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Analysis of Spare Parts Inventory Planning for Machinery with Monte Carlo Simulation, Reorder Point, and Safety Stock

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ABSTRACT

PT. XYZ is a company engaged in the management of mall buildings. The implementation of operations in malls often experiences obstacles, namely the availability of machine spare parts which is less than 95% of the standard inventory availability. The impact of this problem is the ability of PT. XYZ in meeting the needs of consumers. The results of observations and interviews with supervisors show that there is a lack of stock of escalator spare parts, especially for Sigma brands such as Ballasstrude Newel Chain Roller Escalator Sigma Vera, Roller Press Handrail (70x60) Sigma Ares, Roller Press Handrail Escalator Sigma Vera and Roller Step ESC Sigma (6204). This study compares three forecasting methods: exponential smoothing, linear regression, and Monte Carlo simulation. The stages of the research consist of problem identification, determination of data patterns, inventory planning with montecarlo simulations, raw material planning with safety stock and reorder points. The results of this study were obtained that the best method to handle this case was Monte Carlo simulation because it has a high level of accuracy compared to other methods. The accuracy result obtained was a Mean Absolute Percentage Error (MAPE) of 17.03%. The results of the Montecarlo simulation obtained safety stock of 9-16 units and reorder points of 18-28 units. This research can reduce delays in fulfilling production demand, if safety stock and reorder point policies can be implemented.

Keywords: *Inventory, Forecasting, Monte Carlo Simulation, Safety Stock, Reorder Point.*

Introduction

People of all ages, from children to the elderly, can spend their weekends at the mall with family or relatives. Mall visitors engage in various activities, including dining at their favorite restaurants, shopping, and simply browsing the goods on display [1]. There are several malls located in Balikpapan, one of which is Mall X. Currently, Mall X is operated by PT. XYZ. In managing this mall, there are many aspects that PT. XYZ, as the operator, needs to consider, one of which is the maintenance of the machines that support the mall's operations. The escalator machine is a vertical transportation device that can transport one or more individuals from the lower level to the upper level or vice versa [2]. Escalators are used as transportation tools for visitors and kiosk owners. If an escalator experiences trouble, it can disrupt the comfort of visitors and kiosk owners, potentially causing further damage if maintenance is not carried out promptly. This can lead to losses for the company. PT. XYZ stated that they are facing an issue with maintenance delays due to insufficient spare parts inventory. This problem occurred with Sigma-brand escalators and specific spare parts, including the Ballasstrude Newel Chain Roller Escalator Sigma Vera, Roller Press Handrail Escalator Sigma Vera, Roller Press Handrail Escalator (70x50) Sigma Ares, and Roller Step ESC Sigma (6204).

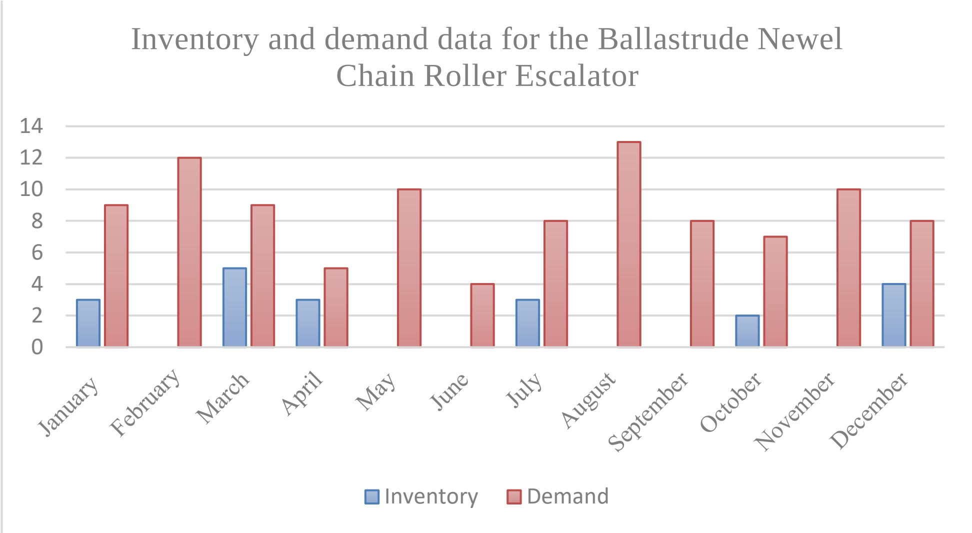

Figure 1. Inventory and Demand Data for Ballasstrude Newel Chain Roller Escalator Sigma Vera Spare Parts.

Figure 1 shows that the demand for spare parts each month in 2023 was not met. This was due to the company not having sufficient spare parts stock, resulting in a delay in maintenance until the following month. Consequently, the availability of the escalator machine did not meet the company's standard of 95%.

