Increase Employee Productivity
Provide Optimal Customer Service Quality	Increase Customer Satisfaction
Offer Competitive Pricing	Increase Customer Satisfaction
Ensure Services Are Always Available and Accessible	Increase Service Quality
Build Strong Relationships with Customers	Increase Customer Loyalty

3. Determining Key Performance Indicators (KPIs)

The BSC framework was used to translate business objectives into specific KPIs. These indicators cover four perspectives: Financial, Customer, Internal Business Processes, and Learning and Growth.

Table 3 Key Performance Indicators (KPIs)

Key Performance Indicators
Profit Margin: Measures the percentage of profit generated from each sale after all costs and taxes are deducted. Total Sales Total Sales−Total Costs−Taxes×100%
Total Revenue: Measures the total revenue generated from sales of products or services to customers. Number of Products/Services Sold Selling Price
Customer Satisfaction: Measures the level of customer satisfaction with the company's products or services. Number of Customers Surveyed Number of Satisfied Customers ×100%
Customer Retention Rate: Measures the percentage of customers who continue to use the company's products or services over a specified period. Number of Customers at Start of PeriodNumber of Customers at End of Period−Number of New Customers×100%
Task Completion Time: Measures the average time taken by employees to complete their tasks. Average Task Completion Time per Employee
Service Satisfaction: Measures the level of customer satisfaction with the services received from the company. Number of Customers Receiving ServiceNumber of Customers S atisfied with Service×100%
Market Share: Measures the percentage of the market controlled by the company. Total Market Sales Company Sales×100%
Employee Performance: Measures the performance level of employees in achieving their targets. Set Target Employee Achievement Target×100%
Training Program Satisfaction: Measures the level of employee satisfaction with training and development programs. Number of Employees Participating in ProgramNumber of Empl oyees Satisfied with Program×100%

4. Financial Perspective

KPIs under this perspective measure the company's financial health and profitability. Examples include revenue growth, profit margins, and cost management.

5. Customer Perspective

Customer satisfaction and loyalty are critical for business success. KPIs in this area include customer satisfaction scores, retention rates, and market share.

6. Internal Business Processes Perspective

This perspective focuses on the efficiency and effectiveness of internal operations. KPIs include process cycle times, defect rates, and operational efficiency.

7. Learning and Growth Perspective

Employee development and organizational learning are essential for long-term success. KPIs in this perspective measure employee satisfaction, training effectiveness, and innovation capacity.

Table 4 Strategy Objectives Based on the Four Perspectives of BSC

Perspective	Code	Strategy Objective
Financial	F 1	Increase Company Profitability
	F 2	Increase Customer Revenue
Customer	C 1	Increase Customer Satisfaction
	C 2	Increase Customer Loyalty
Internal Business Process	IBP 1	Increase Employee Productivity
	IBP 2	Improve Service Quality
	IBP 3	Increase Customer Quantity
Learning and Growth	LG 1	Enhance Employee Skills
	LG 2	Increase Employee Satisfaction

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8. Validation of KPIs

The identified KPIs were validated through a series of steps, including stakeholder feedback, comparative analysis, and expert judgment. This validation ensures that the KPIs are relevant, reliable, and aligned with the company's strategic objectives.

Table 5 KPI Selection

Key Performance Indicator	Selected
Measure the percentage of profit generated from each sale after deducting all costs and taxes.	✓
Measure the total revenue generated from sales of products or services to customers.	✓
Measure the level of customer satisfaction with the company's products or services.	✓
Measure the percentage of customers who continue using the company's products or services over a specific period.	✓
Measure the time taken by employees to complete their tasks.	✓
Measure the level of customer satisfaction with the services received from the company.	✓
Measure the percentage of market share controlled by the company.	✓
Measure the level of employee performance in completing tasks and achieving targets.	✓
Measure employee satisfaction with training and development programs.	✓

9. Hierarchical Weighting of KPIs

To prioritize the KPIs, a hierarchical weighting system was applied. This system assigns different weights to each KPI based on its importance and impact on overall performance. The hierarchical structure helps in focusing on the most critical areas for improvement.

10. KPI Weighting Using Pairwise Comparison

Pairwise comparison is crucial in AHP (Analytic Hierarchy Process). Decision-makers compare two different alternatives using a scale ranging from 1 (equally important) to 9 (absolutely more important).

The weighting of Balanced Scorecard Perspectives. The priorities of the four perspectives are summarized in Table It shows the weights from respondents regarding the importance of each main criterion for performance evaluation.

Table 6 Balanced Scorecard Perspective Weights

Perspective	Weight
Financial	0.053-0.084
Customer	0.223-0.296
Internal Business Process	0.133-0.166
Learning and Growth	0.501-0.550

Table 7 Financial Perspective Weights

Sub criteria	Weight
Profitability	0.860-0.875
Revenue	0.125-0.140

F1: Profit percentage after all costs and taxes.
F2: Total revenue from sales.

Table 7 Customer Perspective Weights

Sub criteria	Weight
Customer Satisfaction	0.860-0.888
Customer Loyalty	0.112-0.140

C1: Customer satisfaction with products/services.
C2: Percentage of loyal customers over time.

Table 8 Internal Business Process Weights

Sub criteria	Weight
Task Completion Time	0.192-0.210
Service Quality	0.675-0.784
Market Share	0.011-0.115

IBP1: Time taken by employees to complete tasks.
IBP2: Customer satisfaction with services.
IBP3: Market share percentage.

Table 9 Learning and Growth Perspective Weights

Sub criteria	Weight
Employee Performance	0.800-0.887
Training Satisfaction	0.113-0.137

LG1: Employee performance in task completion.
LG2:Employee satisfaction with training programs.

Table 10 Final Weights of Criteria

Criterion	Weight
Financial	0.084
Customer	0.296
Internal Business Process	0.166
Learning and Growth	0.454

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Financial Perspective Final Weights
Table 11 Financial Perspective Final Weights

Sub criteria	Weight
Profitability	0.875
Revenue	0.125

Customer Perspective Final Weights
Table 12 Customer Perspective Final Weights

Sub criteria	Weight
Customer Satisfaction	0.888
Customer Loyalty	0.112

Internal Business Process Final Weights
Table 13 Internal Business Process Final Weights

Sub criteria	Weight
Task Completion Time	0.210
Service Quality	0.675
Market Share	0.115

Learning and Growth Final Weights
Table 14 Learning and Growth Final Weights

Sub criteria	Weight
Employee Performance	0.667
Training Satisfaction	0.333

V. DISCUSSION AND ANALYSIS

1. Analysis of Integrated Performance Measurement System (IPMS**)**

PT Cahaya Utama Sidoarjo Branch employs the Integrated Performance Measurement System (IPMS) to assess its performance. This method involves identifying stakeholders and analysing their desires. The study focuses on three main stakeholders: Leaders, Employees, and Customers.

Employees are crucial as they drive business and revenue growth. Their desires include personal development, salary increases, and a comfortable work environment. Customer satisfaction is essential for business continuity, with their desires being product quality and friendly service. Leaders are responsible for the company’s direction and strategy, aiming for profitability, operational efficiency, and a positive company image.

Through external monitoring, the company’s ability to meet stakeholder desires was evaluated. Results indicate that the company has made efforts in employee development and infrastructure improvement to support their performance.

Based on stakeholder desires, nine business objectives were formulated, and classified according to common desires among stakeholders. The implementation of IPMS at PT Cahaya Utama Sidoarjo Branch demonstrates the company's commitment to success by meeting stakeholder needs, helping focus on crucial aspects, and achieving performance targets.

2. Analysis of Balanced Scorecard (BSC)

The Balanced Scorecard (BSC) analysis is used to enhance human resource performance from various perspectives, including financial, customer, internal business process, and learning and growth. The Key Performance Indicators (KPIs) derived from strategy objectives are categorized into these BSC perspectives.

The KPIs include:

1. Measuring profit percentage from sales after all costs and taxes.
2. Measuring total revenue from product or service sales.
3. Measuring customer satisfaction with the company's products or services.
4. Measuring the percentage of customers who continue using the company's products or services over time.
5. Measuring the time taken by employees to complete their tasks.
6. Measuring customer satisfaction with the company's service.
7. Measuring the market share controlled by the company.
8. Measuring employee performance in completing tasks and meeting targets.
9. Measuring employee satisfaction with training and development programs.

These KPIs were validated through a questionnaire assessing their relevance to the company's conditions. Responses from company leaders confirmed that all KPIs were deemed appropriate, indicating the validity of the KPIs.

3. Analysis of KPI Weighting Using Pairwise Comparison Method

Weighting is conducted to represent the importance of each perspective and KPI. A higher weight for a perspective indicates its

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greater significance and impact on improving PT Cahaya Utama Sidoarjo Branch's performance.

