Analysis of Inventory Control Using Economic Order Quantity Model - A Case Study in PT. Wijaya Agung Hutama

Faiz Kevin Naufal, Farel Hylmi Hakim, and Yasmin Aziza Putri
Industrial Engineering Department
Universitas Indonesia
Depok, West Java, Indonesia
faiz.kevin@ui.ac.id, farel.hylmi@ui.ac.id, yasmin.aziza@ui.ac.id

Abstract
As one of the most critical issues that arise in industries, inventory control is important for operations in the industry. As one of the small and medium enterprises industries in Indonesia, PT. Wijaya Agung Hutama is able to apply EOQ to solve their problem regarding inventory control of raw materials, especially EMAL 270N that are used to make the company's hand soap product. This paper examines the phenomenon in the company based on its historical data from January 2020 until December 2020 and forecasts the demand of EMAL 270N for the next 12 months of operation. By using the EOQ method for controlling inventory, this company can minimize the inventory cost by 88.21% in 2020 and predicted to be reduced by 81.66% in 2021 and determine the most efficient order quantity of each purchase.

Keywords
Inventory Control, Economic Order Quantity, Forecasting, EMAL 270N

1. Introduction
PT. Wijaya Agung Hutama is a Business to Business company that manufactures cleaning chemicals and supplies cleaning equipment and cleaning services based in Jakarta. Established in 2000, this company started to sell cleaning chemicals and supply its product to other companies and malls in Jakarta, such as Mall Ambassador, Jamsostek, and so on. With the brand BESTKP (formerly BEST), PT. Wijaya Agung Hutama has owned more than 30 types of cleaning chemical products, including floor care products, cleaning and sanitation products, and special cleaning products.

Inventory control is one of the most critical issues that arises in various industries these days (Jackson et. al, 2019). To overcome this complexity of problem, many practitioners use stochastic inventory control. But in some small and medium enterprise (SME) industries, the use of traditional tools like EOQ takes the upper hand (Dumas, 2008). MRPII and ERP, two of the modern inventory management systems, offer a complete solution, but little research has been conducted to prove that modern inventory management gives a competitive advantage for SMEs.

Based on the interview with the production manager from PT. Wijaya Agung, the company doesn't have a clear method for inventory control. At some point, this results in out of stock that can disturb the production. Otherwise, when the company doesn't have much demand from customers, this results in overstock of raw material. The biggest demanded product from PT. Wijaya Agung Hutama is BEST - Hand Soap. This product consists of EMAL 270N, solvent F, cellosize, dye, perfume, and EDTA 4 NA. The largest ingredient from this product is EMAL 270N. In this paper, we want to optimize the inventory control of raw materials, EMAL 270N, to prevent shortage of stocks and overstocking of the raw materials.

1.1 Objectives
The objective of the study is to determine the optimal inventory cost of EMAL 270N through application of two different traditional inventory control methods. Because there's no clear information from the company regarding the actual inventory cost, we will compare inventory cost from EOQ Method and Min-Max Method. From its result,

we can provide recommendations for the company's issue regarding inventory control for EMAL 270N using the most effective method tested.

2. Literature Review

2.1 Forecasting

Forecasting is an activity that is used to predict conditions that will happen for a certain period in the future, either for medium or long-term. For manufacturing companies, forecasting is used to estimate customer demand in the future, then the forecast result will be used as a consideration when making decisions regarding how the manufacturers will produce their product for a certain time in the future, such as resource allocation and planning, production planning and scheduling, budgeting, and inventory management.

Forecasting methods can be classified into two kinds, quantitative and qualitative methods, that can be determined based on the pattern of the demand for certain products. For qualitative forecasting methods, they're using experts, intuition, surveys, or certain judgment to produce its estimation, hence the fact that it is also named as a subjective forecasting method. The forecast results may have little to no relevance to historical data, if they are available from the organization or company. For quantitative forecasting methods, they rely on mathematical models to make predictions. There are several examples of quantitative models, such as regression models, moving averages, exponential smoothing, ARIMA, and also advanced methods such as Bayesian method and simulation. (Zellner et al., 2021)