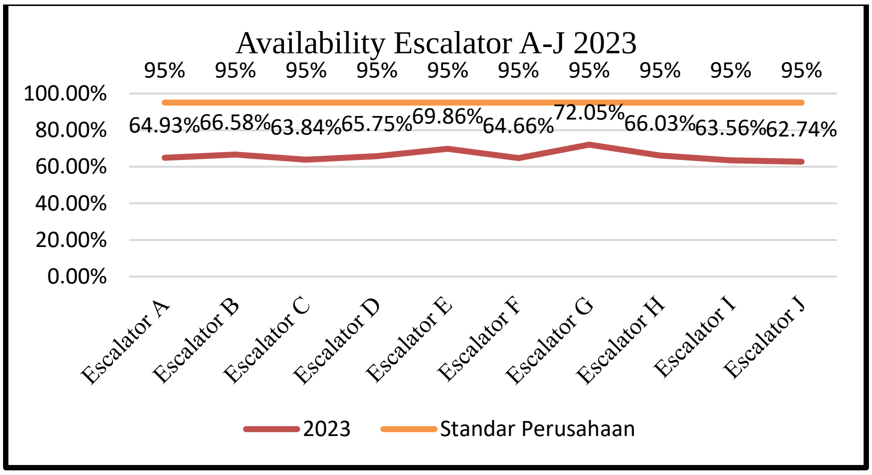

Figure 2 Escalator A – J Availability Data for the Period of January – December 2023
Source: Engineering Department, PT. XYZ, 2024

Figure 2 shows that the mean availability of the escalator machines at Mall X in 2023 was below the company's standard of 95%. The impact of inventory fulfillment being below 95% affected the ability to meet demand. This is because spare parts were only ordered when a component was damaged, and the spare parts fulfillment standard was not met. Therefore, inventory planning must be conducted by applying a forecasting method to determine the quantity of spare parts to be provided. This inventory issue can be addressed through forecasting, an essential element in the decision-making process. Forecasting is typically based on historical data, which is then analyzed. By considering these factors, we can attempt to predict future events. In this context, accuracy or discrepancies must be taken into account. The accuracy test aims to minimize forecasting errors, which are the differences between actual results and predictions [3]. Forecasting is used as a reference in decision-making, and accurate forecasts are crucial for predicting demand for the upcoming period. The results of the forecast are then used for comparison with the Monte Carlo simulation results in managing the escalator spare parts inventory by comparing their accuracy values.

The probabilistic simulation method, known as Monte Carlo simulation, uses random numbers and sample data to solve problems [4]. According to Rahim & Fuad [5], citing Nizar in 2016, random events that occur during each time interval of a random variable are represented by random numbers that follow the changes occurring sequentially in the simulation process. Another factor supporting the use of this method to address the issue is the determination of safety stock, which is inventory held as a precaution against the risk of delays in the arrival of ordered goods [6].

Based on the research conducted by Fahlevi [7], where forecasting was carried out by the company but did not align with actual demand, Monte Carlo Simulation was used in inventory planning for spare parts such as Bearing (6138081) and Gasket (6140120). The results obtained from the Monte Carlo simulation calculations were closer to the actual demand, as the Standard Error of Forecasting (SEF) in the Monte Carlo Simulation was nearly zero, making it a useful technique for inventory planning. The selection of this method was due to the background issue of the lack of inventory planning, which led to the use of Monte Carlo Simulation to estimate the spare parts needs for the escalator machines by the engineering department at PT. XYZ. Additionally, there was no determination of safety stock and reorder points to address maintenance delays caused by insufficient spare parts inventory.

This research is expected to contribute to resolving the issue of unmet consumer demand related to machine maintenance, which is caused by spare parts being below the established standard. The study can also provide inventory control policies, allowing the company to overcome the challenges faced.

Research Methods

Inventory Management

According to Handoko (2015, as cited in Santoso [8]), inventory refers to any goods or resources that are stored within an organization. Furthermore, inventory management in the context of industrial organizations should not be overlooked. Meyliawati and Suprianto (2016, as cited in Lutfiana Indriyana Puspitosari [9]) explain that inventory management involves efforts to control materials from the stages of receipt, storage, maintenance, to distribution, all of which are closely related to the outcomes of procurement and storage activities within the organization.

Forecasting

Forecast analysis is a methodical and practical approach to projecting future events based on relevant historical data. The actual conditions, the purpose of the forecast, and the current situation all influence the time span of the projection. Commonly used time periods include monthly, weekly, semiannual, annual, and daily intervals [10]. The following is the exponential smoothing formula [11].

$$Ft + 1 = \alpha\, Xt + (1 - \alpha\,)Ft - 1$$

The measure of the relationship between two or more variables, expressed as a relationship or function, is known as the linear regression method. A clear distinction between the independent variable, commonly denoted by the symbol *X*, and the dependent variable, usually denoted by the symbol *Y*, is necessary to determine the type of relationship (regression). The following is the formula for linear regression [12].

$$\boldsymbol{Y = a + bX}$$

Monte Carlo simulation

In mathematics, product or goods demand can be forecasted using the Monte Carlo simulation. Therefore, by understanding the prognosis or projection of product demand, stock levels can be managed to meet consumer demand and prevent stock shortages [13]. Based on historical data, the Monte Carlo Simulation Model calculates the probability and frequency of an event [14], as stated by Giles [15].

$$\boldsymbol{Pi = \frac{fi}{n}}$$

By summing the values from the probability distribution to the preceding values, we can obtain the cumulative probability distribution. Thus, the cumulative distribution is derived by adding the values from the probability distribution. Therefore, the equation is as follows [16].

$$DPK = Pi + Ki$$

After obtaining the probability distribution and cumulative distribution, the next step in the Monte Carlo simulation is to create random number intervals. These intervals are constructed using the previously obtained probabilities and cumulative distribution, and then used to generate random numbers to determine probabilities [16]. One method for generating random numbers is by using Microsoft Excel and the function "=RAND()" [13].

