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Supply Control Of Oil Filter Spareparts Using EOQ And Min-Max Methods Based On Sales Forecast (Case Study: PT Astra International Tbk Soekarno Hatta)

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Abstract

Planning and controlling product inventory is very important for a company to ensure demand is met and maximize profits from sales effectively and efficiently. In addition, inventory planning and control are carried out to prevent excess or shortage of inventory. This study aims to predict sales and calculate inventory control to overcome excess stock and increased inventory costs on oil filter spare parts. The forecasting method used is Holt's Double Exponential Smoothing method to determine the number of sales of the four types of oil filter spare parts in the future and overcome the problem of oil filter spare parts inventory using the EOQ and Min-Max methods. Based on the research results, the resulting forecasting is accurate and the EOQ method results in a lower total inventory cost than the Min-Max method.

Keywords: Inventory Control, Economic Order Quantity, Min-Max, Forecasting

MSC (2020):
90B05 Inventory, storage, reservoirs
91B42 Consumer behavior, demand theory

1. Introduction

The economy is one of the fields that drives the development of a country. This has led to the emergence of many companies that participate in realizing the welfare of society. Tight business competition forces each company to meet consumer demand by maintaining quality, quantity, and timely delivery. PT Astra International Soekarno Hatta, one of the companies engaged in the automotive industry and one of its services is selling oil filter spare parts. Oil filter is one of the spare parts whose demand is quite high and as a result orders are made in large quantities so that there is often a buildup of stock and storage costs increase. To overcome this problem, companies need to carry out inventory planning and control, as well as forecasting future sales of oil filter spare parts based on past sales data.

Previous research related to inventory problems that are used as references in this study are as follows.

Roslin et al (2015) examined the inventory control of four types of spare parts, namely engine oil, oil filters, air filters, and spark plugs using the EOQ method and three forecasting methods, namely Exponential Smoothing, Weighted Moving Average and Simple Moving Average. Şenses, (2021) examines the inventory control of heavy mining equipment using the Min-Max method. Rizqi, (2020) examined the application of the Min-Max method to prevent shortages and excess inventory of raw materials. Siregar (2021) examines the inventory control of car spare parts using the EOQ and Min-Max methods.

Based on the previous description, research was conducted on the problems experienced by PT Astra International Soekarno Hatta using the Holt's Double Exponential Smoothing forecasting method and inventory control using the EOQ and Min-Max methods. The research title "Sales Forecasting and Inventory Control of Oil Filter Spare Parts at PT Astra International Tbk Soekarno Hatta" was obtained.

2. Literature Review

2.1. Forecasting

Forecasting is a way to predict future conditions using past tests (Lesmana et al, 2017). In a resource planning and control, forecasting serves to reduce production uncertainty, so that anticipatory action can be taken for production scheduling purposes. Forecasting can be influenced by external and internal environments. The external environment can be customer revenue, customer characteristics, competitor promotions, competitor prices, product availability, and so on. Meanwhile, the internal environment can be in the form of policies carried out within a company such as promotion and cost policies (Fithri et al, 2019). There are four types of data patterns in forecasting, namely horizontal, seasonal, cyclical, and trend (Makridakis & Wheelwright, 2003).

2.2. Holt's Double Exponential Smoothing Method

The Holt's Double Exponential Smoothing method is a forecasting method with data that shows a trend (Makridakis & Wheelwright, 2003). There are two smoothing constants used in this method, namely smoothing level (α) and smoothing trend (β). Smoothing level is a smoothed estimate of the data value at the end of each period, while smoothing trend is a smoothed estimate of the average growth at the end of each period. Holt's Double Exponential Smoothing calculation can be done using the following equation

$$F_{t+m} = L_t + b_t m \quad (1)$$
$$L_t = \alpha Y_t + (1-\alpha)(L_{t-1} + b_{t-1}) \quad (2)$$
$$b_t = \beta(L_t - L_{t-1}) + (1-\beta)b_{t-1} \quad (3)$$

where:
F_{t+m} : Forecasting for the period $t + m$
Y_t : Actual value of period-t
L_t : Estimated level of period-t
L_{t-1} : Estimated level of period-$t - 1$
b_t : Estimated trend of period-t
b_{t-1} : Estimated trend of period-$t - 1$
m : Forecasting period
α : Level smoothing parameter $0 < \alpha < 1$
β : Trend smoothing parameter $0 < \beta < 1$
There are two initializations in this method, namely:

$$L_1 = Y_1 \quad (4)$$
$$b_1 = Y_2 - Y_1 \quad (5)$$

where:
L_1 : Estimated level of period-1
b_1 : Estimated trend of period-1
Y_1 : Actual value of period-1
Y_2 : Actual value of period-2