1. The financial perspective has the highest priority with a weight of 0.454. This means that learning and growth should be prioritized over financial, customer, and internal business process perspectives. Improving revenue growth affects company performance through increased sales.
2. From a financial perspective, employee productivity costs a weight of 0.875. This indicates that measuring profit percentage from sales should be prioritized to enhance company profit, optimize financial management, and ensure sustainable finances.
3. From the customer perspective, the KPI for measuring customer satisfaction with products or services weight 0.888. Prioritizing this KPI is crucial for improving customer satisfaction and loyalty, ultimately benefiting the company's reputation and service quality.
4. From the internal business process perspective, the KPI measuring the time taken by employees to complete tasks weight 0.675. Prioritizing this KPI contributes to employee performance and operational efficiency, positively impacting business processes.
5. From the learning and growth perspective, the KPI measuring employee performance in achieving targets is weighted at 0.667. This KPI should be prioritized to support company growth through effective employee performance and target achievement.

VI. CONCLUSION

Based on the research conducted, the following conclusions can be drawn:

The Key Performance Indicators (KPIs) using the Integrated Performance Measurement System (IPMS) method and Balanced Scorecard (BSC) framework at PT Cahaya Utama Sidoarjo Branch are based on stakeholders, as well as the company's vision and mission. Nine KPIs have been established:

1. Measuring the percentage of profit generated from each sale after deducting all costs and taxes.
2. Measuring the total revenue generated from the sale of products or services to customers.
3. Measuring the level of customer satisfaction with the company's products or services.
4. Measuring the percentage of customers who continue using the company's products or services over a certain period.
5. Measuring the time taken by employees to complete their tasks.
6. Measuring the level of customer satisfaction with the service received from the company.
7. Measuring the percentage of market share controlled by the company.
8. Measuring employee performance in completing tasks and achieving targets.
9. Measuring employee satisfaction with training and development programs.

Recommendations

The following recommendations are provided for future researchers: Future researchers may use different variables for Key Performance Indicators to provide more accurate results for the implementation of proposed improvements.

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Forecasting the Gold Price of LM Antam using the Double Exponential Smoothing Approach

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Abstract — Antam Precious Metal (LM) gold investment is one of the investment choices favored by the public from the many investment choices available. One of the things that must be done if you want to invest in gold is to monitor the price movement of Antam Gold. This study uses the Double Method approach of Exponential Smoothing with the software Minitab 20. Double Method Exponential Smoothing is one of the forecasting methods used for trending data patterns. The gold price data to be forecasted is Antam Precious Metal (LM) gold produced by PT Antam Tbk. The purpose of this study is to obtain a forecast of Antam LM gold prices for the next twelve months from September 2024 to August 2025. The results of the study for the next twelve months the highest price forecast from September 2024 to August 2025 is in August 2025. The price of Antam gold in August 2025 is IDR 1,806,990 and the forecast error value (MAPE) is 2.31% or has a forecast accuracy of 97.69%.

Keywords: Gold Price, LM Antam, Double Exponential Smoothing, Forecasting

1. INTRODUCTION

During the global economic recession, investment has become a very hot topic of conversation. Antam Precious Metal (LM) gold investment is one type of investment choice that is favored by the public from the many investment options available. Currently, the ease of buying and reselling can be accessed from various digital platforms or directly at LM outlets. Antam LM Gold Investment is considered a low-risk investment, protected from inflation, quite promising profits, and safe long-term. One of the things that must be done if you want to invest in gold is to monitor the movement of Antam Gold prices. Because, every day, the purchase and buyback prices of Antam LM Gold always tend to change, either up or down. By knowing the latest Antam LM Gold price, you can determine when is the right time to start buying Gold or selling gold back (buyback). The lack of accurate information makes it difficult for investors to determine the value or price of gold in the next few months or years.

Research on forecasting has been widely conducted. Sagala and Enita used the Arima method to predict the Antam Gold Price in June 2023. The results of the study showed a slight difference between the forecast and the actual data. Then research by Sofiyanti et al. to estimate the price of gold in investment using the Fuzzy method Time Series. Gold price prediction results on July 1, 2023.

Based on these problems, researchers want to know the forecast of LM Antam gold prices for the next 12 months starting from the research time, namely August 2024. This study uses the Double Digit method approach. Exponential Smoothing is expected to get the LM Antam gold price forecast for the period from September 2024 to August 2025. Double Method Exponential Smoothing is one of the forecasting methods used for trend data patterns. The gold price data to be forecast is Antam Precious Metal gold produced by PT Antam. The Antam price data pattern is obtained from the official Antam price history website per month which shows an increase over time.

Gold is one of the profitable investments. Its investment value continues to increase, is not easily affected by inflation, is flexible for buying and selling transactions and the open market makes gold a choice for investment. Investment is a current commitment to gain profit in the future.

Forecasting is a process for obtaining future vision through past data. The method used

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in forecasting very much it is very important so that the desire can achieved. The results of the forecast obtained will become a material consideration in making decisions [4]

Forecasting cannot be done without error (error). Researchers are only capable try to make an error occur as minimally as possible [5]. Method forecasting It is very necessary for investors to know and be required to make decisions in uncertainty. Forecasting is done based on analysis and calculations will be more useful and accepted compared to predictions without any basis. Forecasting done with accuracy will produce benefits in the form of satisfaction among customers, personal pride, trust in the company, control of the operation company, and profit or financial status [6]. Method forecasting can shared in 2 categories main, namely method quantitative and qualitative methods. Quantitative can shared in a series of periodic or sequence times (time series) and methods casual, whereas method qualitative can share become method exploratory and normative.

The method used in this research is Double Exponential Smoothing**. Method qualitative**, Forecasting with method qualitative done with considerations, namely past data Then Not yet Once There is or difficulty obtained, past data trends estimated. The technique used is approach exploratory and normative. The method is quantitative; Forecasting with the method quantitative can done with several conditions, namely past data Can be obtained and quantified, and past data estimates own trend the same as future data. The method used among other methods constant, linear trend, exponential, moving average, single exponential smoothing, and Double Exponential Smoothing.

Several calculation methods are commonly used in calculating prediction errors (forecasts). Error). One way to evaluate forecasting techniques is MAPE. The average absolute percentage error or Mean Absolute Percent Error (MAPE). MAPE is the average absolute differentiation between forecasted and actual values, expressed as a percentage of actual values. MAPE is calculated as the average absolute differentiation between forecasted and actual values, expressed as a percentage of actual values. The MAPE value can be found using the formula in Equation 1.

$$\text{MAPE} = \frac{1}{n}\sum\frac{|A - F|}{A} \quad (1)$$

Where: At = actual value on data t Ft = forecast value on data tn = number of data periods.

The use of MAPE in evaluating prediction results can avoid measuring the accuracy of the actual value and predicted value. The MAPE value criteria are shown in Table 1.

Table 1. MAPE Value Criteria

MAPE Value	Criteria
<10%	Very good
10% - 20%	Good
20% - 50%	Enough
> 50%	Bad

Double Exponential Smoothing is a method that continuously improves forecasting by taking the average value of past smoothing values from time series data in a decreasing manner (exponential). Linear Exponential Method Smoothing (Double Exponential Smoothing). The forecast value can be found using equation 2-4 [8].

Double Formula Exponential Smoothing Brown :

$$S't = \alpha Xt + (1-\alpha) S't-_1 \quad (2)$$
$$S''t = \alpha S't + (1-\alpha) S''t-_1 \quad (3)$$
$$aT = 2S't - S''t \quad (4)$$

The advantage of the Brown DES method compared to other forecasting methods is its ability to handle data that has significant trends and fluctuations. Unlike simple forecasting methods such as moving averages or single exponential methods that only rely on the latest historical data, Brown DES also takes into account changes in data trends gradually. This makes it more responsive to changes in complex and unstable data patterns, such as those that often occur in the coal extraction and export industry. This method also allows for the accounting of seasonal effects or cyclical patterns

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in the data, although not as comprehensive as dedicated seasonal forecasting methods. Thus, this method provides sufficient flexibility in dealing with natural variations in coal production for export purposes, while still providing relatively accurate estimates in the short to medium term.

2. RESEARCH METHODS

Data collection

The data used in this study is secondary data, namely the price of Antam gold. The sample taken in this study is the gold price for the period 1 Tren 2022 - 1 August 2024. So the number of data is 32 data. The downloaded data is historical monthly data on gold prices that are summarized and can be seen in Table 2.

Data Types and Sources

Data collection begins with a preliminary research stage, namely a literature study by studying previous research related to this research topic. At this stage, a review of the data needed is also carried out, namely regarding the type of data, data availability and an overview of how to process the data. The next stage is the main research which is used to collect all the data needed to answer the objectives of the research and enrich the literature to support the quantitative data obtained.

Data Analysis Methods

The data analysis method used by researchers is one of the methods with forecasting techniques. Researchers use the Double Exponential Smoothing. The software used is Minitab 20. The steps taken in this study are shown in Figure 1.