Accuracy Test

If the forecasted value and the actual value of a variable match, the forecast is considered perfect. It is expected that forecasting be conducted with minimal error, as it is very difficult to achieve consistently accurate predictions. The difference between the actual value of a variable and the forecasted value for the same period is called the forecasting error [17]. According to Sultan [18], several calculation techniques can be used to determine the extent of forecasting inaccuracy, as follows.

$$MSE = \frac{1}{n}\sum(At - Ft)^2 \tag{5}$$

$$MAD = \frac{1}{n}\sum|At - Ft|^2 \tag{6}$$

$$MAPE = \left(\frac{100}{n}\right)\sum\left|\frac{At - F_t}{A_t}\right| \tag{7}$$

In comparing the forecasting accuracy between one method and another, MAPE (Mean Absolute Percentage Error) is a good choice as a benchmark because it shows the level of forecasting error as a percentage of the error value relative to the actual condition [19]. Meanwhile, when using MAD (Mean Absolute Deviation) and MSE (Mean Squared Error) to compare the accuracy of error values from several methods, the forecasting results may not be directly comparable. This is because MAD and MSE are absolute measures that are highly dependent on the scale of the time series data [20].

Safety Stock

Safety stock is an essential requirement for companies to avoid difficulties caused by stockouts or delays in the delivery of spare parts needed during operational processes. Companies create this stock reserve as a step to reduce potential losses caused by stockouts. Therefore, the use of safety stock is crucial to address such uncertainties [6]. The formula for standard deviation is as follows [21].

$$\bar{x} = \frac{d}{n} \tag{8}$$

$$\sigma = \sqrt{\frac{\sum(x - \bar{x})^2}{n}} \tag{9}$$

The next step in calculating safety stock is to determine the desired service level [22], which can be defined as the level of probability that the company aims to achieve in meeting demand requirements [23]. The formula for safety stock is as follows [24].

$$SS = Z\sigma\sqrt{LT} \tag{10}$$

Reorder Point

The time designated for reordering to maintain uninterrupted service is known as the reorder point (ROP). To ensure the availability of items, each critical spare part must have a specified reorder point value [25].

$$ROP = (d\ x\ LT) + SS \tag{11}$$

The method used is to compare the three forecasting methods, in order to determine the optimal forecasting method for inventory control. The selection of this method is based on achieving optimal accuracy, thereby reducing stockouts.

Results and Discussion

Identification of Historical Data Patterns for Forecasting

An identification of the historical demand patterns was carried out for the four types of spare parts used in this study. The results of the historical demand pattern analysis for the Ballasstrude Newel Chain Roller Escalator Sigma Vera spare part can be seen in Figure 3.

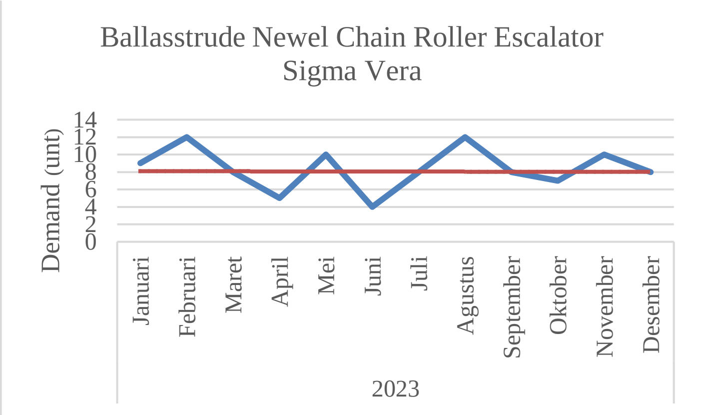

Figure 3. Historical Demand Pattern of the Ballasstrude Newel Chain Roller Escalator Sigma Vera Spare Part

Based on Figure 3, the data presented exhibits a seasonal pattern, and similar seasonal and horizontal patterns are also observed in the other spare parts. Therefore, exponential smoothing and linear regression methods were selected as the forecasting methods for these spare parts.

Forecasting Calculation

The forecasting calculation was carried out using the methods determined based on the data patterns derived from the historical demand for spare parts. Each item exhibited seasonal and horizontal patterns; therefore, exponential smoothing and linear regression methods were applied in this study. These methods were chosen because they are suitable for both seasonal and horizontal data patterns. The forecasting calculation using the exponential smoothing method for the Ballasstrude Newel Chain Roller Escalator Sigma Vera spare part can be seen in Table 1.