2.3. Evaluation of Forecasting Results

Evaluating forecasting results is used to determine the accuracy of the forecasting results that have been carried out with actual data. Mean Absolute Percentage Error (MAPE) is the average of the number of percentage errors. The smaller the resulting MAPE value, the better the forecasting method will be used.

$$PE_t = \left(\frac{Y_t - F_t}{Y_t}\right) \times 100 \quad (6)$$
$$MAPE = \frac{1}{n}\sum_{t=1}^{n}|PE_t| \quad (7)$$

where:
t : Period-t
Y_t : Actual value of period-t
F_t : Forecasting for period-t
n : Number of periods

According to Sumari et al (2021), MAPE can be interpreted as Table 1.

Table 1: Interval MAPE

MAPE	Description
$< 10\%$	Highly Accurate Forecasting
$10\% - 20\%$	Accurate Forecasting
$20\% - 50\%$	Fairly Accurate Forecasting
$> 50\%$	Inaccurate Forecasting

2.4. Golden Section Search

The Golden Section Search (GSS) method is a one-variable non-linear optimization algorithm based on the elimination of the search region containing the optimal point (Syifahati et al, 2023). The modified GSS can generate the optimum points of a multi-variable non-linear optimization problem and can be used to estimate the smoothing parameters of the Holt's Double Exponential Smoothing forecasting method.

The modified GSS form for the Holt's Double Exponential Smoothing method with two smoothing parameters $(\alpha \; dan \; \beta)$ then the objective function is to minimize the MAPE value with the following constraints

minimization:
$$\text{MAPE} = f(\alpha, \beta) \tag{8}$$

with constraints
$$\begin{cases} 0 < \alpha < 1 \\ 0 < \beta < 1 \end{cases} \tag{9}$$

The steps of the GSS method to find parameters α or β can follow the following algorithm:

1. Enter the objective function, stopping criteria (error tolerance), upper limit (a_1) and lower limit (d_1) for α, and upper limit (a_2) and lower limit (d_2) for β. In this study, the error tolerance used is $\varepsilon = 1 \times 10^{-3}$. The α value limit is $0 < \alpha < 1$ and the β value limit is $0 < \beta < 1$.
2. Calculate the golden ratio (r)
$$\text{r} = \frac{-1 + \sqrt{5}}{2} = 0.61803389 \tag{10}$$
3. Determine the new evaluation point
$$\alpha_1 = r \times a_1 + (1 - r)d_1 \tag{11}$$
$$\alpha_2 = a_1 + d_1 - \alpha_1 \tag{12}$$
$$\beta_1 = r \times a_2 + (1 - r)d_2 \tag{13}$$
$$\beta_2 = a_2 + d_2 - \beta_1 \tag{14}$$
4. Evaluate the values of $f(\alpha_1, \beta_1), f(\alpha_1, \beta_2), f(\alpha_2, \beta_1)$, and $f(\alpha_2, \beta_2)$ using the new points.
5. Reduces interval limits α to $|a_1 - d_1| < \varepsilon$ and β to $|a_2 - d_2| < \varepsilon$.
6. If the new interval is larger and the error tolerance or iterations performed are less than the maximum number of iterations, repeat step 4 until the stopping criteria are met with the following conditions

$$\text{If } f(\alpha_1, \beta_1) \text{ maximum, } \begin{cases} a_1 = \alpha_1 \\ \alpha_1 = \alpha_2 \\ d_1 = d_1 \\ \alpha_2 = a_1 + d_1 - \alpha_1 \\ a_2 = \beta_1 \\ \beta_1 = \beta_2 \\ d_2 = d_2 \\ \beta_2 = a_2 + d_2 - \beta_1 \end{cases}$$
$$\text{If } f(\alpha_1, \beta_2) \text{ maximum, } \begin{cases} a_1 = \alpha_1 \\ \alpha_1 = \alpha_2 \\ d_1 = d_1 \\ \alpha_2 = a_1 + d_1 - \alpha_1 \\ d_2 = \beta_2 \\ \beta_2 = \beta_1 \\ a_2 = a_2 \\ \beta_1 = ra_2 + (1 - r)d_2 \end{cases} \tag{15}$$