In this paper, we'll be focusing on three methods, which are linear regression model, moving average, and exponential smoothing. Linear regression model. Linear regression model is a statistical tool used to help predict future values from past values. A linear regression trendline uses the least squares method to plot a straight line through prices so as to minimize the distance between the prices and the resulting trendline. Moving average methods are slightly different from other methods that are available because it utilizes past forecast errors in a regression-like model. Exponential smoothing is one of the time series forecasting analyses that were developed in the 1950s that generates reliable forecasts quickly for a wide range of time series (Hyndman and Athanasopoulos, 2018). There are three variations in this model, such as simple exponential smoothing (SES), Holt's Model or double exponential smoothing (DES), and Holt-Winters Model or triple exponential smoothing (TEST).

2.2 Inventory

Inventory is something that can be owned in the form of goods that will be used to fulfill a certain purpose. Inventory can be considered as a liability but can also be considered as an asset. Apart from being a liability and an asset, inventory can also serve as a method of reducing the possibility of delays in delivery, preventing shortages, fulfilling the needs and demands from customers, and maintaining the continuity of production.

In general, inventory is in the form of goods, but in the service industry, inventory that is owned can be in the form of information that is collected if you take an example from a consultant service. In the manufacturing industry, inventory can be divided into 2 categories based on the manufacturing process and based on the purpose of the inventory. In the category of manufacturing process, inventory is divided into 4, i.e. raw materials, semi finished products, MRO (maintenance, operations, and supply), and finished goods (Fithri, et al., 2019). In the category based on the purpose of the inventory, the inventory is divided into 2, safety stock and transit stock. Safety stock is an inventory that functions as an inventory to anticipate the uncertainty of supply and demand, while transit stock is an inventory that is in transit.

2.3 Inventory Cost

Inventory costs are the entire expenditure caused by the inventory activities. There are four types of cost of inventory, i. e. purchasing cost, procurement cost, carrying cost, and stock out cost. The expenses used to purchase goods with a certain amount depending on the number of items purchased and price per unit is called the purchasing cost. Procurement cost covers the costs related to the purchasing of goods outside of the company. Procurement cost is also called ordering cost. Ordering cost is the annual demand divided by amount per order times setup cost for each order, and assumed constant for each time period. Carrying costs are the expenditure resulting from the activities of saving goods in a certain period. Carrying cost is often called holding cost with half of the amount per order times holding cost per year being the formula. There are two parts of inventory holding cost: financial cost and warehousing cost (Çalışkan, C.,2021). Stock out cost, or shortage cost, describes the economic consequences of inventory stock out. This cost would be a trouble for the company because the stock out would slow down the company's manufacturing process.

2.4 Inventory Control

Inventory Control is an activity to determine the level and composition of parts, raw materials, and finished goods with a view to protect production process and sales. This activity also includes the regulation and supervision of the necessary ingredients. Three objectives of inventory control are to prevent companies from stock-out, not overproduced or underproduced, and determine the amount of purchases and procurements to lower ordering cost (Fithri, et al., 2019).

2.5 Economic Order Quantity

Economic order quantity (EOQ) model is a most standard, mathematical model in managing inventory (Çalışkan, C., 2021). In other words, EOQ determines the lot size of one production. EOQ aims to decide the reorder point for independent demand. The formula of the EOQ is

$$EOQ = Q^* = \sqrt{\frac{2AD}{h}}$$

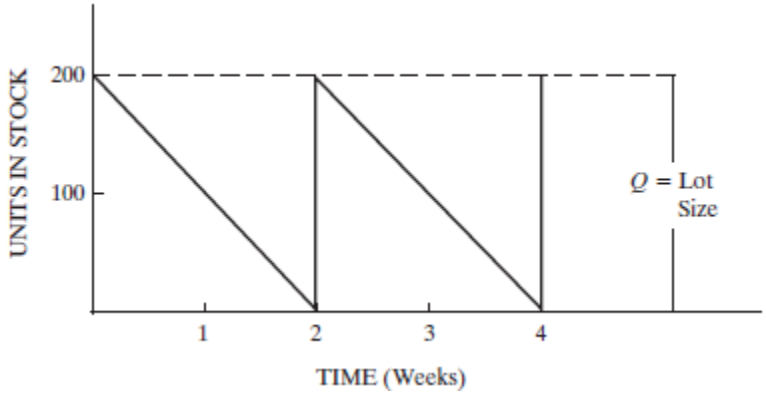

Figure 1. Inventory on hand over time

Figure 2 shows an EOQ graph. It contains carrying/holding costs, procurement/ordering costs, and the total costs.