Table 1. *Forecasting Ballasstrude Newel Chain Roller Escalator Sigma Vera a = 0,1*

No	Period	Actual	Period	Forecasting
1	Januari 2023	9	Januari 2024	7
2	Februari 2023	12	Februari 2024	7
3	Maret 2023	8	Maret 2024	8
4	April 2023	5	April 2024	8
5	Mei 2023	10	Mei 2024	8
6	Juni 2023	4	Juni 2024	8
7	Juli 2023	8	Juli 2024	7
8	Agustus 2023	12	Agustus 2024	7
9	September 2023	8	September 2024	8
10	Oktober 2023	7	Oktober 2024	8
11	November 2023	10	November 2024	8
12	Desember 2023	8	Desember 2024	8

Table 2. Forecasting Recapitulation Using the Exponential Smoothing Method (α = 0.1 – 0.9)

Ballasstrude Newel Chain Roller Escalator Sigma Vera	**MAD**	**MSE**	**MAPE (%)**
α = 0,1	2,08	7,42	27,70%
α = 0,2	2,15	7,00	29,25%
α = 0,3	2,32	7,49	31,95%
α = 0,4	2,49	8,06	34,34%
α = 0,5	2,66	8,69	36,55%
α = 0,6	2,82	9,39	38,62%
α = 0,7	2,97	10,17	40,57%
α = 0,8	3,11	11,06	42,42%
α = 0,9	3,23	12,05	44,16%

Based on Tables 1 and 2 above, the forecasting recap results for one of the escalator spare parts, the Ballasstrude Newel Chain Roller Escalator Sigma Vera, can be observed using α = 0.1 – 0.9 to determine the accuracy values of MAD (Mean Absolute Deviation), MSE (Mean Squared Error), and MAPE (Mean Absolute Percentage Error). The results show that the lowest error value was obtained at α = 0.1. This result serves as the reference for forecasting the Ballasstrude Newel Chain Roller Escalator Sigma Vera spare part. The forecasting recapitulation for the other spare parts also uses the exponential smoothing method with the alpha (α) value that yields the lowest error.

After obtaining the forecasting results using the exponential smoothing method, forecasting was then conducted using linear regression. The forecasting calculation using the linear regression method for the Ballasstrude Newel Chain Roller Escalator Sigma Vera spare part was performed with the help of Excel, resulting in an intercept of 8.666 and an X variable coefficient of -0.038, as shown in Table 3.

Table 3 Forecasting Ballasstrude Newel Chain Roller Escalator Sigma Vera

No	**Period**	**Actual**	**Period**	**Forecasting**
1	January 2023	9	January 2024	9
2	February 2023	12	February 2024	9
3	March 2023	8	March 2024	9
4	April 2023	5	April 2024	9
5	May 2023	10	May 2024	8
6	June 2023	4	June 2024	8
7	July 2023	8	July 2024	8
8	August 2023	12	August 2024	8
9	September 2023	8	September 2024	8
10	October 2023	7	October 2024	8
11	November 2023	10	November 2024	8
12	December 2023	8	December 2024	8

Based on the calculations performed, the result for January 2024 is 9 units. The accuracy calculation results for the Ballasstrude Newel Chain Roller Escalator Sigma Vera spare part are as follows: MAD (Mean Absolute Deviation) 1.75, MSE (Mean Squared Error) 5.58, and MAPE (Mean Absolute Percentage Error) 25.43%.
After obtaining the forecasting results using exponential smoothing and linear regression, the next step is the Monte Carlo simulation.

Monte Carlo Simulation

The Monte Carlo simulation is used to calculate the optimal inventory amount for one period by generating random numbers with the same distribution as the historical data. Random numbers can be generated using the Excel function "=Rand()", where the random number represents the inventory data of the escalator spare parts for a given period. In this study, 10 iterations, or 10 random number generations, are used for one period, and the average value of the simulation results from these random number generations is taken. The Monte Carlo simulation calculation for the Ballasstrude Newel Chain Roller Escalator Sigma Vera spare part can be seen in Table 4.

Table 4. Probability of Generated Random Numbers.

Demand	Frequency	Probability	Cumulative Probability Distribution	Random Number Interval
4	1	0,083	0,083	0-0,083
5	1	0,083	0,167	0,084-0,167
7	1	0,083	0,250	0,168-0,250
8	4	0,333	0,583	0,251-0,583
9	1	0,083	0,667	0,584-0,667
10	2	0,167	0,833	0,668-0,833
12	2	0,167	1,000	0,834-1,000
Total	**12**	**1**		

After obtaining the frequency results in Table 4, the probability is determined using the equation in (3) and the cumulative probability distribution using the equation in (4), where the cumulative probability distribution results are then used to determine the random number interval before generating the random numbers.