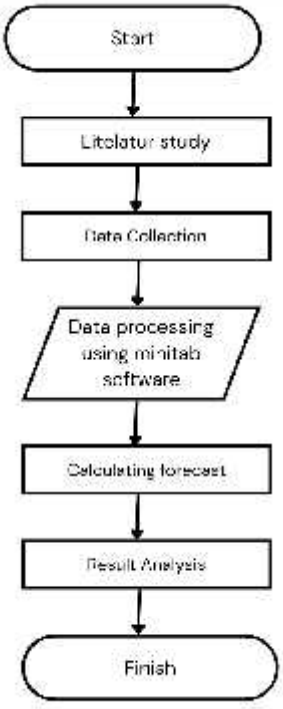

Figure 1. Research Flow Diagram

3. RESULTS AND DISCUSSION

Gold Price Data; This study uses monthly gold prices with a period of 32 months. The gold price data used is for the period 1 Tren 2022 to 1 August 2024. The data was obtained from the logammulia.com site. The gold price download data can be seen in Table 2.

Table 2. Gold Price Data

No	Month	Price
1	Jan-22	938
2	Feb-22	927
3	Mar-22	977
4	Apr-22	989
5	May-22	975
…	…	…
28	Apr-24	1254
29	May-24	1310
30	Jun-24	1336
31	Jul-24	1363
32	Aug-24	1433

Source: logammulia.com [8]

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Data analysis

Data analysis using descriptive statistical data aims to measure data centralization, to find out the distribution of data visually in the form of a time series plot which can be seen in Figure 2.

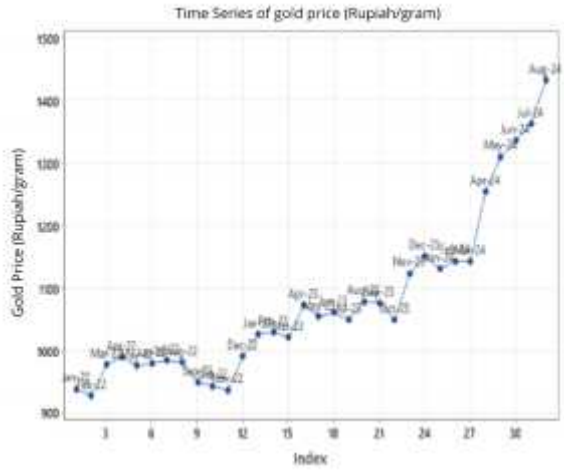

Figure 2. Gold Price Data

Figure 2 is a gold price graph for period 1 Tren 2022 to August 1, 2024. Based on the graph above, it can be seen that within 32 months, the lowest gold price was in February 2022 at IDR 927,000 per gram. While the highest per gram. From the graph, it can be seen that the movement of LM Antam gold prices tends to be an upward trend.

Forecasting Results

This study uses a Double Approach to Exponential Smoothing. Antam LM price data is processed using software Minitab 20 then the following output can be seen in Figure 3.

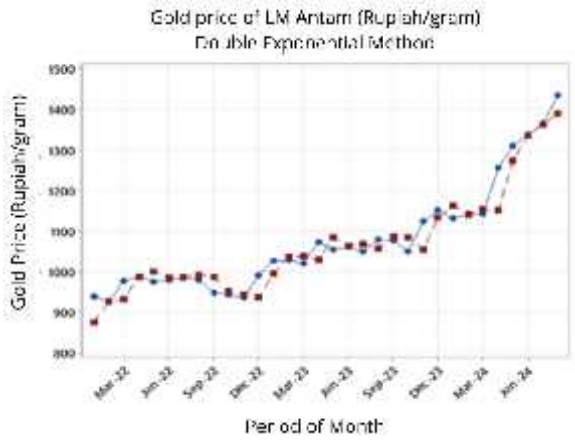

Figure 3. Double Exponential Smoothing

Test results using the software Minitab 20 with Double approach Exponential Smoothing show that the predicted value graph pattern is almost the same as the actual data value pattern. The parameter value used is alpha (α). The predicted value closest to the actual value is when α = 0.9. From the results of the Double Exponential Smoothing calculation, the value initialization holds a very vital role in mark results prediction. Double MAPE test Exponential The most optimal smoothing is obtained when α= 0.9 with a MAPE value of 2.31. The smaller the MAPE value that appears, the better the test results will be. The MAPE value and when α = 0.9 can be seen in Figure 4.

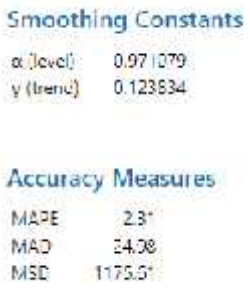

Figure 4. MAPE Value

Forecast Results forward

From the data in Table 2. Forecasting going forward starting from period 33. In this study, the price prediction of LM Antam was carried out for the next twelve months, namely the 33rd to 44th period. By using software Minitab 20 forward calculation of the 33rd to 44th period, the value can be seen in Table 3. From the calculation results, it can be seen that the price of LM Antam gold tends to continue to increase without any decrease each month. The highest price prediction in the 44th period, namely August 2025, is IDR 1,806,990 with a lower price threshold of IDR 1,383,000 and an upper price threshold of IDR 2,230,850.

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Table 3. Forecast Result of 12-month forward

No	Forecast	Upper	Lower
33	1462.998	1524.205	1401.791
34	1494.27	1585.985	1402.556
35	1525.543	1649.406	1401.68
36	1556.815	1713.461	1400.17
37	1588.087	1777.821	1398.354
38	1619.36	1842.35	1396.369
39	1650.632	1906.984	1394.281
40	1681.905	1971.685	1392.124
41	1713.177	2036.432	1389.921
42	1744.449	2101.214	1387.685
43	1775.722	2166.02	1385.423
44	1806.994	2230.846	1383.142

Source: Process Data, 2024

The next twelve months are September 2024 to August 2025. Using α = 0.9, the MAPE value that appears is 2.31, the MAD value is 24.98, while the MSD value is 1175.61. The graph can be seen in Figure 5. It can be seen that the graph pattern tends to increase regularly every month. This can be interpreted that investment, especially LM Antam gold, can be an attractive alternative because its value is stable and protected from inflation and has a safe long-term investment value.

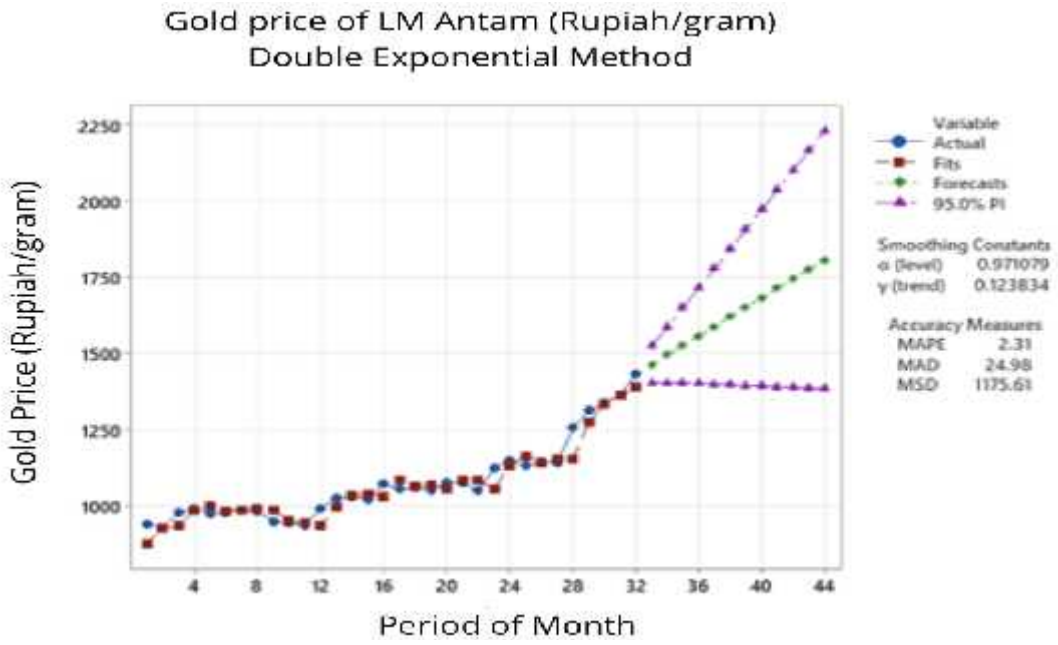

Figure 5. Forecast of Gold Price

4. CONCLUSION

From the results of the study on the LM Antam gold price forecast, there is a trending gold price data pattern with a tendency for data to always increase in each period. The highest price forecast using the Double Exponential Smoothing approach for the next twelve months from September 2024 to August 2025 is in August 2025. The highest LM Antam gold price for the 44th period in August 2025 was IDR 1,806,990 with a lower price threshold of IDR 1,383,000, an upper price threshold of IDR 2,230,850 and a forecast error value of 2.31% or a forecast accuracy of 97.69%. It can be seen from the graph pattern that it tends to increase regularly every month. This can be interpreted that investment, especially LM Antam gold, can be an attractive alternative because its value is stable and protected from inflation and has a safe long-term investment value.

