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Enchasing Production Planning and Inventory Management : A Quantitative Approach to Forecasting for Bottled Mineral Water Products at PT Arima

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Abstract

PT Arima is a company engaged in the production of bottled mineral water. The demand for bottled mineral water is experiencing fluctuations, with demand increasing at the end, so companies must carry out optimal production planning to avoid stock buildup. Production planning at PT Arima is carried out by identifying demand levels using quantitative forecasting methods, namely moving average (n = 3) and exponential smoothing (α = 0.05) to maintain optimal production levels and stock in the warehouse does not accumulate. The results of processing the level of forecasting accuracy using 12 months of demand data obtained using the moving average method showed that the production level = 39,733 boxes in January 2024. MAD = 3733.22; MSE = 21566024.78 and MAPE = 0.10. Based on the exponential smoothing method, the production level = 38,081 boxes in January 2024. MAD = 5773.50; MSE = 43466303 and MAPE = 0.15. Based on the results of comparing the MAPE values of the two forecasting methods, the lowest MAPE value was obtained, namely the average method (n=3) of 0.10 with the production level of bottled mineral water to maintain optimal supply conditions in January 2024 of 39,733 boxes.

Keywords: Demand Forecasting**,** Error Level Accuracy, Optimal Production

INTRODUCTION

The development of the bottled mineral water industry currently has a very high level of business competition. The availability of sufficient spring water resources means that industrial players can carry out production activities optimally. The optimal production process must be supported by ideal marketing activities so that the production results can be absorbed by the market and can reduce the risk of goods piling up in the warehouse (Santosa et al., 2022). PT Arima has problems in production planning so that bottled water products often accumulate in the warehouse. Accumulation of products in the warehouse can be caused by the company not carrying out an optimal production planning process by identifying the level of consumer demand (Bieniek, 2021; Malladi et al., 2020)

Production planning at PT Arima is currently carried out only based on data from customer orders and the process of identifying consumer demand is still carried out intuitively without carrying out demand forecasting analysis. Demand forecasting is an activity in the production system to identify fluctuations in consumer demand for optimal production planning (Ramin et al., 2018).

Demand forecasting is carried out using historical data from the company's marketing activities (Duplakova et al., 2018; Sinaga & Irawati, 2018). The demand forecasting process requires identification of error levels so that the forecasting results have a high level of accuracy to be used as a basis for production planning (Muhammad Rizal et al., 2021; Santosa & Hidayat, 2019)

The optimal production planning process starts from the demand forecasting process which is then used as data in aggregate planning so that the production disaggregation process can be carried out optimally (Chou & Tran, 2018). Forecasting demand using quantitative methods based on historical demand data to determine data patterns so that analysis of demand levels can be carried out optimally (Jodlbauer & Strasser, 2019). The level of accuracy of the forecast results is one of the stages in the forecasting process used to make decisions on selected production levels from several forecasting methods used (Rizqi & Zahran, 2024; Stevenson et al., 2005)

The increase in the stock condition of bottled mineral water products at PT Arima has caused the company to carry out a demand forecasting process so that the quantity of consumer needs can be produced optimally to maintain ideal stock in the warehouse. Optimal stock conditions in the warehouse can protect products from damage due to being stored in the warehouse for too long (De Nerol et al., 2024; Shuhaila et al., 2024). The problem of stock buildup in companies requires handling in the production planning process where analysis related to demand forecasting becomes the basis for determining the company's optimal production. Accumulation of stock in the warehouse can increase storage costs which can result in company losses (Stevenson et al., 2005). Stock management can be done by identifying product demand using a forecasting approach so that the resulting production is optimal and in line with market needs (Chou & Tran, 2018).

The demand forecasting process is a process that must be carried out by PT Arima to maintain stock conditions based on the number of consumer requests so that research needs to be carried out regarding the suitability of data trends and forecasting methods to obtain optimal production planning quantities so that product stock conditions can be well maintained in the warehouse. The historical demand data trend at PT Arima is a time series which in 2022 will increase so that you can use the moving average or exponential smoothing method. The novelty of this research is to develop a forecasting model based on the smallest error level of accuracy for bottled mineral water products.