Table 5. Random Number Generation

Iteration	Random Number (Simulation Result)											
	Jan 24	**Feb 24**	**Mar 24**	**Apr 24**	**Mei 24**	**Jun 24**	**Jul 24**	**Aug 24**	**Sep 24**	**Oct 24**	**Nov 24**	**Dec 24**
1	0,827 (10)	0,867 (12)	0,622 (9)	0,145 (5)	0,969 (12)	0,341 (8)	0,558 (8)	0,949 (12)	0,616 (9)	0,089 (5)	0,437 (8)	0,779 (10)
2	0,946 (12)	0,709 (10)	0,059 (4)	0,443 (8)	0,164 (5)	0,349 (8)	0,188 (7)	0,402 (8)	0,054 (4)	0,780 (10)	0,708 (10)	0,074 (4)
3	0,468 (8)	0,508 (8)	0,692 (10)	0,559 (8)	0,926 (12)	0,258 (8)	0,918 (12)	0,831 (10)	0,894 (12)	0,859 (12)	0,951 (12)	0,786 (10)
4	0,038 (4)	0,919 (12)	0,444 (8)	0,357 (8)	0,928 (12)	0,081 (4)	0,525 (8)	0,938 (12)	0,665 (9)	0,540 (8)	0,957 (12)	0,128 (5)
5	0,967 (12)	0,906 (12)	0,199 (7)	0,878 (10)	0,522 (8)	0,646 (9)	0,710 (10)	0,789 (10)	0,751 (10)	0,920 (12)	0,013 (4)	0,852 (12)
6	0,543 (8)	0,653 (9)	0,957 (12)	0,918 (12)	0,697 (10)	0,870 (12)	0,338 (8)	0,981 (12)	0,029 (4)	0,554 (8)	0,986 (12)	0,335 (8)
7	0,349 (8)	0,769 (10)	1,000 (12)	0,961 (12)	0,602 (9)	0,296 (8)	0,054 (4)	0,293 (8)	0,823 (10)	0,635 (9)	0,394 (8)	0,115 (5)
8	0,209 (7)	0,157 (5)	0,028 (4)	0,035 (4)	0,473 (8)	0,983 (12)	0,589 (9)	0,594 (9)	0,771 (10)	0,402 (8)	0,798 (10)	0,662 (9)
9	0,558 (8)	0,868 (12)	0,312 (8)	0,926 (12)	0,929 (12)	0,031 (4)	0,375 (8)	0,574 (8)	0,084 (4)	0,143 (5)	0,350 (8)	0,359 (8)
10	0,695 (10)	0,704 (10)	0,368 (8)	0,101 (5)	0,478 (8)	0,352 (8)	0,518 (8)	0,950 (12)	0,494 (8)	0,129 (5)	0,875 (12)	0,085 (5)
$\bar{x}$	**9**	**10**	**8**	**8**	**10**	**8**	**8**	**10**	**8**	**8**	**10**	**8**

Based on Table 5, which presents the results of random number generation using Microsoft Excel with the formula “=Rand()”, the generated random numbers have a range from 0 to 1, which are then used as a representation of the predicted demand for spare parts based on their random number intervals. The random number generation is performed for 10 iterations for each spare part demand period, and the simulation results for the demand are averaged to obtain the final predicted demand value. The prediction results using the Monte Carlo simulation for January 2024, with 10 iterations, yield an average value of 9 units.

Table 6. Monte Carlo Simulation Results

No	Month	Actual	Month	Simulation
1	January 2023	9	January 2024	9
2	February 2023	12	February 2024	10
3	March 2023	8	March 2024	8
4	April 2023	5	April 2024	8
5	May 2023	10	May 2024	10
6	June 2023	4	June 2024	8
7	July 2023	8	July 2024	8
8	August 2023	12	August 2024	10
9	September 2023	8	September 2024	8
10	October 2023	7	October 2024	8
11	November 2023	10	November 2024	10
12	December 2023	8	December 2024	8
	Total	**101**		**105**

Based on Table 6, which presents the actual data and the results of the Monte Carlo simulation, a total of 101 units was obtained for the Ballasstrude Newel Chain Roller Escalator Sigma Vera spare part for the period of January – December 2023. After forecasting for the subsequent period, the total spare parts for the period of January – December 2024 is predicted to be 106 units.

Comparison Analysis of Forecasting Methods.
Forecasting has been conducted using the exponential smoothing method, linear regression, and Monte Carlo simulation based on historical demand data for spare parts in 2023. The discussion focuses on a comparison of the forecasting results along with the comparison of their accuracy values. The recap of the comparison for the Ballasstrude Newel Chain Roller Escalator Sigma Vera spare part is as follows.

