AI-Assisted Forecasting of UNIBA SEHAT Water Demand Using Exponential Triple Smoothing and Weighted Moving Average Methods

Ainorrofiqie [1], Nur Holes[2], Emon Rifa'i[3], Mareta Kurnia Sari[4]

First-Third Department, First-Third University

Departement of Accounting, Universitas KH. Bahaudin Mudhary Madura, Jl. Raya Lenteng No. 10, Sumenep and 69451, Indonesia
afiazizie@gmail.com

Departement of Management, Universitas KH. Bahaudin Mudhary Madura, Jl. Raya Lenteng No. 10, Sumenep and 69451, Indonesia
nurholish2019@gmail.com

Departemen of Industrial Engineering, Universitas KH. Bahaudin Mudhary Madura, Jl. Raya Lenteng No. 10, Sumenep and 69451, Indonesia
emonrifai@unibamadura.ac.id

Departemen of Informatica, Universitas KH. Bahaudin Mudhary Madura, Jl. Raya Lenteng No. 10, Sumenep and 69451, Indonesia
maretakurniasari.92@gmail.com

Abstract— This study focuses on the implementation and analysis of demand forecasting methods for bottled mineral water products at PT. ARSINUM, located on Jl. Raya Lenteng No. 10, Batuan, Sumenep - Madura. Currently, the company employs a basic forecasting approach that relies solely on data from the previous period, resulting in low forecasting accuracy and effectiveness. To address this issue, the study evaluates two forecasting methods: Exponential Triple Smoothing (ETS) and the Weighted Moving Average. The objective is to identify the most accurate method to minimize forecast errors and improve operational and supply chain efficiency. The research methodology includes interviews, observations, historical data analysis, and literature review. Based on the findings, the Exponential Smoothing method with a smoothing constant (α) of 0.2 proved to be the most accurate, with a forecasted demand of 3,040 units of bottled mineral water in various packaging sizes for December 2024. This recommendation aims to support PT. ARSINUM in enhancing its demand planning and inventory management processes.

Keywords — *Forcasting, Exponential Triple Smoothing, Weighted Moving Average methods.*

1. Introduction

The rapid development of small and medium enterprises (SMEs) has led to increasingly intense competition, requiring businesses to minimize operational costs while maximizing efficiency and effectiveness. In today's market environment, consumers expect products to be available quickly and of high quality, making efficient operational management and supply chain execution crucial for maintaining competitiveness. A key factor in achieving this is the ability to accurately forecast consumer demand.

Accurate demand forecasting enables companies to optimize inventory levels, reduce waste, and ensure timely delivery. For example, in the e-commerce industry, product availability and delivery speed are major competitive advantages. Poor forecasting can result in stockouts causing customer dissatisfaction or in excessive inventory, which increases storage costs and risks spoilage or obsolescence.

The importance of accurate forecasting was particularly evident during the COVID-19 pandemic, when the surge in demand for essential items such as masks and medical equipment overwhelmed supply chains. In many cases, the inability to forecast demand accurately led to significant shortages and inflated prices. Similar challenges affect various industries, including food and beverages, textiles, and fast-moving consumer goods, where poor forecasting impairs service quality and responsiveness.

Demand forecasting errors have two major consequences. Underestimation can lead to raw material and product shortages, missed sales opportunities, and decreased customer satisfaction. Overestimation, on the other hand, can result in overstocked inventories, increased costs, and reduced sustainability due to the potential expiration or wastage of unused materials. These issues not only affect profitability but also contribute to broader environmental concerns.

Previous studies (e.g., Klimberg & Ratick, 2017; Liu et al., 2024) have examined various forecasting techniques and evaluated their accuracy using performance metrics such as Mean Absolute Deviation (MAD), Mean Absolute Percentage Error (MAPE), and Mean Squared Error (MSE). However, despite the importance of accurate forecasting, PT. ARSINUM currently lacks a structured forecasting method. The company relies primarily on historical sales data from the most recent period or intuition, which compromises the effectiveness of its operational and inventory management.

Furthermore, according to Kim & Kim (2016), reliance on informal forecasting methods can hinder operational efficiency. Interviews with PT. ARSINUM's management revealed a strong need for a forecasting method that is not only accurate but also simple enough to be adopted and applied by staff without requiring complex training (Rahman et al., 2025). This highlights a clear research gap: the need to identify and implement a practical, accurate, and easy-to-use forecasting model tailored to the company's operational context.

Therefore, this study aims to analyze and implement two forecasting methods Weighted Moving Average and Exponential Triple Smoothing (ETS) to determine which provides the most accurate and practical forecasting results for PT. ARSINUM. The goal is to support more effective demand planning for bottled mineral water products, ultimately improving operational efficiency and customer satisfaction.