$$\text{If } f(\alpha_2, \beta_1) \text{ maximum}, \begin{cases} d_1 = \alpha_2 \\ \alpha_2 = \alpha_1 \\ a_1 = a_1 \\ \alpha_1 = ra_1 + (1-r)d_1 \\ a_2 = \beta_1 \\ \beta_1 = \beta_2 \\ d_2 = d_2 \\ \beta_2 = a_2 + d_2 - \beta_1 \end{cases}$$

$$\text{If } f(\alpha_2, \beta_2) \text{ maximum}, \begin{cases} d_1 = \alpha_2 \\ \alpha_2 = \alpha_1 \\ a_1 = a_1 \\ \alpha_1 = ra_1 + (1-r)d_1 \\ d_2 = \beta_2 \\ \beta_2 = \beta_1 \\ a_2 = a_2 \\ \beta_1 = ra_2 + (1-r)d_2 \end{cases}$$

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2.5. Economic Order Quantity Method

The EOQ method is a way to determine the number of items that must be ordered to meet demand forecasts at the minimum possible inventory cost (Fithri et al, 2019). The equation for calculating the optimal order quantity can be calculated using the following equation

$$q_0 = \sqrt{\frac{2AD}{H}} \tag{16}$$

The equation for calculating the total cost of inventory can be calculated using the following equation

$$T_b = (B \times D) + \frac{A}{q}D + \frac{H}{2}q \tag{17}$$

where:

q_0 : Optimal order quantity
A : Booking fee for each order
D : Demand for goods per period
H : Cost of storing goods per period

2.6. Min-Max Method

The Min-Max method is an inventory control method based on the assumption that inventory is at a minimum level and a maximum level. The Min-Max method aims to find out how much minimum inventory and maximum inventory must be available in the warehouse so that there is no waste of inventory costs (Robayo-Salazar, 2018). There are several stages in the Min-Max method (Kinanthi et al, 2016):

1. Determining Safety Stock

   According to Rizqi, (2020), safety stock can be calculated using the following equation

   $$SS = Sd \times \sqrt{LT} \tag{18}$$

   The standard deviation of demand can be calculated using the following equation

   $$Sd = \sqrt{\frac{\sum_{t=1}^{n}(D_t - \overline{D})^2}{n}} \tag{19}$$

   where:

   SS : Safety stock
   Sd : Standard deviation of demand
   LT : Lead time
   D_t : Demand in period-t
   $\overline{D}$: Average demand
   n : Number of data

2. Determining Minimum and Maximum Inventory

   Minimum inventory can be calculated using the following equation

$$\text{Minimum Stock} = (\overline{D} \times LT) + SS \tag{20}$$

Maximum inventory can be calculated using the following equation

$$\text{Maximum Stock} = 2 \times (\overline{D} \times LT) + SS \tag{21}$$

3. Order Quantity (Q)

Determination of the number of orders in one message (Q) can be calculated using the following equation (Rizqi, 2020)

$$Q = 2 \times \overline{D} \times LT \tag{22}$$

3. Materials and Methods

3.1. Materials

The object used in this study is sales data of spare parts Oil Filter LT, Oil Filters TBR, Oil Filters E2, and Oil Filters P165 EURO2 from January 2020 to December 2022 from PT Astra International. The data used is secondary data or data collected by others. The method used to calculate forecasting is the Holt's Double Exponential Smoothing method. The methods used to analyze inventory control are the Economic Order Quantity method and the Min-Max method.

3.2. Methods

The steps taken to complete this research are as follows:

1. Plotting and identifying patterns of oil filter spare parts sales data from January 2020 to December 2022.
2. Specify α and β using the Golden Section Search method with the equation (11), (12), (13), and (14) until the stopping criteria are met.
3. Perform forecasting with the Holt's Double Exponential Smoothing method using the equation (1)
4. Evaluate forecasting results with MAPE using the equation (7).
5. Obtained sales forecasting results for the next period.
6. Calculate the optimal order quantity using the equation (16) and equation (22).
7. Calculate the total optimal cost using the equation (17).

4. Results and Discussion

4.1. Identification of Data Patterns

Graphs of sales data for the four types of oil filter spareparts can be seen in Figures 1, 2, 3 and 4.