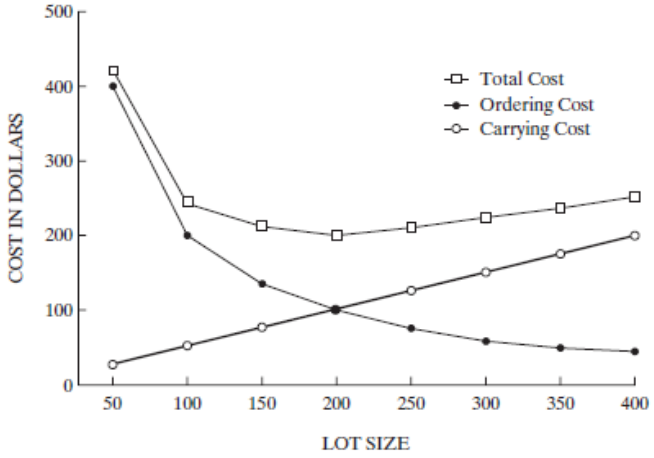

Figure 2. Cost versus lot size

Total Cost is the sum of ordering costs and carrying costs, resulting in this formula below:

Total Cost

$$= \frac{A}{Q} \times S + \frac{Q}{2} \times c \times i$$

There are six assumptions to apply to the EOQ model. First is the demand must be constant, uniform, and deterministic. This assumption requires historical data of demand of a company. Second, the price per unit of production is constant. This assumption requires purchasing data of the raw materials. Third, the storage cost per unit per year must be constant. Next, the ordering cost per order must be constant. Fifth, the time between orders and lead time must be constant. Last, there's no shortage of goods or return orders.

2.6 Safety Stock

Safety stock is the amount of products in inventory that act as a back-up stock if customer orders of the company exceed the amount of products that have been manufactured based on forecasts due to uncertainties. For its calculation, safety stock follows an equation that can be summarized as follows:

$$SSL = SF(SL) \times \sigma_D$$

with SSL as safety-stock level [units]; SF as safety factor depending on service level [–]; SLas service level [–]; $\sigma_D$as standard deviation of demand [units/shop calendar day (SCD)].

To determine safety stock, there are several components that are required to be able to calculate it, such as demand, lead time, stock out costs, service level, production process and external factors that came through investigation as a way to prevent shortage (Sudjatmiko & Sahroni, 2018).

3. Methods

The research methodologies used in this paper are conducting literature study, observing the problems, defining problems, stating the hypothesis, collecting data, processing data, analyzing the data, and drawing the conclusions. We use qualitative research to examine the inventory needs for producing specific end products.

Problem observations were held to specify real conditions occurring in the related company. The problem is that PT. Wijaya Agung Hutama has no clear method in predicting and controlling the amount of hand soap ordered, causing an unbalanced stock of EMAL 270N. Without clear control of EMAL 270N, there is more likely to be out of stock and the production of BEST - Hand Soap will be delayed. Thus, we want to optimize the inventory control of raw material EMAL 270N and the cost of inventory that this company's spend is already optimal.

Data required to solve this planning and inventory problem are historical data for purchasing and sales from July 2020 to April 2021, ordering cost, and holding cost of EMAL 270N. These historical data of sales/demand used to forecast the demand of BEST - Hand Soap for the next 12 months and calculate the optimal ordering cost and inventory cost based on the EOQ method. The result of this calculation would be compared to the present condition to decide whether the inventory cost is already optimal or not.

4. Data Collection

4.1 Sales History

The price listed at the company for BEST - Hand Soap is Rp 42.000,00 or $3,00 per gallon, Rp 287.000,00 or $ 20,50 per pail, and Rp 10.500,00 or $ 0,75 per liter. The price could be lower like shown on the table because of the discount for certain customers. However, the average price/liter is around Rp 8,500.00 because of the quantity discount given by the gallon and pail package. Table 1 below shows the sales history from the 1st year of observation. The sales are grouped to the weekly period and the grand total shows the total demand of BEST - Hand Soap (in liter) in each week.