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Digital Pivot Strategies for MSMEs: A Case Study of BirkinPet in the Era of Economic Uncertainty

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Abstract **- Amid economic uncertainty, adopting digital pivot strategies has become crucial, particularly for Micro, Small, and Medium Enterprises (MSMEs) to sustain business growth. Social media marketing, as a vital component of the digital pivot, offers a platform for entrepreneurs to reach audiences more efficiently and effectively. This study aims to explore the correlation between social media metrics and the monthly revenue of MSMEs, focusing on BirkinPet, a pet harness apparel business. A multiple linear regression analysis method was employed to evaluate the relationship between the number of posts, likes, followers, shares, and engagement rate with monthly revenue. The analysis results indicate that the number of posts has a significant negative relationship with monthly revenue (β = -1.1224; p = 0.051), while likes, shares, followers, and engagement rate showed no significant relationship. These findings highlight the importance of a more focused and relevant content strategy in social media marketing to support business revenue growth. In conclusion, while social media holds substantial potential as a marketing tool, success is not entirely dependent on the quantity of activity. A data-driven strategic approach is a key factor in converting social media activities into revenue growth, warranting further exploration to identify the most effective optimization strategies.**

Keywords: **digital pivot, social media marketing, regression analysis, MSMEs, content strategy.**

1. INTRODUCTION.

1.1. Background.

Amid the economic uncertainties caused by various factors such as the global pandemic and market fluctuations, Micro, Small, and Medium Enterprises (MSMEs) face significant challenges in maintaining business operations. Compared to large corporations, MSMEs are more vulnerable to economic instability as they have limited access to resources and capital [1]. MSMEs bear full responsibility for their communities and business activities [2]. Therefore, effective and adaptive business strategies are essential to mitigate risks and capitalize on opportunities.

One effective strategy for helping businesses navigate economic uncertainties is the digital pivot. According to [3], a digital pivot involves adopting and integrating digital technologies into business operations to enhance efficiency, reach broader markets, and create added value for customers. Furthermore, [4] highlights that digital technologies, particularly social media, have proven to be effective marketing tools for improving visibility, building customer relationships, and facilitating business transactions. [5] notes that online reviews of products and services significantly influence customer attitudes and purchase intentions.

Using social media as a marketing medium represents an initial step for MSMEs [6]. Social media has become essential for business operations to reach audiences and increase revenue [7]. Social media leverages web- and mobile-based technologies to create interactive platforms and modify content [8]. Content analysis provides insights into the quantity and quality of social media usage for

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communication purposes [9]. Digital pivot strategies in marketing require technology to achieve marketing goals [10], and big data analytics significantly enhances marketing success [11]. Digital technology can optimize business pivots by enhancing digital capabilities such as digital sensing, digital seizing, and digital transforming, which are highly relevant in unstable environments [12]. Innovative marketing strategies through social media, such as SEO, content-based marketing, email campaigns, and data-driven analytics, have become essential tools for boosting competitiveness and fostering sustainable growth for SMEs [13].

Birkin Pet is a business led by a young entrepreneur in the pet apparel industry, exploring digital pivot strategies through the use of social media as a marketing tool. This study aims to understand how variables such as the number of posts, likes, shares, and followers on social media platforms correlate with revenue and how the strategic management of these platforms can be used as an efficient and effective digital pivot strategy.

1.2. Problem Statement.

a. How do social media variables interact with revenue?
b. How can Birkin Pet implement a digital pivot strategy through social media to increase revenue, particularly amid economic uncertainties?

1.3. Objectives.

a. To analyse the impact of social media marketing activities (number of posts, likes, shares, followers, and engagement rate) on Birkin Pet's monthly revenue.
b. To identify social media marketing metrics that significantly influence revenue.

2. LITERATURE REVIEW

2.1. Social Media Marketing and Revenue.

Social media marketing has proven to be an essential tool for businesses to enhance brand awareness and revenue [14]. The use of social media platforms enables businesses to connect directly with their audiences and build closer relationships with consumers, ultimately fostering loyalty and brand advocacy [15]. Unique and engaging content strategies on social media platforms can influence consumer perceptions and purchasing decisions [16]. Influencers play a significant role as role models, encouraging actions and adding value to brands, thereby attracting customers to purchase products highlighted in their posts [17].

2.2. Digital Pivot Strategies.

Digital pivot strategies involve significant transformations in business models through the utilization of digital technology to adapt to ever-changing market conditions [3]. The implementation of digital strategies includes developing e-commerce, enhancing social media presence, and leveraging data analytics to understand consumer behaviour and market trends [18]. Digital pivot strategies enable organizations to identify and capitalize on available opportunities [19]. These strategies foster digital innovation to create or modify business processes and models [20]. Innovation management within a digital pivot applies systematic approaches to generating, developing, and implementing new ideas, solving problems, and creating business opportunities [21].

2.3. The Relationship Between Social Media Marketing and Revenue.

Several studies have shown a positive relationship between social media marketing activities and a company's financial performance. [22] found that effective digital marketing strategies can expand market reach, ultimately increasing revenue. The relationship between the number of posts and the level of interaction draws attention to the importance of relevant and value-adding content in fostering significant engagement [23]. Participants who engage with authentic and well-known influencers experience elevated Para social interactions, which significantly influence their purchasing tendencies [24].

2.4. Conceptual Framework

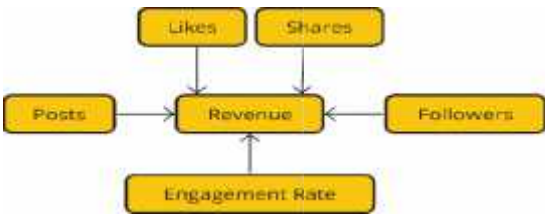

Figure 1. Conceptual Framework

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The conceptual framework, developed as a multiple linear regression model, illustrates the relationships between independent variables (Posts, Likes, Shares, Followers, and Engagement Rate) and the dependent variable (Revenue). Each arrow connecting these variables represents the hypothesis that an increase in independent variables—such as a higher number of posts leading to greater customer interaction—may contribute to increased revenue.

3. METHODOLOGY

3.1. Type of Research.

This study employs quantitative exploratory research, aimed at exploring and measuring the impact of social media variables on revenue through the analysis of numerical and statistical data.

3.2. Research Design.

The research design is a case study focusing on "Birkin Pet," a business run by a young entrepreneur specializing in pet harness apparel.

3.3. Data Collection Methods.

a. Secondary Data: Collected from historical records within the business and literature reviews to gather theoretical and empirical insights.
b. Primary Data: Obtained through surveys or interviews with relevant stakeholders.

3.4. Data Analysis Techniques.

The study employs Multiple Linear Regression Analysis to evaluate the influence of multiple independent variables (Posts, Likes, Shares, Followers, and Engagement Rate) on the dependent variable (Revenue).

3.5. Research Phases

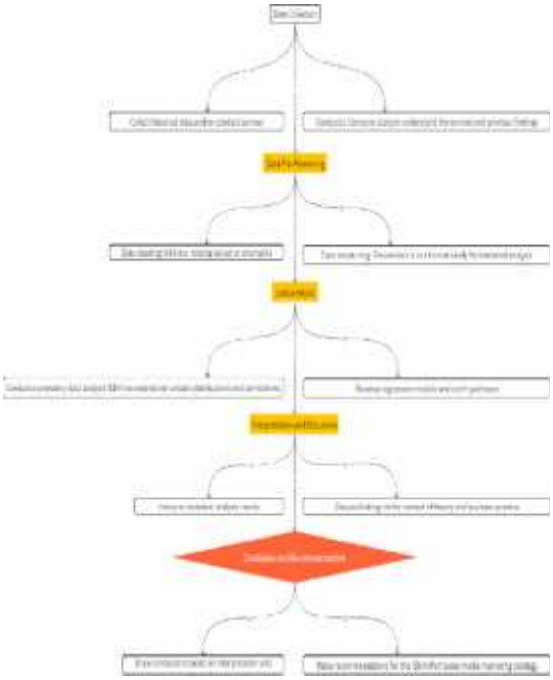

Figure 2. Research Phases

The research is conducted in structured phases, including data collection, data processing, statistical analysis, and interpretation of results to ensure a comprehensive evaluation of the relationship between social media activities and revenue.

4. ANALYSIS AND DISCUSSION

4.1. Hypotheses

a. Hypothesis 1: Relationship Between Number of Posts and Revenue
   - H0: There is no significant relationship between the number of social media posts and monthly revenue.
   - H1: There is a significant relationship between the number of social media posts and monthly revenue.
b. Hypothesis 2: Relationship Between Number of Likes and Revenue
   - H0: There is no significant relationship between the number of likes on social media and monthly revenue.
   - H1: There is a significant relationship between the number of likes on social media and monthly revenue.

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c. Hypothesis 3: Relationship Between Number of Shares and Revenue
   - H0: There is no significant relationship between the number of shares on social media and monthly revenue.
   - H1: There is a significant relationship between the number of shares on social media and monthly revenue.

d. Hypothesis 4: Relationship Between Number of Followers and Revenue
   - H0: There is no significant relationship between the number of followers on social media and monthly revenue.
   - H1: There is a significant relationship between the number of followers on social media and monthly revenue.

e. Hypothesis 5: Relationship Between Engagement Rate and Revenue
   - H0: There is no significant relationship between engagement rate on social media and monthly revenue.
   - H1: There is a significant relationship between engagement rate on social media and monthly revenue.