Table 7. Comparison of Forecasting Results for Ballasstrude Newel Chain Roller Escalator Sigma Vera Spare Parts

No	Period	Actual (2023)	*Forecasting α = 0,1*	Regression Linear	Simulation
1	January	9	7	9	9
2	February	12	7	9	10
3	March	8	8	9	8
4	April	5	8	9	8
5	May	10	8	8	10
6	June	4	8	8	8
7	July	8	7	8	8
8	August	12	7	8	10
9	September	8	8	8	8
10	October	7	8	8	8
11	November	10	8	8	10
12	December	8	8	8	8
	Total	**101**	**92**	**100**	**105**
	MAD		**2,08**	**1,75**	**1,00**

No	Period	Actual (2023)	*Forecasting α = 0,1*	Regression Linear	Simulation
	MSE		**7,42**	**5,58**	**2,83**
	MAPE		**27,70%**	**25,43%**	**17,30%**

Based on Table 7, the comparison of the three forecasting methods for the Ballasstrude Newel Chain Roller Escalator Sigma Vera spare parts shows that the exponential smoothing method with α = 0.1 results in a forecast lower than the actual data, with a total of 92 units compared to the actual 101 units, and has the lowest accuracy with a MAPE of 27.70%. The linear regression method provides a forecast that is closer to the actual value, with a total of 100 units, but is less responsive to monthly variations, even though its MAPE is 25.43%. Meanwhile, the Monte Carlo simulation method gives the most accurate results, with a total of 105 units and a MAPE of 17.30%, and is better able to capture data variations compared to the other methods. Based on this evaluation, Monte Carlo is considered the most effective method, followed by linear regression, while exponential smoothing has the lowest accuracy.

Safety Stock

Safety stock is implemented to minimize the potential for stock shortages. To optimize the spare parts inventory, a service level of 95% (z = 1.65) will be used, and the lead time for spare parts delivery is 30 days. Then, the formulas in equations (8) and (9) are used to calculate the standard deviation, and the calculation result for the standard deviation of the Ballasstrude Newel Chain Roller Escalator Sigma Vera spare parts is 0.92. After obtaining the standard deviation, the next step is to calculate the safety stock for these spare parts using the formula in equation (10).

$$Safety\ stock = Z\sigma\sqrt{LT}$$

$$= 1{,}65\ x\ 0{,}92\ x\ \sqrt{30}$$

$$= 8{,}35 \approx 9\ \text{Units}$$

The minimum inventory or safety stock that needs to be kept in the company's warehouse, based on the calculation, is 9 units for the Ballasstrude Newel Chain Roller Escalator Sigma Vera spare parts.

Reorder Point

The calculation of the reorder point is done using a lead time of 30 days, which equals 1 month. The reorder point is used to determine the point at which a new order for spare parts should be placed to prevent stockouts. For each spare part, the reorder point is calculated using equation (11), and for example, the reorder point calculation for the Ballasstrude Newel Chain Roller Escalator Sigma Vera spare part is as follows.

$$Reorder\ Point = (d\ x\ LT) + SS$$

$$= \left(\frac{105}{12}\ x\ 1\right) + 8$$

$$= 17{,}8 \approx 18\ \text{Units}$$

The reorder point for the Ballasstrude Newel Chain Roller Escalator Sigma Vera spare part is triggered when there are only 18 units remaining.

Table.8 Recap of Safety Stock and Reorder Point for Escalator Spare Parts

No.	Nama Spare Parts	Safety Stock	Reorder Point
1	Ballasstrude Newel Chain Roller Escalator Sigma Vera	9	18
2	Roller Press Handrail Escalator (70x50) Sigma Ares	16	28
3	Roller Press Handrail Escalator Sigma Vera	10	23
4	Roller Step ESC Sigma (6204)	10	25

Conclusion

Based on the research and data analysis conducted, it can be concluded that the results of the Monte Carlo simulation show a forecasting error range of 9.38% to 18.43%. The optimal spare parts inventory for the period of January–December 2024 is 105 units for the Ballasstrude Newel Chain Roller Escalator Sigma Vera, 140 units for the Roller Press Handrail Escalator (70x50) Sigma Ares, 146 units for the Roller Press Handrail Escalator Sigma Vera, and 180 units for the Roller Step ESC Sigma (6204). In addition, the safety stock (SS) and reorder point (ROP) for each spare part have also been calculated. For the Ballasstrude Newel Chain Roller Escalator Sigma Vera, the safety stock is set at 9 units, with the reorder point triggered when the stock reaches 18 units. The Roller Press Handrail Escalator (70x50) Sigma Ares has a safety stock of 16 units and a reorder point at 28 units, the Roller Press Handrail Escalator Sigma Vera has a safety stock of 10 units and a reorder point at 23 units, and the Roller Step ESC Sigma (6204) has a safety stock of 10 units and a reorder point at 25 units. This inventory control approach can help address stockout issues, optimize incurred costs, and enable the company to increase its profits.

References

[1] F. Fauzi and H. Herindiyati, "TINJAUAN PUSAT PERBELANJAAN DI KOTA JAKARTA DARI BERBAGAI ASPEK ARSITEKTUR," *Jurnal KaLIBRASI - Karya Lintas Ilmu Bidang Rekayasa Arsitektur, Sipil, Industri*, vol. 5, no. 1, pp. 45–66, 2022, doi: 10.37721/KALIBRASI.V5I1.972.

[2] D. Nur Prakoso, Y. Prasetyo, B. Winarno, B. Triyono, P. Teknik Listrik, and J. Teknik Politeknik Negeri Madiun, "Design System Warning & Safety Escalator dengan HMI Berbasis PLC," *JTEIN: Jurnal Teknik Elektro Indonesia*, vol. 4, no. 2, pp. 490 – 501–490 – 501, Aug. 2023, doi: 10.24036/JTEIN.V4I2.356.