2. Literature Review

Forecasting demand has become an essential component of operational management and supply chain strategy, particularly for small and medium enterprises (SMEs) facing increasing market competition. Accurate forecasting plays a critical role in improving service levels, optimizing inventory, and reducing operational costs (Yang et al., 2015). In contrast, inaccurate forecasting especially when based solely on intuition or single-period historical data can lead to inefficiencies such as inventory shortages or overstock, both of which negatively impact customer satisfaction and increase costs (Kim & Kim, 2016).

Various forecasting techniques have been developed to enhance accuracy. Among the most commonly used are **Exponential Triple Smoothing (ETS)** and the **Weighted Moving Average (WMA)** methods. The ETS method gives more weight to recent data by applying exponentially decreasing weights, making it highly responsive to short-term demand fluctuations and suitable for dynamic market environments (Shahani et al., 2021). Meanwhile, the WMA method assigns specific weights to historical data points based on their relative importance, offering a flexible approach to capturing demand patterns over time (Houshmand et al., 2023).

Comparative studies have shown that the choice of forecasting method significantly impacts forecast accuracy. Davydenko and Fildes (2013) emphasize the importance of selecting a method that not only yields accurate results but is also easy to implement within an organization. Practicality, simplicity, and ease of employee training are key considerations for method adoption (Rahman et al., 2025).

To evaluate forecasting accuracy, metrics such as **Mean Absolute Deviation (MAD)** and **Mean Absolute Percentage Error (MAPE)** are widely used. These metrics provide standardized ways to measure deviation from actual demand, with lower values indicating better forecasting performance (Flores, 1986).

Additionally, in light of growing environmental and sustainability concerns, inaccurate demand forecasting may lead to overproduction, excessive resource consumption, and increased environmental footprints. Klimberg and Ratick (2017) argue that implementing robust forecasting methods is not only vital for operational efficiency but also an ethical responsibility in sustainable business practices.

Recent applications of ETS and WMA methods have shown promising results in various sectors. For example, Baykal et al. (2022) successfully applied exponential smoothing to forecast climate boundary changes, demonstrating its adaptability to complex and volatile data. Liu et al. (2024) introduced a hybrid model with time-varying weights that outperformed traditional methods in forecasting accuracy.

In summary, the literature strongly supports the application of advanced smoothing and averaging methods in demand forecasting. For companies such as PT. ARSINUM, adopting these models can lead to more accurate demand predictions, better inventory management, and improved service delivery.

3. Method

This research was conducted at PT. ARSINUM, located at Jl. Raya Lenteng No. 10, Batuan, Sumenep – Madura. The research employed a qualitative and quantitative approach, including direct observations and interviews with employees responsible for operational management and forecasting activities.

The primary objective was to gather historical demand data for bottled mineral water products from January 2024 to November 2024. This data serves as the basis for analyzing and comparing the performance of different forecasting methods.

Following the approach used by Baykal et al. (2022), this study evaluates forecasting accuracy by calculating the forecast errors of each method. Specifically, the Exponential Triple Smoothing (ETS) and Weighted Moving Average (WMA) models were applied to the collected data. The performance of each method was then assessed using standard error measurement tools such as MAD and MAPE, to determine which method produces the most accurate and reliable demand forecasts for PT. ARSINUM.

A. Exponential Triple Smoothing (ETS)

The Exponential Triple Smoothing (ETS) method is a moving average forecasting technique that gives more weight to more recent data and less weight to earlier data, so that the forecast has a sensitive and accurate response to actual changes. This method uses a smoothing constant, namely α. The value of α that is getting closer to 1 gives the greatest emphasis on the current value while the value that is getting closer to 0 will give emphasis to previous data (Shahani et al., 2021).

Exponential Triple Smoothing can be calculated using the following formula:

$F_{t+1} = \alpha A_t + (1 - \alpha) F_t$

Description:

α = constant smoothing value ($0 < \alpha < 1$)

F_{t+1} = new forecast

F_t = previous period forecast

At = previous period actual demand

B. Weighted Moving Average (WMA)

According to (Houshmand et al., 2023), Weighted Moving Average (WMA) is a moving average that has weight. This method is a simple moving average forecasting technique and is widely used to analyze trends in data fluctuations from a certain time sequence. The use of weights is based on trial and error, if the latest data is given too much weight, the forecast will overreact to random fluctuations, if given too little weight, the forecast will be insensitive to changes in demand behavior (Rusdiana et al., 2020).