4.2. Data Collection

a. Independent Variables:
   - Number of Posts (per month)
   - Number of Likes (total per month)
   - Number of Shares (total per month)
   - Number of Followers (per month)
   - Engagement Rate = (Likes + Shares) / Followers × 100%

b. Dependent Variable:
   - Revenue (monthly, in millions)

4.3. Data Cleaning

4.3.1. Missing Value Inspection

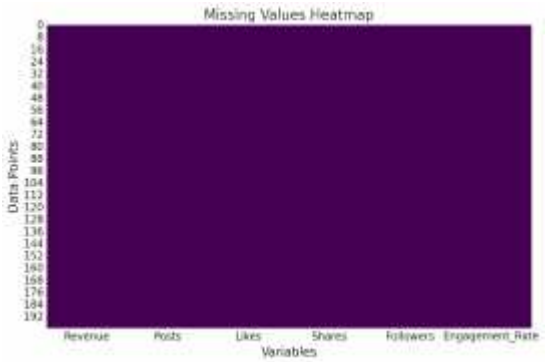

Figure 3. Missing Values Heatmap

No missing values were detected in the dataset; all columns have 0 missing values. The heatmap above visualizes the absence of missing data in the dataset.

4.3.2. Anomaly Detection

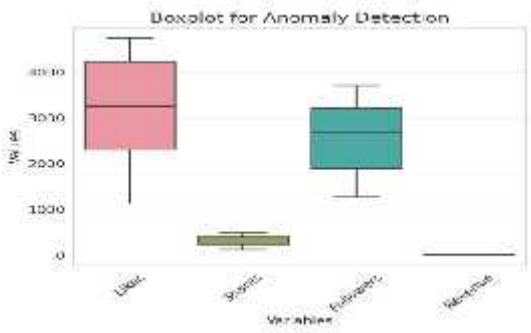

Figure 4. Boxplot for Anomaly Detection

No anomalies or unreasonable values were found in the dataset. All numerical columns contain 0 values less than or equal to zero. This ensures that the data is clean and ready for further analysis.

4.4. Data Structuring

The dataset comprises various columns with specific data types: Month is an object (string), while Posts, Likes, Shares and Followers are integers. Additionally, Engagement Rate and Revenue are represented as float data types. This structured data allows for analysis focused on time trends and correlations.4.4.1. Monthly Revenue Over Time

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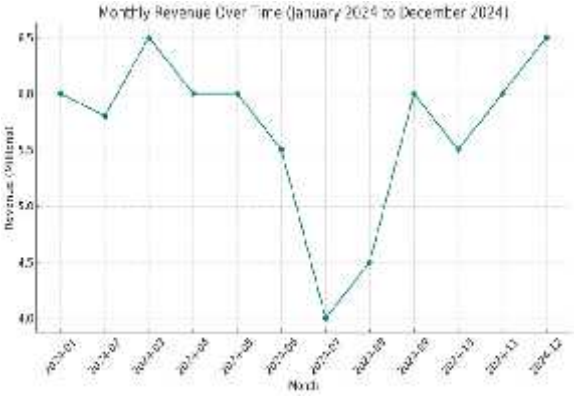

Figure 5. Monthly Revenue Over Time

The x-axis represents the months from January 2023 to December 2023, while the y-axis represents monthly revenue within a predetermined range. Each point on the line indicates the revenue for a specific month, and the line connecting these points demonstrates the trend of revenue movement over time.

4.4.2. Monthly Posts, Likes, and Shares Over Time

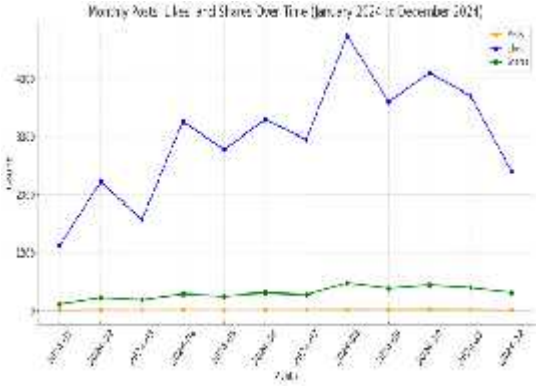

Figure 6. Monthly Posts, Likes, and Shares Over Time

The x-axis represents the months from January 2023 to December 2023, while the y-axis shows the number of Posts, Likes, and Shares. The legend provides color-coded labels for Posts, Likes, and Shares, allowing for clear differentiation between the metrics.

4.4.3. Follower Growth Over Time

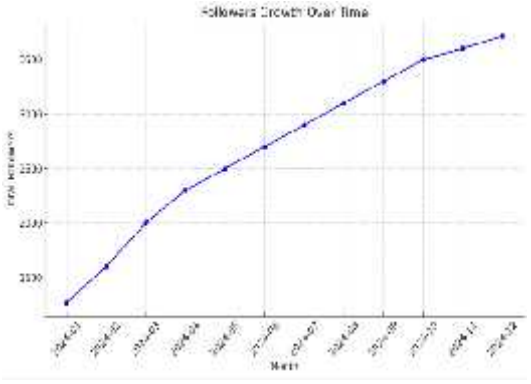

Figure 7. Follower Growth Over Time

The x-axis represents the months from January 2023 to December 2023, while the y-axis represents the cumulative total number of followers. The blue line in the plot illustrates the growth in followers over time, with new followers added each month, showing a steady increase.

4.4.4. Correlation Heatmap

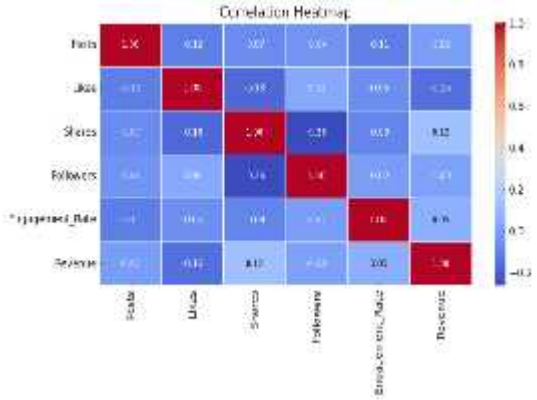

Figure 8. Correlation Heatmap

Correlation values range from -1 to 1, where 1 indicates a perfect positive correlation, -1 indicates a perfect negative correlation, and 0 indicates no correlation. The cells in the heatmap are color-coded based on the correlation values, with warmer colors (closer to 1) representing strong positive correlations and cooler colors (closer to -1) representing strong negative correlations.

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4.5. Initial Data Exploration
4.5.1. Descriptive Analysis

a. Posts: The average number of posts per month is approximately 23, ranging from 17 to 29 posts.
b. Likes: The average number of likes per month is around 3,131, with a minimum of 1,130 and a maximum of 4,735 likes.
c. Shares: The average number of shares per month is approximately 315, ranging from 121 to 485 shares.
d. Followers: The average number of followers is 2,557, growing from 1,269 to 3,715 followers during the observed period.
e. Engagement Rate: The average engagement rate is 146.70%.
f. Revenue: The average monthly revenue is approximately 18.30 million, with a standard deviation of 4.78 million.

4.5.2. Variable Distribution
4.5.2.1. Post Distribution

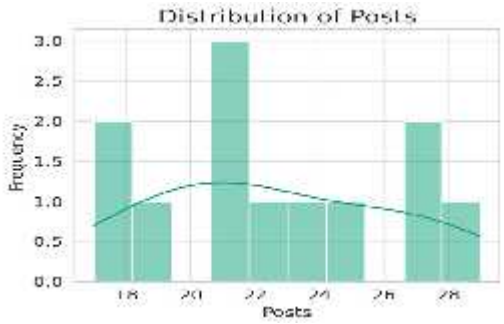

Figure 9. Post Distribution

The distribution of posts per month is uniform, with no specific month showing an unusually high or low number of posts.
4.5.2.2. Likes Distribution

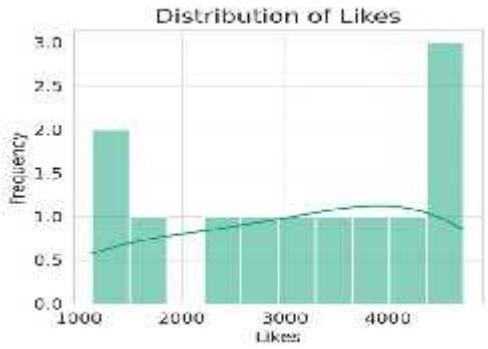

Figure 10. Likes Distribution

The distribution of likes shows some variation, with certain months receiving significantly higher likes compared to others.
4.5.2.3. Shares Distribution

Figure 11. Shares Distribution

The distribution of likes shows some variation, with certain months receiving significantly higher likes compared to others.
4.5.2.4. Distribution of Followers

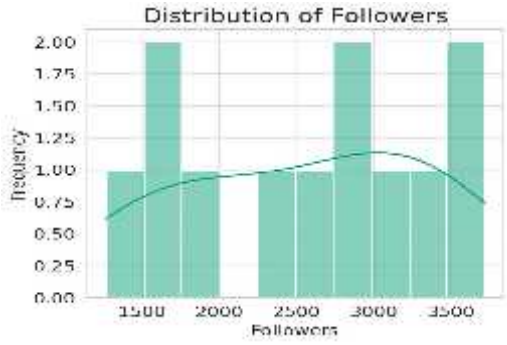

Figure 12. Distribution of Followers

The distribution of followers shows consistent growth, reflecting the accumulation of followers over time.
4.5.2.5. Distribution of Engagement Rate.