METHODS

Production planning in this research focuses on demand forecasting analysis so that companies can determine production levels each month based on consumer demand (Nisa, 2024). The method used is a quantitative forecasting method with a level of accuracy to see errors in the forecast results obtained. The research method is as follows: (Parmana, 2024)

1. Moving Averages
   Moving average is a forecasting method based on historical time series data patterns where the data pattern appears to be decreasing or increasing (Aziza, 2022). This method is used by carrying out a moving average process from historical data because the company's demand data has a time series type. The moving average method approach can be used to identify demand levels with time series data trends (Cadenas et al., 2010). The formulation of the Moving average method is as follows:

$$Moving\ Average\ (MA) = \frac{nX1+nX2+\ldots+nXp}{p}$$

2. Exponential smoothing
   Exponential smoothing is a method for predicting demand levels by using real level values from each movement of historical data used with time series model (de Oliveira & Cyrino Oliveira, 2018). The logic for predicting demand levels using the exponential method is as follows: (de Oliveira & Cyrino Oliveira, 2018)

$$F_{n+1} = F_n + \alpha\ (X_n - F_n)$$

Where:
Fn+1 = Actual data from previous year
Fn = Data from previous year's forecasting results
Xn = First year forecast demand
α = real leveldimana:

3. Error Accuracy Level
   The level of accuracy in the forecasting method is to determine the error level of the resulting forecasting results. This error level is carried out by comparing at least two forecasting methods to obtain the lowest error so that the accuracy of the forecast results can be in accordance with requirements (Chou & Tran, 2018). The formulation of the level of accuracy related to forecasting error results is as follows: (Cadenas et al., 2010)

$$Mean\ Absolute\ Deviation\ (MAD) = \frac{1}{x}\sum_{t=1}^{x} |\ yt\ |$$

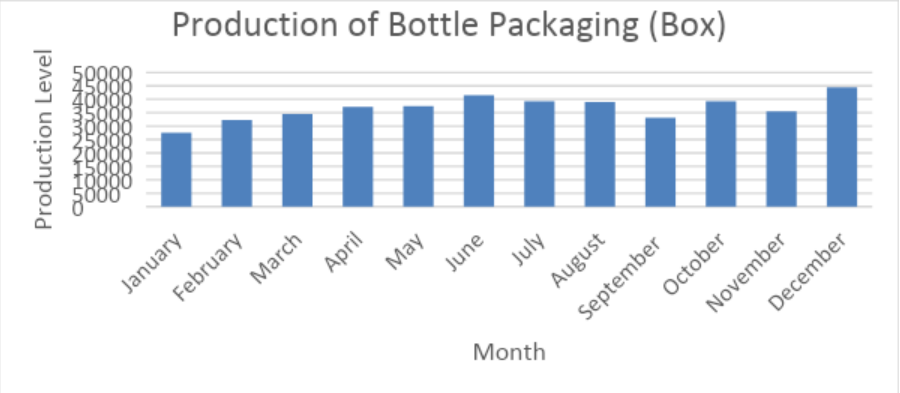
$$Mean\ Absolute\ Percentage\ Error\ (MAPE) = \frac{1}{x}\sum_{t=1}^{x} |\ Pyt\ |$$

RESULTS AND DISCUSSION

PT Arima is a company that produces bottled mineral water with the largest sales, namely bottled drinking water. The demand for bottle packaging products in companies fluctuates in demand, so it requires an optimal production planning process. Optimal production planning is carried out to maintain production quantities in accordance with consumer demand so that product stock in the warehouse does not accumulate and the company experiences over stock. The company's current production planning is only based on customer orders so the company cannot maintain optimal stock conditions in the warehouse.

Production planning based only on orders has problems related to fluctuations in demand that cannot be properly identified so that more production results will end up in inventory rather than being sold to consumers. The demand planning process begins with a demand forecasting process where demand is identified through historical data on sales of bottled mineral water products. The forecasting process is carried out by comparing two forecasting methods to see the lowest error rate in the forecast results obtained.

Determining the appropriate forecasting method is carried out by analyzing the type of demand data owned by the company. Based on the food identification results, data on the demand for bottled mineral water from PT Arima in 2024 can be seen in Figure 1.



Gambar 1 Demand Production of Bottle Packaging (Box) in 2023

Based on the results of historical data identification, it can be seen that the data trend is a time series where the data trend is increasing. This historical data trend is the basis for determining an appropriate demand forecasting method. The methods used to identify the level of demand for bottled mineral water are Moving Average and Exponential Smoothing. The comparative results of forecasting analysis using the moving average and exponential smoothing methods can be used to

obtain optimal demand with the lowest error value so that stock conditions can be maintained optimally (Rizqi & Zahran, 2024).These two methods will compare their error levels so that demand forecasting results can have optimal accuracy and can reduce stock buildup in the warehouse. Data on demand for bottled drinking water in 2023 can be seen in Table 1.

Table 1 Data on Demand for Bottled Mineral Water Products

Month	Production (Box)
January	27500
February	32250
March	34500
April	37225
May	37450
June	41500
July	39200
August	39000
September	33125
October	39200
November	35500
December	44500

Based on demand data, forecasting analysis was carried out using the Moving Average (N = 3) and Exponential Smoothing (α = 0.05) approaches. The moving average method uses a moving average value of 3 to obtain the ideal level of demand according to the company's needs. The results of processing demand forecasting using the moving average method can be seen in Table 2.