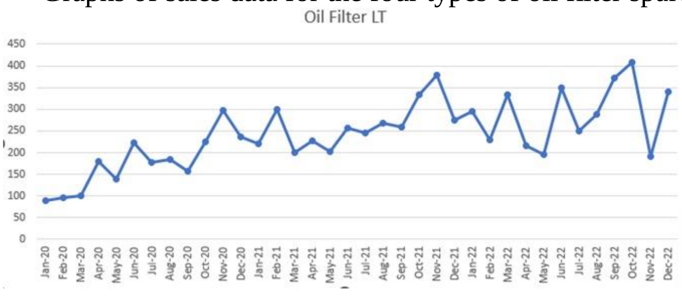

Figure 1: Oil filter LT

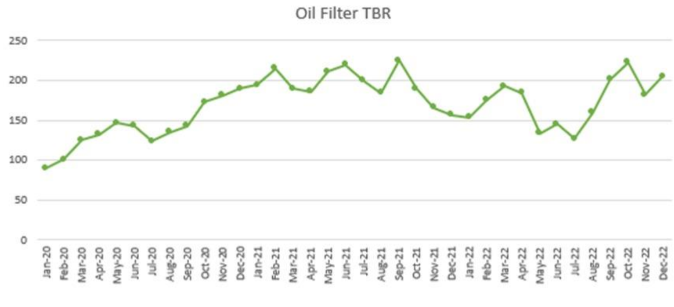

Figure 2: Oil filter TBR

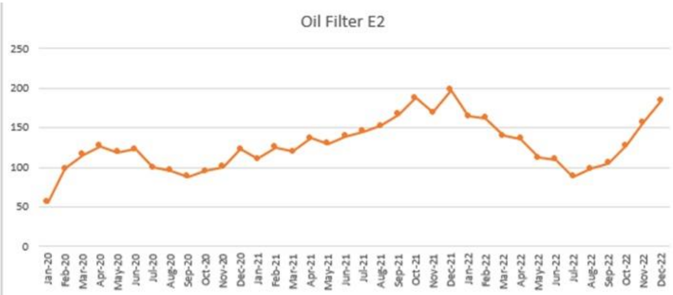

Figure 3: Oil filter E2

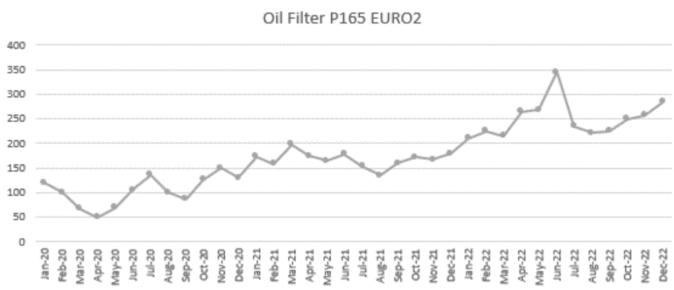

Figure 4: Oil Filter P165 EURO2

In Figures 1, 2, 3 and 4, it can be seen that the sales data for the four types of Oil Filter spareparts tend to have a pattern with an upward trend and there is no seasonality. Therefore, forecasting can be done using the Holt's Double Exponential Smoothing method.

4.2. Forecasting of Spareparts Oil Filter

4.2.1. Forecasting Demand of Sparepart Oil Filter LT

The determination of parameters α and β in the Holt's DES method is determined by the GSS method to obtain optimum results using equations (11), (12), (13), and (14) until the stopping criteria are met. The error used in this study is 1×10^{-3}. The optimum parameter α is 0,25233 and β is 0,20473.

Then two initializations are determined using equation (4) and equation (5). $L_1 = 90$ and $b_1 = 5$ are obtained. Using equation (2) and equation (3), the level and trend values are obtained. The values obtained are used to calculate the forecasting value using equation (1). So that demand forecasting can be obtained for the 37th period to the 48th period, namely January 2023 to December 2023, which is shown in Table 2.

Table 2: Results of Forecasting demand for Oil Filter LT

Month	Period	F_t (pcs)
Jan-23	37	316
Feb-23	38	319
Mar-23	39	323
Apr-23	40	326
May-23	41	330
Jun-23	42	333
Jul-23	43	337
Aug-23	44	340
Sep-23	45	344
Oct-23	46	347
Nov-23	47	351
Dec-23	48	354
Amount		4020

Evaluation of forecasting results is carried out using MAPE which gives a result of 19.93502%. Based on Table 1, it can be seen that the forecasting results are accurate.

4.2.2. Forecasting Demand of Sparepart Oil Filter TBR

The determination of parameters α and β in the Holt's DES method is determined by the GSS method to obtain optimum results using equations (11), (12), (13), and (14) until the stopping criteria are met. The error used in this study is 1×10^{-3}. The optimum parameter α is 0,85365 and β is 0.10361.