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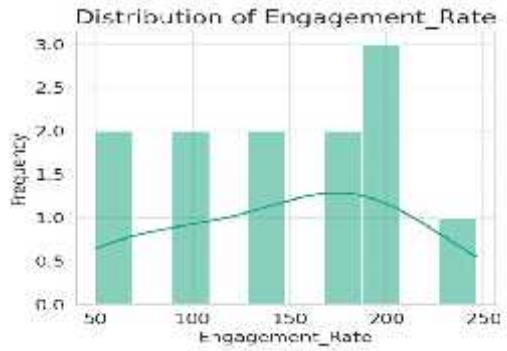

Figure 13. Distribution of Engagement Rate

The engagement rate demonstrates a wide distribution, indicating variation in the level of audience interaction with posts.

4.5.2.6. Distribution of Revenue

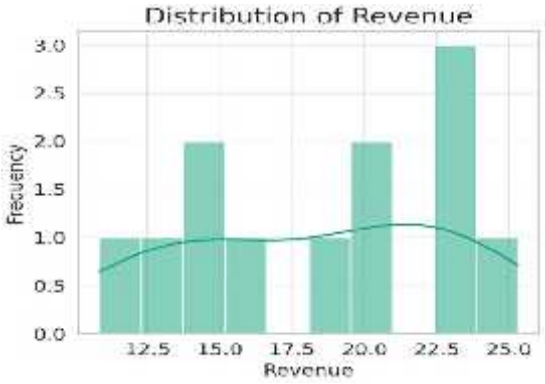

Figure 14. Distribution of Revenue

Monthly revenue shows variability, with certain months exhibiting significantly higher revenue compared to others.

4.6. Multiple Linear Regression Model.

The regression model equation:

Revenue = 19.5637 − 1.1224 × Posts + 0.0025 × Likes + 0.0011 × Shares + 0.0017 × Followers + 0.0788 × Engagement Rate

4.6.1. Regression Model Coefficients

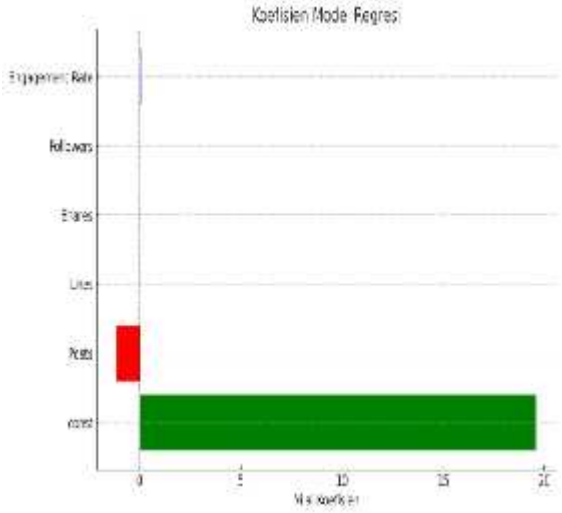

Figure 15. Regression Model Coefficients

Const: The intercept of the model, represents the expected revenue when all predictor variables are zero. Posts, Likes, Shares, Followers, Engagement Rate: The coefficients represent the impact of each independent variable on the dependent variable (Revenue).

4.6.2. Key Metrics

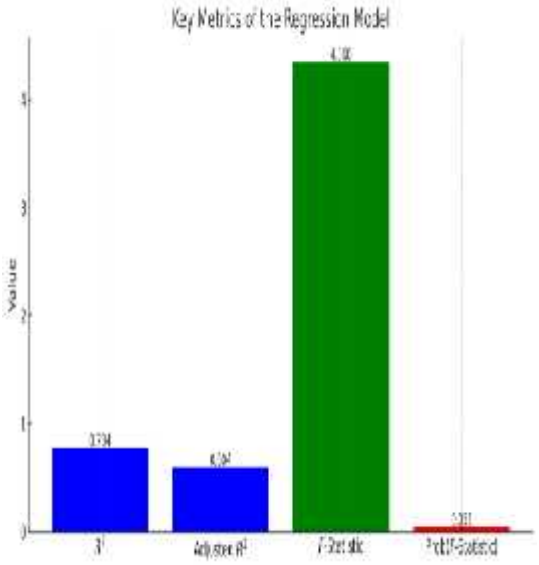

Figure 16. Key Regression Model Metrics

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R^2 (78.4%): Indicates that the model explains 78.4% of the variability in revenue. Adjusted R^2 (60.4%): Corrects for the number of variables in the model. F-Statistic (4.360): Measures the overall significance of the model. Prob (F-Statistic) (0.0507): The p-value for the F-statistic indicates the statistical significance of the model.

4.6.3. Model Evaluation

4.6.3.1. Linearity

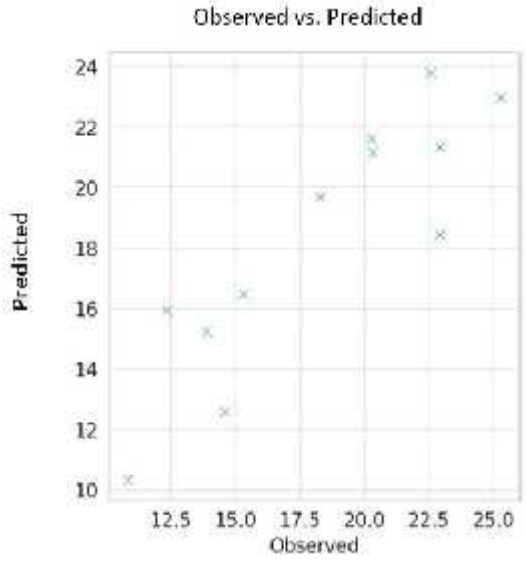

Figure 17. Observed vs. Predicted Plot

Some patterns in the data suggest the relationship may not be entirely linear.

4.6.3.2. Homoscedasticity

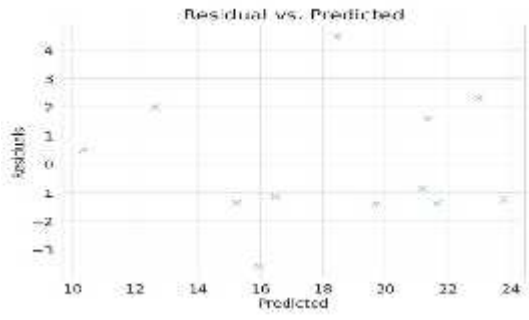

Figure 18. Residuals vs. Predicted Values Plot

The plot shows random patterns, suggesting the homoscedasticity assumption is reasonably met, despite some slight clustering.

4.6.3.3. Residual Normality

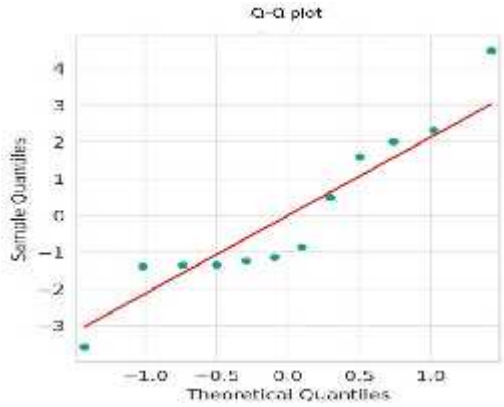

Figure 19. Q-Q Plot

Residuals are not entirely normal, particularly at the distribution's tails. The "S" shape in the plot indicates deviations from normality.

4.7. Interpretation of Regression Results

4.7.1. Interpretation of Coefficients

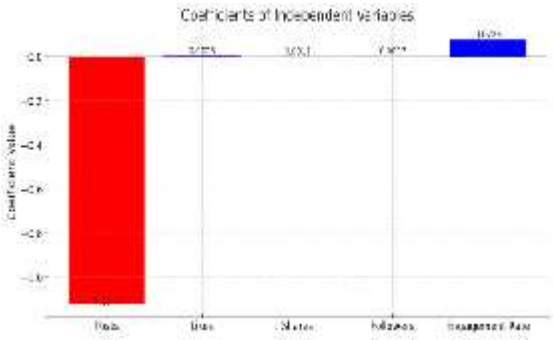

Figure 20. Independent Variable Coefficients

Posts: Coefficient of -1.1224 (red). An additional post is associated with a decrease in revenue of 1.1224 units. Likes: Coefficient of 0.0025 (blue). An additional like is associated with an increase in revenue of 0.0025 units. Shares: Coefficient of 0.0011 (blue). An additional share is associated with an increase in revenue of 0.0011 units. Followers: Coefficient of 0.0017 (blue). An additional follower is associated with an increase in revenue of 0.0017 units. Engagement Rate: Coefficient of 0.0788 (blue). A 1% increase in engagement rate is associated with an increase in revenue of 0.0788 units.