Sales week	Grand Total		**Sales week**	Grand Total	
	Volume/ltr	Total		Volume/ltr	Total

1	1,340	$ 809.00	**27**	3,604	$ 2,141.06
2	2,693	$ 1,679.13	**28**	3,216	$ 1,953.66
3	5,114	$ 2,992.34	**29**	3,244	$ 1,996.56
4	4,286	$ 2,575.02	**30**	5,888	$ 3,467.01
5	4,010	$ 2,444.49	**31**	5,652	$ 3,315.09
6	3,696	$ 2,211.21	**32**	3,636	$ 2,195.26
7	4,900	$ 2,872.57	**33**	2,676	$ 1,653.46
8	1,590	$ 961.48	**34**	5,348	$ 3,248.21
9	4,471	$ 2,699.88	**35**	5,064	$ 2,993.35
10	6,069	$ 3,502.48	**36**	8,008	$ 4,752.29
11	1,840	$ 1,157.94	**37**	3,832	$ 2,357.98
12	3,706	$ 2,298.01	**38**	3,676	$ 2,281.05
13	6,325	$ 3,648.30	**39**	6,684	$ 4,141.73
14	4,588	$ 2,702.79	**40**	8,040	$ 4,769.51
15	3,898	$ 2,386.35	**41**	3,576	$ 2,119.05
16	2,712	$ 1,612.90	**42**	2,760	$ 1,735.73
17	3,611	$ 2,204.93	**43**	11,476	$ 6,806.14
18	3,606	$ 2,084.05	**44**	7,744	$ 4,812.48
19	3,944	$ 2,317.50	**45**	6,144	$ 4,607.76
20	5,376	$ 3,140.19	**46**	7,052	$ 5,289.12
21	5,020	$ 3,127.30	**47**	6,837	$ 5,127.74

22	6,156	$ 3,559.98	**48**	8,918	$ 6,688.55
23	3,624	$ 2,240.19	**49**	10,271	$ 7,703.31
24	1,194	$ 735.61	**50**	3,985	$ 2,988.96
25	5,819	$ 3,390.03	**51**	7,878	$ 5,908.38
26	2,496	$ 1,488.55	**52**	9,277	$ 6,957.94

Total demand of BEST - Hand Soap in all variants in the first year is 256,570 liters. One liter of BEST - Hand Soap required 71,5 grams of EMAL 270N, so total demand of EMAL 270N of BEST - Hand Soap is 1,8344,779 grams.

4.2 Purchasing Cost

Table below shows the purchasing history of EMAL 270N in the first year. Purchasing of EMAL 270N is not made in April 2020, Juni 2020, August 2020, and October 2020. There's 2 week of consecutive purchasing in EMAL 270N in November 2020. The purchasing of 1 kg of EMAL 270N is Rp 22.000,00 or $ 1,57. Table 2 shows the purchasing of EMAL 270N made in each week that purchasing occurs.

	Emal 270N (gram)	
Purchasing year	Volume	Total
2020	17,170,835.00	$ 22,049.63

4.3 Ordering Cost

Ordering costs are estimated to be 3% of each purchase. This 3% of cost consists of transportation cost, administration cost, and other cost that is related to ordering cost. Table 3 shows the ordering cost each week that purchasing occurs.

	Ordering Cost of EMAL 270N
Ordering Year	Total
2020	$ 661.49

4.4 Holding Cost

Holding Cost is estimated to be the price per unit per gram of EMAL 270N. This cost already included the warehousing cost and financial cost. Table 4 shows the holding cost for every purchasing period. Initial stock of 1st January 2020 is 697,435 gram.

Holding Cost	Total
2020	$ 0.005

5. Results and Discussion

In this section, we will discuss the forecasting method that we used to predict the demand from the customer, EOQ method and min-max method to calculate the inventory cost, and compare the EOQ and Min-max method inventory-cost wise.