[3] S. Anggraeni and J. Arifin, "Peramalan Permintaan Printing Menggunakan Metode Double Exponential Smoothing dan Pengujian Hasil Menggunakan Grafik Tracking Signal pada PT. XYZ," *Jurnal Ilmiah Wahana Pendidikan*, vol. 8, no. 13, pp. 430–439, Aug. 2022, doi: 10.5281/ZENODO.6962720.

[4] Yusmaity, J. Santony, and Y. Yunus, "Simulasi Monte Carlo untuk Memprediksi Hasil Ujian Nasional (Studi Kasus di SMKN 2 Pekanbaru)," *Jurnal Informasi dan Teknologi*, vol. 1, no. 4, pp. 1–6, Dec. 2019, doi: 10.37034/JIDT.V1I4.21.

[5] R. Rahim and R. N. Fuad, "APLIKASI DALAM SIMULASI PENJUALAN DENGAN MENGGUNAKAN METODE MONTE CARLO," *Ready Star*, vol. 2, no. 1, pp. 235–239, Nov. 2019, Accessed: Sep. 05, 2023. [Online]. Available: https://ptki.ac.id/jurnal/index.php/readystar/article/view/61

[6] H. Hazimah, Y. A. Sukanto, and N. A. Triwuri, "Analisis Persedian Bahan Baku, Reorder Point dan Safety Stock Bahan Baku ADC-12," *Jurnal Ilmiah Universitas Batanghari Jambi*, vol. 20, no. 2, pp. 675–681, Jul. 2020, doi: 10.33087/jiubj.v20i2.989.

[7] D. S. Fahlevi, M. Zaky, and A. Nadifa, "ANALISIS PERENCANAAN PERSEDIAAN SPAREPART DENGAN PENDEKATAN METODE SIMULASI MONTECARLO PADA PT PUPUK ISKANDAR MUDA," *Jurnal Industri Samudra*, vol. 3, no. 2, pp. 9–9, Oct. 2022, Accessed: Oct. 09, 2023. [Online]. Available: https://ejurnalunsam.id/index.php/jis/article/view/6934

[8] R. Santoso and F. Santoso, "PERANCANGAN SISTEM INFORMASI MANAJEMEN PERSEDIAAN BARANG PADA PT.KENCANA MITRA TINELO JAKARTA," *Indonesian Journal of Networking and Security (IJNS)*, vol. 10, no. 3, Sep. 2021, doi: 10.55181/IJNS.V10I3.1728.

[9] L. Lutfiana Indriyana Puspitosari, "Analisis Manajemen Persediaan UMKM Jazid Bastomi Batik di Purworejo," *Jurnal Ekonomi Syariah, Akuntansi, dan Perbankan*, vol. 4, no. 1, pp. 55–66, 2020, Accessed: Sep. 24, 2023. [Online]. Available: https://www.neliti.com/publications/326625/

[10] A. Afifah Muhartini, O. Sahroni, S. Dwi Rahmawati, T. Febrianti, and I. Mahuda, "ANALISIS PERAMALAN JUMLAH PENERIMAAN MAHASISWA BARU DENGAN MENGGUNAKAN METODE REGRESI LINEAR SEDERHANA," *Jurnal Bayesian : Jurnal Ilmiah Statistika dan Ekonometrika*, vol. 1, no. 1, pp. 17–23, Mar. 2021, doi: 10.46306/BAY.V1I1.2.

[11] R. Raihan, M. S. Effendi, and A. Hendrawan, "Forcasting Model Exsponensial Smoothing Time Series Rata Rata Mechanical Availability Unit Off Highway Truck CAT 777D Caterpillar," *POROS TEKNIK*, vol. 8, no. 1, pp. 1–9, 2016, doi: 10.31961/POROSTEKNIK.V8I1.375.

[12] A. M. Ajeng, S. Oman, D. R. Septi, F. Tanti, and M. Isnaini, "ANALISIS PERAMALAN JUMLAH PENERIMAAN MAHASISWA BARU DENGAN MENGGUNAKAN METODE REGRESI LINEAR SEDERHANA," *Jurnal Bayesian : Jurnal Ilmiah Statistika dan Ekonometrika*, vol. 1, no. 1, pp. 17–23, Mar. 2021, doi: 10.46306/BAY.V1I1.2.

[13] I. Syata, T. Azisah Nurman, and A. Nabilla Baroqah Adnan, "Simulasi Monte Carlo Dalam Meramalkan Pola Permintaan Tanaman Hias Melalui Usaha Rumahan di Tengah Pandemi Covid 19," *Jurnal Matematika dan Statistika serta Aplikasinya* , vol. 10, no. 2, pp. 79–84, Dec. 2022, doi: 10.24252/MSA.V10I2.32401.