4.7.2. Interpretation of P-Values

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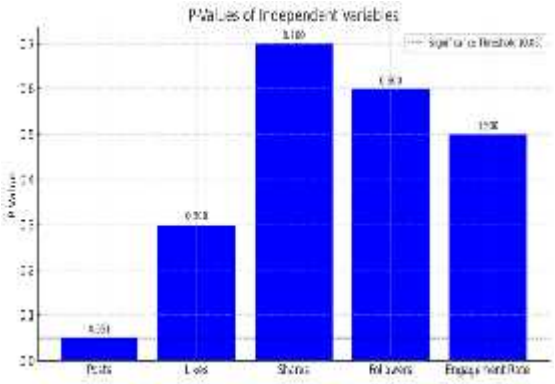

Figure 21. P-Values of Independent Variables

Posts: P-value of 0.051, nearly significant at the 0.05 level. Likes, Shares, Followers, Engagement Rate: P-values well above 0.05, indicating these variables are not statistically significant predictors of revenue.

5. CONCLUSION

a. Utilizing the multiple linear regression model, this study reveals that a higher number of posts is associated with a decrease in revenue (with a coefficient of -1.1224) and is nearly significant (P-value of 0.051). In contrast, Likes, Shares, Followers, and Engagement Rate do not have a significant impact on revenue, suggesting that social media interactions are not directly linked to revenue growth.

b. In implementing a digital pivot strategy for BirkinPet through social media to increase revenue, particularly amidst economic uncertainty, it was found that a higher number of posts does not necessarily lead to higher revenue. This could be attributed to factors such as the high costs and time investment required for content creation, an overabundance of irrelevant content reducing audience interest, excessive posting causing consumers to lose focus or become disinterested, and economic instability influencing audience consumption behavior.

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Electronic Supply Chain Management Model for Monitoring Plant System Performance at PT. XYZ

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Abstract **- PT. XYZ is a company that does business in paper production, one of the revolutions in the field of network distribution based on Internet technology. E-SCM technology has many advantages such as optimizing data recording, and data distribution and facilitating remote monitoring of data systems using WAN Network Topology. Based on the results that have been analyzed, a supply chain management model is needed that can help monitor data systems using WAN network topology distribution that can be accessed by PC Server to the intended International WAN Access.**

Keywords: Distribution, **Monitoring System, Supply Chain Management, WAN**

I. INTRODUCTION

Business competition between companies today getting tighter and stricter every day, along Information Technology Developments have changed the way companies do business, For this reason, companies are required to always be able to change their business strategy and tactics to be better. (Ramadhan, 2019)

The Internet is a global communication forum that connects millions of computer networks via telephone lines. Where the internet is organized by many parties or groups, organizations, or other private institutions. (Jogiyanto, 2005) Many people use the internet to broaden their insight into life. A lot of information is taken from all over the world via the internet.

WAN is a collection of LANs or workgroups that are connected using modem communication tools and internet networks, from or to the head office and branch offices, as well as between branch offices. (Mulyadi, 2014)

According to Pujawan, (2017), a supply chain is a network of companies that work together to create and deliver a product to the end user.

Current industrial developments require the industry to continue to improve supply chain management. Electronic supply chain management (E-SCM) is one of the revolutions in internet-based goods distribution information technology. E-SCM technology has many advantages such as optimizing data recording, data distribution & system monitoring.
Darmawan et al., (2018) conducted research aims to know the process of providing raw materials and improving production quality up to when delivery will be made. So companies need a Supply chain management information system (SCM) which is expected to be able to manage existing needs in the company. Supply chain management (SCM) itself is a supply chain management process starting from the process of procuring raw materials, and production until the finished product reaches the hands of consumers.

Supply Chain Management (SCM) is a system that can coordinate processes of movement of materials, information, and finances in a company. One of the factors that requires costs in marketing the product, namely Logistics management consisting of design products, material procurement, production, control inventory, and storage of goods. Coordination What's happening isn't just inside the company, but also for all outside activities company. The goal is for the management of the need for raw material supplies to become more effective and efficient (Setiawan & Setiyadi, 2017)

Wati et al., (2022) implement a Supply Chain Management Information System (Supply Chain Management) that can make it easier to manage inventory, starting from the ordering process made by suppliers, procurement of goods, and managing goods to customers. This application is designed using XAMPP and the Hypertext Preprocessor (PHP) programming language and uses a MySQL database. This application helps companies/agencies to store any data that is still manual or not yet

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computerized which aims to maximize the performance and profits of the company, suppliers, and customers who can provide satisfaction to the company.

Ika Jaya, (2016) developed a supply chain management information system with multiple stages including: analyzing the business processes running there, analyzing the existing problems in the procurement process as well as considering the impact and constraints of what will happen if the implementation of SCM. The main solutions offered by these systems are their user interfaces that involve suppliers bidding directly through the price system. Notifications, negotiation, and approval are done online, which is expected to make the time of ordering raw materials becomes shorter. Tests on new research on the functional system using black box testing methods.

Information systems and supply chains have a strategic role in managing, measuring, and improving business performance with a sustainable competitive advantage. Mustafid, (2015) designed the basic theoretical concepts of information systems for an enterprise knowledge-based sustainable supply chain. These systems are in the form of a sustainable supply chain information system designed based on enterprise resource knowledge and directed by the objectives and indicators of business performance in a sustainable by taking into account environmental, economic, and societal. Concepts and theoretical basics of this system can be used as a basis for research development and application in the field of information systems and supply chain sustainability. The application of this system can be used to help management manage and optimize enterprise knowledge resources by the potential of the enterprise to improve business performance overall and sustainability.

Saputro et al, (2018) developed an Electronic Supply Chain Management information system that can assist in improving the company's performance to achieve efficiency and effectiveness in its business processes. Software development is done using a waterfall model, where several steps must be done sequentially. On testing software functionality using the black-box method and the white-box method. Based on the results of functionality testing that has been done indicates that this system has met the needs by the specified specifications, and also the results of compatibility testing show that the system can run well on various browsers.

(Hasriani et al, (2018) are to create a WEB application database to speed up the process of information and facilitate the customers in terms of the order or ordering goods hello to the company. The system is expected to simplify and save time during the process of ordering goods is in progress. Recapitulation of Region 60, Cyclomatic Complexity 60, and Independent Path 60 is worth the same conclusion that the application is designed free of logic errors.

Khotantri et al, (2023) designed and built an ordering information system by utilizing a website and using PHP programming, and a MySql database. The results obtained in this study are an information system capable of supporting business organizations and customers in website-based fruit-ordering transaction activities. In addition, the information system built can produce various reports according to needs quickly.

Ramadhan, (2019) analyzed that the supply chain management system requires the existence of an information system that is reliable, accurate, and adequate to assist the system. Currently, the raw material procurement process is hampered due to slow response from supplier’s purchase orders, total delivery errors that occur to suppliers, and difficulty predicting raw materials

PT XYZ, so far in running the company's business, has not had an integrated system that can optimize data recording and distribution, making it easier to monitor data systems remotely using a WAN Network Topology. This research has a goal to be achieved, namely implementing E-Supply Chain Management to monitor the performance of plant systems based on WAN (Wide Area Network) and providing a direct contribution to data system management at PT. XYZ.

II. METHODS

The methodology in this study consists of literature study, process analysis, modeling business, system needs analysis, design system, implementation, testing, and conducting conclusions and suggestions.

PT. XYZ requires an integrated system that can monitor comprehensively. In carrying out this activity, steps or stages are required, namely,

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among others: Conducting monitoring and control, Communicating objectives to a system with E-SCM, Know the monitoring distance to the objectives to be achieved.
In creating an Integrated E-SCM performance system, here are some things to pay attention to: determine what will be measured and monitored to create alignment between the E-SCM strategy and standardized measurements, and apply detailed E-SCM metrics to measure related performance. PT. XYZ requires an integrated system that can monitor comprehensively. In carrying out this activity, steps or stages are needed, namely, among others.