5.1 Forecasting Method and Calculation of Error

There are four kinds of forecasting methods that we evaluate based on the MAPE, MAD, and MSD. In this paper, we will determine the most effective forecasting method based on MAPE (Mean Absolute Percentage Error) because it's interpretation of relative percentage error is intuitive (Myttenaere, et al., 2016). Table 5 below shows the value of 1st year demand data history.

Forecasting Method	MAPE	MAD	MSD
Linear Regression	41%	1502	3398757
Moving Average	32%	1289	2764804
Single Exponential Smoothing	39%	1553	3882238
Double Exponential Smoothing	43%	1630	4613623
Winter's Method	5%	194	104546

Winter's Method has the smallest MAPE amongst five methods that we tested. In inventory control, exponential smoothing method is widely used and recommended to apply (Segura, et al. 2001). Thus, we choose Winter's Method or Triple Exponential Smoothing to forecast 2nd year demand and purchasing of BEST - Hand Soap in all variants.

5.2 Forecasting Verification

With the forecasting method using Winter's Method, we can determine the demand and purchasing projection in 2021. Based on the forecast, total BEST - Hand Soap demand is 288,321 liter or 20,614,951.5 gram of EMAL 270N. Total EMAL 270N purchasing based on the forecast is 133,116,638.4 gram or Rp 299,624,364.11., or $21,401.74 With an error of 5%, the forecasting results are pretty accurate, so that we can use these data to represent the real condition of demand and purchase in 2021.

5.3 Inventory Cost Using Economic Order Quantity of Emal 270N

The year 2020:

$$EOQ = \sqrt{\frac{2AD}{H}}$$

$$EOQ = \sqrt{\frac{2 \; x \; \$661.49 \; x \; 18{,}344{,}779 \; gram}{\$0.005}}$$

$$EOQ = 2{,}146{,}860.92 \; gram$$

$$Frequency = \frac{D}{Q}$$

$$Frequency = \frac{18{,}344{,}779\ gram}{2{,}146{,}860.92\ gram}$$

$$Frequency = 8{,}5\ times = 9\ times$$

Table 6. Results of the EOQ method calculation

	2020	**2021**
Ordering Cost	$ 661.49	$ 642.05
Demand	18,344,779 gram	20,614,928 gram
Holding Cost	$ 0.005	$ 0.005
Lot size order	2,146,860.92 gram	2,242,138.5 gram
Frequency	9 times	9 times

Based on the table, we can infer that using the EOQ method of calculation, the lot size order is 2,146,860.92 gram per order for 2020 and 2,242,138.5 gram per order for 2021. Frequency of the purchase each year is 9 times. From the ordering cost and holding cost on the table, we can determine the total ordering cost and total holding cost to calculate the inventory cost.

Year 2020
Inventory Cost = Total Ordering Cost + Total Holding Cost
Inventory Cost = $ 14,635.59

Table 7. Inventory cost using EOQ method calculation

Year	Ordering Cost	Holding Cost	Inventory Cost
2020	$ 5,953.40	$ 8,682.19	$ 14,635.59
2021	$ 5,778.47	$ 7,876.49	$ 13,654.96

Based on table 7, the total ordering cost of the year 2020 and 2021 is $ 5,953.40 and $ 5,778.47. The total holding cost of the year 2020 and 2021 is $ 8,682.19 and $ 7,876.49. The inventory cost of the year 2021 is slightly lower than the inventory cost of the year 2020. It's caused by the higher lot size of order and lower ordering cost in 2021 from table 6.

5.4 Safety Stock Calculation with EOQ Method

From the EOQ Method, we are able to calculate several aspects, starting from the standard deviation, we can find safety stock, reorder point, and maximum inventory of EMAL 270N.