Then two initializations are determined using equation (4) and equation (5). $L_1 = 90$ and $b_1 = 11$ are obtained. Using equation (2) and equation (3), the level and trend values are obtained. The values obtained are used to calculate the forecasting value using equation (1). So that demand forecasting can be obtained for the 37th period to the 48th period, namely January 2023 to December 2023, which is shown in Table 3.

Table 3: Results of Forecasting demand for Oil Filter TBR

Month	Period	F_t (pcs)
Jan-23	37	206
Feb-23	38	209
Mar-23	39	212
Apr-23	40	215
May-23	41	219
Jun-23	42	222
Jul-23	43	225
Aug-23	44	228
Sep-23	45	231
Oct-23	46	234
Nov-23	47	237
Dec-23	48	241
Amount		2,679

Evaluation of forecasting results is carried out using MAPE which gives a result of 10.6683%. Based on Table 1, it can be seen that the forecasting results are accurate.

4.2.3. Forecasting Demand of Sparepart Oil Filter E2

The determination of parameters α and β in the Holt's DES method is determined by the GSS method to obtain optimum results using equations (11), (12), (13), and (14) until the stopping criteria are met. The error used in this study is 1×10^{-3} The optimum parameter α is 0.74293 and β is 0.85365.

Then two initializations are determined using equation (4) and equation (5). $L_1 = 56$ and $b_1 = 42$ are obtained. Using equation (2) and equation (3), the level and trend values are obtained. The values obtained are used to calculate the forecasting value using equation (1). So that demand forecasting can be obtained for the 37th period to the 48th period, namely January 2023 to December 2023, which is shown in Table 4.

Table 4: Results of Forecasting demand for Oil Filter E2

Month	Period	F_t (pcs)
Jan-23	37	213
Feb-23	38	243
Mar-23	39	273
Apr-23	40	303
May-23	41	333
Jun-23	42	363
Jul-23	43	393
Aug-23	44	423
Sep-23	45	453
Oct-23	46	482
Nov-23	47	512
Dec-23	48	542
Amount		4,533

Evaluation of forecasting results is carried out using MAPE which gives a result of 10.50649%. Based on Table 1, it can be seen that the forecasting results are accurate.

4.2.4. Forecasting Demand of Sparepart Oil Filter P165 EURO2

The determination of parameters α and β in the Holt's DES method is determined by the GSS method to obtain optimum results using equations (11), (12), (13), and (14) until the stopping criteria are met. The error used in this study is 1×10^{-3}. The optimum parameter α is 0.64389 and β is 0.11027.

Then two initializations are determined using equation (4) and equation (5). $L_1 = 120$ and $b_1 = -20$ are obtained. Using equation (2) and equation (3), the level and trend values are obtained. The values obtained are used to calculate the forecasting value using equation (1). So that demand forecasting can be obtained for the 37th period to the 48th period, namely January 2023 to December 2023, which is shown in Table 5.

Table 5: Results of Forecasting demand for Oil Filter P165 EURO2

Month	Period	F_t (pcs)
Jan-23	37	280
Feb-23	38	285
Mar-23	39	291
Apr-23	40	296
May-23	41	301
Jun-23	42	307
Jul-23	43	312
Aug-23	44	318
Sep-23	45	323
Oct-23	46	328
Nov-23	47	334
Dec-23	48	339
Amount		3,714

Evaluation of forecasting results is carried out using MAPE which gives a result of 16.23909%. Based on Table 1, it can be seen that the forecasting results are accurate.

4.3. Calculating Inventory Control Using the EOQ Method

The inventory data required in calculating inventory control using the EOQ method is shown in Table 6.

Table 6: Inventory data of sparepart oil filter

Spareparts	Ordering Cost (IDR)	Holding Cost (IDR)	Demand of spareparts (pcs)
Oil Filter LT	2,000,000	135,000	4,020
Oil Filter TBR	2,000,000	135,000	2,679
Oil Filter E2	2,000,000	135,000	4,533
Oil Filter P165 EURO2	2,000,000	135,000	3,714

Based on the inventory data in Table 6, the calculation of the optimal order quantity (q_0) of the total inventory cost of each type of spareparts can be done using equation 16 and equation 17. The calculation results will be shown in table 7.

Table 7: EOQ method calculation result

Spareparts	Optimal order quantity (q_0)	Total Cost
Oil Filter LT	345	46,591,845
Oil Filter TBR	282	38,034,984
Oil Filter E2	366	49,475,448
Oil Filter P165 EURO2	332	44,783,479

4.4. Calculating Inventory Control Using the Min-Max Method

Calculations using the Min-Max method will be applied to each type of oil filter spareparts. The calculation results will be shown in Table 8.