[14] W. N. Cahyo, "PENDEKATAN SIMULASI MONTE CARLO UNTUK PEMILIHAN ALTERNATIF DENGAN DECISION TREE PADA NILAI OUTCOME YANG PROBABILISTIK," *scholar.archive.org*, vol. 13, no. 2, pp. 11–17, 2008, Accessed: Oct. 05, 2023. [Online]. Available: https://scholar.archive.org/work/ylhphkwo6rh4nmozlienzbxrim/access/wayback/http://jurnal.uii.ac.id/jurnal-teknoin/article/download/791/709

[15] M. B. Giles, "Multilevel Monte Carlo methods," *Acta Numerica*, vol. 24, pp. 259–328, Apr. 2015, doi: 10.1017/S096249291500001X.

[16] R. Prawita, "Simulasi Metode Monte Carlo dalam Menjaga Persediaan Alat Tulis Kantor," *Jurnal Informatika Ekonomi Bisnis*, pp. 72–77, Jun. 2021, doi: 10.37034/INFEB.V3I2.69.

[17] I. Setiawan, "RANCANG BANGUN APLIKASI PERAMALAN PERSEDIAAN STOK BARANG MENGGUNAKAN METODE WEIGHTED MOVING AVERAGE (WMA) PADA TOKO BARANG XYZ," *Jurnal Teknik Informatika*, vol. 13, no. 3, pp. 1–9, 2021, Accessed: Jun. 07, 2024. [Online]. Available: https://ejurnal.ulbi.ac.id/index.php/informatika/article/view/1664

[18] M. Sultan, J. Maulana, and A. Syakhroni, "PERAMALAN PERMINTAAN GULA BULK DAN GULA KEMAS MENGGUNAKAN METODE WINTER'S EXPONENTIAL SMOOTHING DI PT. XYZ," *JURNAL LOGISTICA*, vol. 2, no. 1, pp. 1–6, Dec. 2023, Accessed: Jun. 28, 2024. [Online]. Available: https://journal.iteba.ac.id/index.php/logistica/article/view/157

[19] F. Ahmad, "PENENTUAN METODE PERAMALAN PADA PRODUKSI PART NEW GRANADA BOWL ST Di PT.X," *JISI: Jurnal Integrasi Sistem Industri*, vol. 7, no. 1, pp. 31–39, May 2020, doi: 10.24853/JISI.7.1.31-39.

[20] I. Sungkawa and T. R. Megasari, "Penerapan Ukuran Ketepatan Nilai Ramalan Data Deret Waktu dalam Seleksi Model Peramalan Volume Penjualan PT Satriamandiri Citramulia," *ComTech: Computer, Mathematics and Engineering Applications*, vol. 2, no. 2, pp. 636–645, Dec. 2011, doi: 10.21512/COMTECH.V2I2.2813.

[21] D. Misbachul Umami, M. Fuad Fauzul Mu, and R. Rakhmawati, "ANALISIS EFISIENSI BIAYA PERSEDIAAN MENGGUNAKAN METODE EOQ (ECONOMIC ORDER QUANTITY) PADA PT. XYZ," *JURNAL AGROTEKNOLOGI*, vol. 12, no. 01, pp. 64–70, Jun. 2018, doi: 10.19184/J-AGT.V12I1.8100.

[22] M. N. Piranti and A. Sofiana, "Kombinasi Penentuan Safety Stock Dan Reorder Point Berdasarkan Analisis ABC sebagai Alat Pengendalian Persediaan Cutting Tools (Studi Kasus: PT. XYZ)," *Jurnal Teknik Industri: Jurnal Hasil Penelitian dan Karya Ilmiah dalam Bidang Teknik Industri*, vol. 7, no. 1, pp. 69–78, Jun. 2021, Accessed: Nov. 03, 2023. [Online]. Available: https://ejournal.uin-suska.ac.id/index.php/jti/article/view/12243

[23] R. Wahyudi, "Analisis pengendalian persediaan barang berdasarkan metode eoq di Toko Era Baru Samarinda," *ejournal.hi.fisip-unmul.ac.idR WahyudiEjournal Ilmu Admistrasi Bisnis, 2015•ejournal.hi.fisip-unmul.ac.id*, vol. 2, no. 1, pp. 162–173, 2015, Accessed: Jun. 05, 2024. [Online]. Available: https://ejournal.hi.fisip-unmul.ac.id/site/wp-content/uploads/2015/03/E-journaL%20PDF%20(03-04-15-03-58-13).pdf

[24] M. Hudori, "Formulasi Model Safety Stock dan Reorder Point untuk Berbagai Kondisi Persediaan Material," Jurnal Citra Widya Edukasi Vol X No. 3 Desember 2018 ISSN. 2086-0412. Accessed: Jun. 26, 2024. [Online]. Available: https://www.researchgate.net/publication/334442191_Formulasi_Model_Safety_Stock_dan_Reorder_Point_untuk_Berbagai_Kondisi_Persediaan_Material

[25] G. Gilang Kencana, "Analisis Perencanaan dan Pengendalian Persediaan Obat Antibiotik di RSUD Cicalengka Tahun 2014," *Jurnal Administrasi Rumah Sakit Indonesia*, vol. 3, no. 1, May 2018, Accessed: Nov. 03, 2023. [Online]. Available: https://journal.fkm.ui.ac.id/arsi/article/view/2211