Standard Deviation = $\sqrt{\frac{\Sigma_{i=i}^{i}(y-\underline{y})^2}{n-1}}$

$\texttt{Safety Stock} = Z \times \texttt{Standard Deviation} \times \sqrt{\texttt{Lead Time}}$
Reorder Point = Safety Stock x (Lead time x Average used)
Max Inventory = Safety Stock + EOQ

Table 8. Safety stock calculation with EOQ Method

Year	Standard Deviation	Safety Stock	Reorder Point	Max Inventory
2020	161,991	722,484.25 gram	757,763.2541 gram	2,796,069.364 gram
2021	178,901	797,903.98 gram	837,548.0754 gram	3,079,686.551 gram

Based on table 8, from the standard deviation from 2020 to 2021, which are 161,991 and 178,901, the safety stock from 2020 and 2021 are 722,484.25 gram and 797,903.98 gram. The reorder points from 2020 to 2021 are 757,763.2541 gram and 837,548.0754 gram. The last thing that we can find is that maximum inventory from 2020 to 2021 are 2,796,069.364 gram and 3,079,686.551 gram. From the value that are mentioned above, it is shown that each factors have different percentages that are pretty close between each other, from safety stock that has an increase for 10,44%, reorder point that increased for 10,5% from 2020 to 2021, and 10,1% is the ratio of increase between maximum inventory for 2020 and maximum inventory for 2021.

5.5 Inventory Cost Using Min-Max Method

Min-max method used to compare inventory cost of the company with the EOQ method. Because the inventory cost of this company is classified, we use the min-max method to determine the inventory cost.

The year 2020
Safety Stock = (Maximum used - average used) x Lead time
Safety Stock = 467,750 gram

Min Stock = (average use x lead time) + safety stock
Min Stock = 70,556.8 gram

Max Stock = 2 x average use x lead time
Max Stock = 503,028.4 gram

Reorder Point = Max Stock - Min Stock
Reorder Point = 432,471.6 gram

Table 9. Inventory cost using min-max method

	2020	2021
Safety Stock	467,750	522,861

Minimum Stock	70,556.8	79,288.2
Maximum Stock	503,028.4	562,505.1
Reorder Point	432,471.6	483,216.9
Inventory Cost	$ 124,133.57	$ 74,466.40

Based on table 9, the safety stock from 2020 and 2021 are 467,750 and 522,861. The minimum stock from 2020 and 2021 are 70,556.8 and 79,288.2. The maximum stock from 2020 and 2021 are 503,028.4 and 562,505.1. The reorder points from 2020 and 2021 are 432,471.6 and 483,216.9. The inventory costs from 2020 and 2021 are $124,133.57 and $74,466.40.

5.6 Comparison

Table 10. Comparison of inventory cost between two methods

Year	Inventory Cost		Difference	Difference percentage
	Min-max Method	EOQ Method		
2020	$ 124,133.57	$ 14,635.59	$ 109,497.98	88.21%
2021	$ 74,466.40	$ 13,654.96	$ 60,811.44	81.66%

After applying the EOQ method and Min-Max method, there is a significant difference between inventory costs, both in 2020 and 2021. From the EOQ method calculation, we found out that inventory costs from 2020 to 2021 have decreased from $14,635.59 to $13,654.96. From the Min-Max method, we found out that it also has decreased, from $124,133.57 to $74,466.40.

When we compare between two methods, the differences are huge. Between two methods that are mentioned above, the difference between inventory costs from both methods are very large, with the EOQ method having the least amount of inventory cost from each year. With the difference of 88.21% and 81.66% in 2020 and 2021, this proves that the EOQ method is the best-in-slot method for doing inventory control at PT. Wijaya Agung Hutama.

Comparing the safety stock and reorder point, the min-max method determines the safety stocks lower than the EOQ method. With the difference of 254,734.25 gram and 275,042.98 gram in 2020 and 2021, this huge difference leads to a reduced risk of running out of stock. This implies that this company would run out of raw materials more frequently. This stockout will hamper the production, and the company's profitability couldn't be maximized.

6. Conclusion

Economic order quantity (EOQ) is a tool to calculate the lot size of order in every purchase. With EOQ, we can optimize the inventory cost by determining the order quantity if there's no clear inventory control method. Implementation of EOQ brings many advantages for SMEs, especially in inventory management. Min-max method used to determine the inventory cost when the company decides to classify their inventory cost. This method allows us to calculate the inventory cost using maximum used and average used on the inventory based on customer's demand.