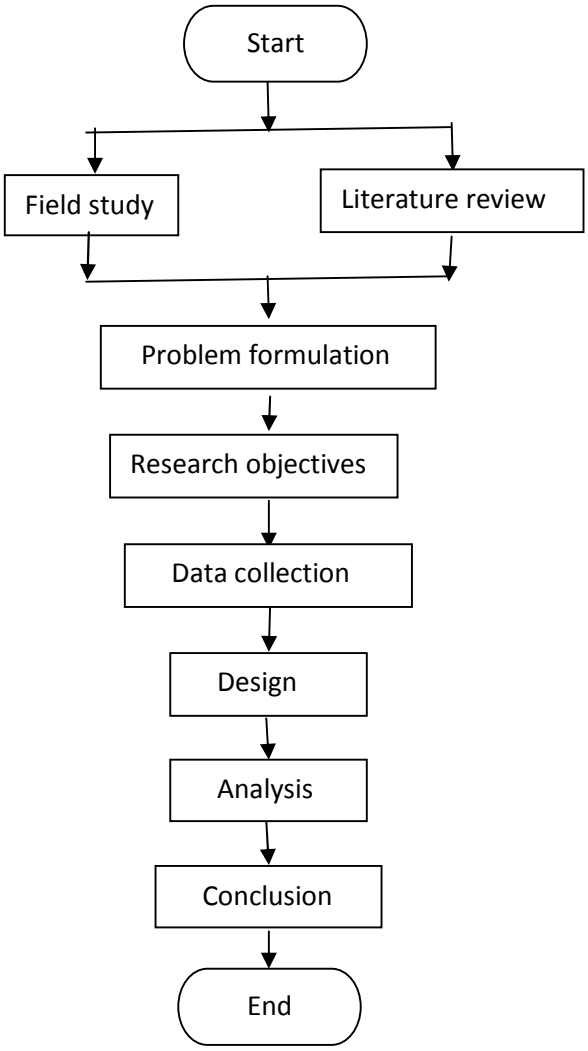

Figure 1 Research Design

The research steps are as follows
1. Start
   Research begins
2. Field study
   research method carried out by collecting data directly at the location or place where the phenomenon being studied occurs.
3. Literature review
   Literature studies related to the problem being researched are used as theoretical references and the basis for solving the problem being researched.
4. Problem formulation
   a very important initial step in research or a scientific project. This process aims to identify and formulate the problem to be studied or solved.
5. Research Objectives
   The purpose of research refers to the reason

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or intention to be achieved in research. This purpose is usually formulated from the beginning of the research and becomes a guideline in determining the direction and methods to be used in the research.

6. Data collection
   a systematic process of gathering information needed for a specific purpose, such as research, analysis, or decision-making. The data collected can be qualitative (descriptive) or quantitative (numerical), depending on the type of information needed.
7. Design
   a creative and systematic process for designing or creating something, be it a product, building, visual display, or other system, to meet a specific need or solve an existing problem.
8. Analysis
   a systematic process of examining or breaking something down into smaller parts to better understand it. In many disciplines, analysis is used to understand data, information, or situations to conclude, make decisions, or find solutions.
9. Conclusion
   part of a discussion or argument that serves to conclude or summarize the core of the topic that has been discussed. Usually, the conclusion is at the end of a writing or discussion to provide a general overview of the results of the analysis or thoughts that have been presented previously
10. End
    Research end

III. RESULT AND DISCUSSION

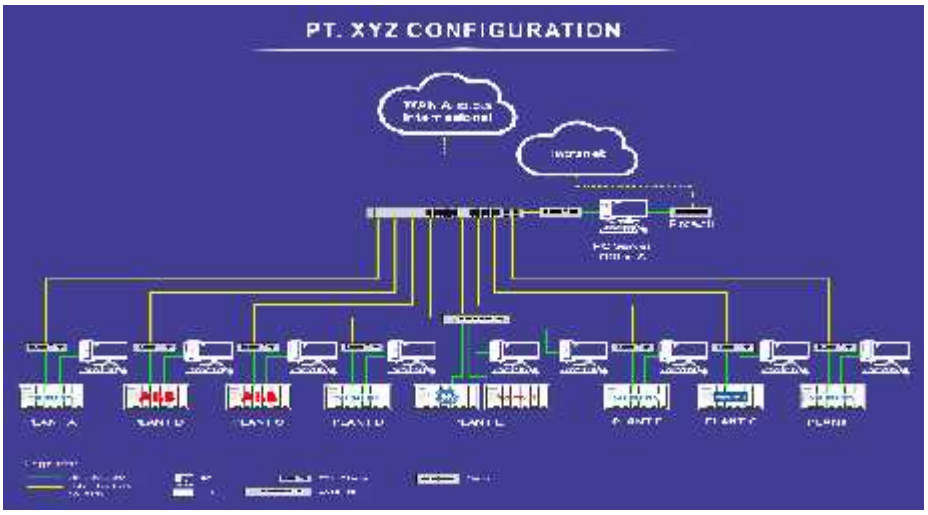

Figure 2 Electronic Supply Chain Management Model for Distribution Network Topology at PT. XYZ

The data monitoring stage is carried out to obtain information about production inventory in each area. If an error occurs in one of the production data, a check must be carried out on the server line in the area that is experiencing a data error. To find out the data, distribute it via a network topology using a WAN that can be accessed by the PC Server to the SCG WAN Access in the intended International. Monitoring is carried out twice a day to ensure the performance of the plant system at PT. XYZ is running well. If a data error occurs during monitoring, a check is carried out on each plant server that is experiencing an error.

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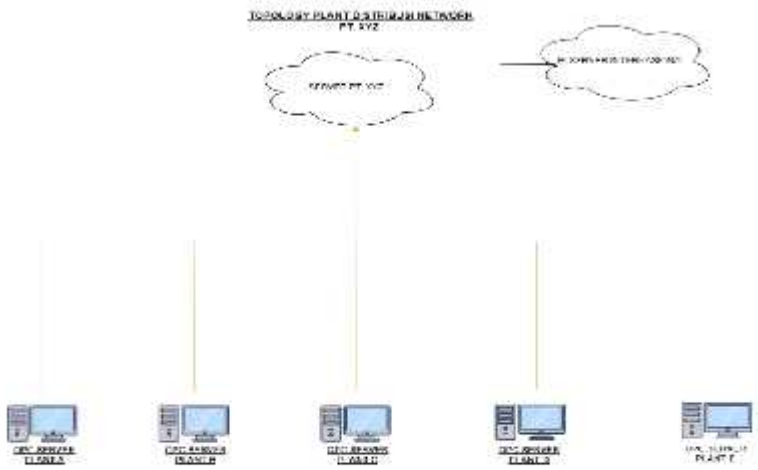

Figure 3 Topology Supply Chain Management for Distribution Network Topology at PT. XYZ

Distribution topology to distribute data from PT. XYZ to the intended International PC Server. Distribution monitoring is done by collecting data from each plant to be combined into the PT. XYZ PC Server which is then distributed to the intended International PC Server. The tool used to connect to the PT. XYZ PC Server is the OPC Server. OPC Server is software that converts the hardware communication protocol used by the PLC into the OPC (Device Connectors) protocol.

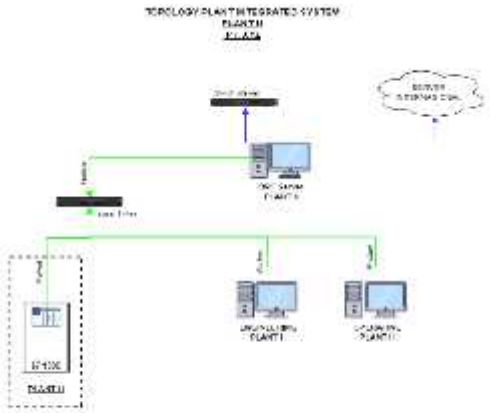

Figure 4 Topology Plant Integrated System at Anaerobic Plant PT. XYZ

The distribution process is carried out from the Engineering PC and Operating PC Server of each plant to the PLC S7-1500 using a profinet cable. Then from the PLC S7-1500, it is communicated via a profinet cable using a Switch Hub tool. Switch Hub is a network device that functions to connect several devices in a local network. The Switch Hub tool is then

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connected to the OPC Server of each plant. The OPC Server can be used to monitor the intended International Server. Distribution monitoring is carried out so that the work is done by the required data such as RPM or motor speed, voltage, amperes, and frequency on the motor engine of the PT. XYZ factory.

Performance management or continuous improvement is one of the fundamental aspects of E-SCM. Therefore, the company PT. XYZ requires an integrated system that can monitor comprehensively. In carrying out this activity, steps or stages are required, namely, among others

a. Conduct monitoring and control
b. Communicate objectives to a system with E-SCM
c. Know the monitoring distance to the objectives to be achieved

In making an Integrated System for E-SCM performance, here are some things to consider

a. Determine what will be measured and monitored to create a match between the E-SCM strategy and standardized measurements.
b. Apply detailed E-SCM metrics to measure related performance.

IV. CONCLUSION

From the discussion that has been done, it can be concluded that the Electronic Supply Chain Management Model for Network Topology Distribution at PT. XYZ can help companies to get solutions in terms of data distribution to PC servers so that they can be accessed using WAN Access at the intended International. The benefits obtained by monitoring the performance of the plant system at PT. XYZ has a significant and positive influence on Supply Chain Management and competitive advantage. The implementation of good Supply Chain Management in manufacturing companies in Gresik will be able to increase the competitive advantage possessed by the company. The implementation of good Supply Chain Management will be able to improve the company's performance, both in terms of financial and operational performance. The increasing competitive advantage of the company will be able to improve the company's performance as well.

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