Table 8: Min-Max method calculation result

Sparepart	Standard	Safety	Minimum	Maximum	Q	Total Cost

	Deviation	Stock	Stock	Stock		(IDR)
Oil Filter LT	12.049	6	83	160	154	62,602,792
Oil Filter TBR	10.88	5	57	108	103	58,971,917
Oil Filter E2	103.24	50	137	224	174	63,848,448
Oil Filter P165 EURO2	87.11	42	113	184	142	61,894,85

4.5. Comparison of Oil Filter Spareparts Inventory Control

The results of the comparison of inventory control calculations using the EOQ method and the Min-Max method are shown in Table 9.

Table 9: Comparison of EOQ and Min-Max calculation results

	EOQ Method		Min-Max Method	
	Order Quantity (pcs)	Total Cost (IDR)	Order Quantity (pcs)	Total Cost (IDR)
Oil Filter LT	345	46,591,845	154	62,602,792
Oil Filter TBR	282	38,034,984	103	58,971,917
Oil Filter E2	366	49,475,448	174	63,848,448
Oil Filter P165 EURO2	332	44,783,479	142	61,894,859
Total Inventory Cost		178,885,756		247,318,017

Based on Table 9, it shows the results of the calculation of the total inventory cost in the EOQ method of Rp178,885,756 and the Min-Max method of IDR 247,318,017. The calculation results of the EOQ method are smaller than the calculation results of the Min-Max method with a difference in total inventory costs of IDR 68,432,261. Thus, the EOQ method is the best method for calculating inventory control and can be used as a reference for companies in saving inventory costs.

5. Conclusion

The results showed that the Holt's Double Exponential Smoothing forecasting method is a good method to use in forecasting the demand for oil filter spare parts at PT Astra International Soekarno Hatta because it produces a MAPE value of less than 20%. And the calculation of total inventory costs using the EOQ method is more optimal than the Min-Max method.

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References

Fithri, P., Hasan, A., & Asri, F. M. (2019). Analysis of Inventory Control by Using Economic Order Quantity Model – A Case Study in PT Semen Padang. *Jurnal Optimasi Sistem Industri*, 116-124.

Kinanthi, A. P., Herlina, D., & Mahardika, F. A. (2016). Analisis Pengendalian Persediaa Bahan Baku Menggunakan Metode Min-Max (Studi Kasus PT. Djitoe Indonesia Tobacco). *Peforma*, 87-92.

Lesmana, E., Subartini, B., & Jabar, D. A. (2018, March). Analysis of forcasting and inventory control of raw material supplies in PT INDAC INT'L. In IOP Conference Series: Materials Science and Engineering (Vol. 332, No. 1, p.012015). *IOP Publishing*.

Makridakis, S., & Wheelwright, S. C. (2003). *Forecasting Methods and Applications.* The Forecasting Perspective.

Rizqi, Z. U., & Khairunisa, A. (2020). Integration of deterministic and probabilistic inventory methods to optimize the balance between overstock and stockout. In *IOP Conference Series: Materials Science and Engineering* (Vol. 722, No. 1, p. 012060). IOP Publishing.

Robayo-Salazar, R., Mejía-Arcila, J., de Gutiérrez, R. M., & Martínez, E. (2018). Life cycle assessment (LCA) of an alkali-activated binary concrete based on natural volcanic pozzolan: A comparative analysis to OPC concrete. *Construction and Building Materials*, *176*, 103-111.

Roslin, N. E., Abdul Razak, S. N., Bahrom, M. Z., & Abd Rahman, M. A. (2015). A Conceptual Model of Inventory Management System using an EOQ Technique - A Case Study in Automotive Service Industry. *Journal of Science & Engineering Technology*.

Şenses, S. (2021). *Development of a multi-scenario simulation model for spare parts inventory optimization in mining operations* (Master's thesis, Middle East Technical University).

Siregar, M. J. (2021). Pengendalian Stock Spareparts Mobil dengan Metode EOQ dan Min-Max Inventory. *Serambi Engineering*, 2096-2101.

Syifahati, T., Triska, A., & Nahar, J. (2023). Forecasting the Indonesian Coffee Production and Consumption Using The Exponential Smoothing Methods with Modified Golden Section Search to Estimate the Smoothing Parameters. *Jurnal Matematika Integratif*, 41-54.