From the analysis above, we conclude that the inventory cost by using the EOQ method is far more efficient than using the Min-Max method. In 2020, the optimal order quantity in each purchase activity is 2,146,860.92 gram, 9 times a year, with the total inventory cost being $14,635.59. Same thing with year 2021, the optimal order quantity

is 2,242,138.5 gram, 9 times a year, with the total inventory cost is $13,654.96. By using the EOQ method for controlling inventory, the company can minimize the inventory cost by 88.21% in 2020 and predicted to be reduced by 81.66% in 2021 and determine the most efficient order quantity of each purchase.

References

Arnold, J. R. T., Chapman, S. N., Clive, L. M., *Introduction to Materials Management*, 6th Edition, Prentice Hall, New Jersey, 2008.

Çalışkan, C.,. The economic order quantity model with compounding. *Omega (United Kingdom)*, *102*. https://doi.org/10.1016/j.omega.2020.102307, 2021.

Dumas, C., Effective Inventory Management in Small to Medium-Sized Enterprises, Mini-Dissertation. *North-West University*, Available: http://repository.nwu.ac.za/bitstream/handle/10394/2603/dumas_charl_2009.pdf?sequence=1&isAllowed=y, 2008.

Hyndman, R.J., Athanasopoulos, G. (2018) *Forecasting: principles and practice*, 2nd edition, OTexts, Melbourne, Australia. Available: https://OTexts.com/fpp2. Accessed on 10 May 2021

Jackson, I., Tolujevs, J., Lang, S., & Kegenbekov, Z., Metamodelling of Inventory-Control Simulations Based on a Multilayer Perceptron. *Transport and Telecommunication*, vol. 20, no. 3, pp. 251–259, 2019.

Muchlisin Riadi, Pengertian, Fungsi dan Jenis-jenis Persediaan (Inventory). https://www.kajianpustaka.com/2018/02/pengertian-fungsi-dan-jenis-persediaan-inventory.html

Myttenaere, A., Golden, B., Le Grand, B., Rossi, F. Mean Absolute Percentage Error for regression models, Neurocomputing, Volume 192. 2016. Pages 38-48. ISSN 0925-2312. https://doi.org/10.1016/j.neucom.2015.12.114.

Priharto, S. Inventory Adalah: Pengertian, Jenis dan Tips dalam Mengelolanya. https://accurate.id/akuntansi/inventory-adalah-pengertian-jenis-dan-tips-dalam-mengelolanya/

Segura, J.V., Vercher, E. A spreadsheet modeling approach to the Holt–Winters optimal forecasting. European Journal of Operational Research. Volume 131, Issue 2. 2001. Pages 375-388. ISSN 0377-2217. https://doi.org/10.1016/S0377-2217(00)00062-X.

Schmidt, M., Hartmann, W., & Nyhuis, P. (2012). Simulation based comparison of safety-stock calculation methods. *CIRP Annals - Manufacturing Technology*, *61*(1), 403–406. https://doi.org/10.1016/j.cirp.2012.03.054

Stewart, H. M. .School of Industrial and Systems Engineering Georgia Institute of Technology, Available: https://www2.isye.gatech.edu/~mgoetsch/cali/logistics_systems_design/forecasting/forecasting.pdf Accessed on 5 May 2021.

Sudjatmiko, B., & Sahroni, T. R. (2018). An investigation of optimum safety stock level for maintenance, reliability and operation materials based on criticality of material and equipment. *International Journal of Supply Chain Management, 7*(2), 52–61.

Zellner, M., Abbas, A. E., Budescu, D. V., and Galstyan, A., A survey of human judgement and quantitative forecasting methods, *Royal Society Open Science*, vol. 8, no. 2, pp. 2-3, 2021.

Biography

Faiz Kevin N. is an undergraduate student at the Industrial Engineering Department of Universitas Indonesia. He is currently active as a laboratory assistant at the Statistics and Quality Engineering Laboratory Universitas Indonesia. His current area of interest is in data analysis, finance, and production systems.

Farel Hylmi H. is an undergraduate student at the Industrial Engineering Department of Universitas Indonesia. His current area of interest is in supply chain management.

Yasmin Aziza P. is an undergraduate student at the Industrial Engineering Department of Universitas Indonesia. Her current area of interest is in human resources management, operation research and business intelligence.