Table 2 Moving Average Forecast Demand Method Results

No	Month	Bottle Production (Box)	Forecast	Error	|Error|	|Absolute|^2	Percentage Error
1	January	27500	-	-	-	-	-
2	February	32250	-	-	-	-	-
3	March	34500	-	-	-	-	-
4	April	37225	31417	5808	5808	33732864	15,60%
5	May	37450	34658	2792	2792	7795264	7,46%
6	June	41500	36392	5108	5108	26091664	12,31%
7	July	39200	38725	475	475	225625	1,21%
8	August	39000	39383	-383	383	146689	0,98%
9	September	33125	39900	-6775	6775	45900625	20,45%
10	October	39200	37108	2092	2092	4376464	5,34%
11	November	35500	37108	-1608	1608	2585664	4,53%
12	December	44500	35942	8558	8558	73239364	19,23%
Total			330633	16067	33599	194094223	87,11%

Based on forecasting results using the moving average method with N=3, it was found that the demand level in January 2024 was 39,733 boxes. This demand forecast level is used to determine the company's production targets where the number of errors must be identified so that the accuracy of production quantities can be identified optimally by comparing with the forecast analysis method. The results of identifying the level of accuracy of the forecasting process can be seen in Table 3.

Table 3 Moving Average Error Level Accuracy

Error Analysis Atribute	Amount
Mean Absolute Deviation (MAD)	3733,22
Mean Square Error (MSE)	21566024,78
Mean Abslute Percentage Error (MAPE)	0,10

Analysis of forecasting demand for bottled water products using the exponential smoothing method with a value of α = 0.05 and the forecast result for the first period is 30,290 boxes. The results of the analysis using the exponential smoothing method can be seen in Table 4.

Table 4 Hasil Peramalan permintaan Metode Excponesial Smoothing

No	Month	Bottle Production (Box)	Forecast	Error	|Error|	|Absolute|^2	Percentage Error
1	January	27500	30290	-2790	2790	7784100	10,15%
2	February	32250	30151	2099	2099	4405801	6,51%
3	March	34500	30256	4244	4244	18011536	12,30%
4	April	37225	30468	6757	6757	45657049	18,15%
5	May	37450	30806	6644	6644	44142736	17,74%
6	June	41500	31138	10362	10362	107371044	24,97%
7	July	39200	31656	7544	7544	56911936	19,24%
8	August	39000	32033	6967	6967	48539089	17,86%
9	September	33125	32381	744	744	553536	2,25%
10	October	39200	32418	6782	6782	45995524	17,30%
11	November	35500	32757	2743	2743	7524049	7,73%
12	December	44500	32894	11606	11606	134699236	26,08%
	Total		286551	63702	69282	521595636	180,28%

Based on the forecasting results using the exponential smoothing method with α = 0.05, the forecast level of demand is 38,081 boxes. The results of the demand forecasting are then analyzed at the level of accuracy to determine the level of error in the forecasting results obtained. The results of the analysis of forecasting error levels using the exponential smoothing method can be seen in Table 5.

Table 5 Exponential Smoothing Error Level Accuracy

Atribut Error Analiisis	Jumlah
Mean Absolute Deviation (MAD)	5773,50
Mean Square Error (MSE)	43466303,00
Mean Abslute Percentage Error (MAPE)	0,15

Accuracy level analysis is then used to compare the two forecasting methods used to determine the ideal demand forecast based on the lowest error value. The results of the comparison of the number of requests and the forecast error rate can be seen in Table 6.

Table 6 Comparison of Demand Rates and Forecasting Errors

Error Level	Moving Average N =3	Exponetial Smoothing α = 0,05
Production (Box)	39733	38081
Mean Absolute Deviation (MAD)	3733,22	5773,50
Mean Square Error (MSE)	21566024,78	43466303,00
Mean Abslute Percentage Error (MAPE)	0,10	0,15

Based on the results of the demand forecasting analysis, the lowest error value was obtained, namely the Moving Average method with N = 3, namely with a MAPE value = 0.10. Based on the lowest error level value, namely the Moving Average method, the production of bottled mineral water which is determined as the production quantity is 39,733 boxes using the Moving Average method.

CONCLUSION

Demand planning at PT Arima is used to determine the ideal production level of bottled mineral water where the method used is a quantitative approach with time series demand data type. Based on the results of the analysis, the appropriate method to use in forecasting the level of product demand in the company is Moving Average with N=3 because it has the lowest error value, namely 0.10. Based on forecast analysis, the company can determine the optimal production level in January 2024, which is 39,733 boxes. The next research that must be developed is to carry out aggregate planning and determine a master production schedule so that the number of on-hand projects in the company can be maintained optimally.

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