The calculation of the weighted moving average uses the following formula:

$WMA_n = \sum W_i A_i$

Description:

W_i = weight for period i, with a value of 0 to 100%

$\sum W_i$ = 1

C. Mean Absolute Deviation (MAD)

MAD is a method of measuring the level of accuracy to determine the average value of absolute errors from different forecasting methods (Flores, 1986) (Kim & Kim, 2016). The smaller the MAD value, the more accurate the forecasting method is.

Here is the MAD calculation formula:

$$MAD = \frac{\sum |D_X - F_X|}{n}$$

Information:

n = number of periods

x = period

D_x = demand in period x

F_x = forecast in period x

| | = absolute value

D. Mean Absolute Percentage Error (MAPE)

This method is a measurement of the level of accuracy of a forecasting method using a mathematical method that adds up the total deviation of the forecast and actual demand data (Flores, 1986) (Kim & Kim, 2016). Here is the formula:

$$MAPE = \frac{1}{n} \sum \left| \frac{Dt - Ft}{Dt} \right|$$

Information:

n = number of periods

t = period

D_t = demand in period t

F_t = forecast in period t

4. Results and Discussion

Exponential Triple Smoothing (ETS)

The following are the results of the calculation and analysis of the demand data bottled mineral water using the forecasting method Exponential Triple Smoothing (α= 0.2) which can be seen in the following Table 1.

Table 1. Forecasting with the Exponential Smoothing Method (α= 0.2)

Bulan	Data Permintaan	Forcast ETS	Dt - Ft
Jan-01	3035		

e-ISSN xxxx - xxxx
Vol. 01, No. 01, April, 2025

Feb-01	2833	2943	-110
Mar-01	2940	2962	-22
Apr-01	2821	2980	-159
May-01	3133	2999	134
Jun-01	3044	3017	27
Jul-01	2997	3036	-39
Aug-01	3005	3054	-49
Sep-01	3207	3073	134
Oct-01	2985	3091	-106
Nov-01	3123	3110	13
Dec-01		3040	
Total	33123		-177
		MAD	**97**
		MAPE	**3.23%**

Source: Processed Secondary Data

Weighted Moving Average (WMA)

The following are the results of calculations and analysis of demand data for bottled mineral water using the weighted moving average forecasting method per 3 months using the previous period weight of 50%, the weight of the previous 2 periods of 30% and the weight of the previous 3 periods of 20%.

Table 2. Forecasting with the Weighted Moving Average Method

DATA PERMINTAAN	FORECAST (WMA3) Bobot: W3= 50%, W2= 30%, W1= 20%	(Dt - Ft)	|Dt - Ft|
3,035			
2,833			
2,940			
2,821	2926.9	-105.9	105.9
3,133	2859.1	273.9	273.9
3,044	3000.8	43.2	43.2
2,997	3026.1	-29.1	29.1
3,005	3038.3	-33.3	33.3
3,207	3010.4	196.6	196.6
2,985	3104.4	-119.4	119.4
3,123	3055.6	67.4	67.4
3,004	3098.4	-94.4	94.4
	3035.9		
36,127	27120		963.2
	MAD		107.0
	MAPE		3.49%

Source: Processed Secondary Data

I. *Measuring the Level of Forecast Accuracy with MAD & MAPE*

The following are the results of forecast calculations in December 2024 and the results of the level of forecast accuracy with the MAD & MAPE method for the weighted moving average method, exponential smoothing (α= 0.2)

Table 3. Level of Forecast Accuracy with the MAD & MAPE Method

METODE PERAMALAN	Peramalan Permintaan Jun 2022	MAD	MAPE
Naïve Model	3004	123.9	4.71%
Weighted Moving Average (3 Bulan)	3036	107.02	3.49%
Exponential Smoothing (α= 0.2)	3040	97.00	3.23%

Source: Processed Secondary Data

According to (Song et al., 2024), MAD is used to measure forecast accuracy expressed in the form of an average error in absolute and to compare forecast accuracy for different forecasting methods. Based on Table 3, the forecasting method with the highest level of accuracy where the smallest MAD & MAPE value is exponential triple smoothing with a smoothing constant value of 0.2. The practical implication is that the exponential smoothing method with α = 0.2 has been empirically proven to produce a higher level of accuracy compared to the naïve model applied by PT. ARSINUM.

5. Conclusion

Analyzing historical data on demand for bottled mineral water products from January 2024 to November 2024 (11 months), we can see that data fluctuations move around the average so that the author chooses the weighted moving average method per 3 months where the largest weight (50%) is given to the previous period, 30% is given to the previous 2 periods and 20% is given to the previous 3 periods and also the exponential smoothing method with a value of α = 0.2.

Using the Mean Absolute Percentage Error (MAPE) and Mean Absolute Deviation (MAD) methods, it can be concluded that the three methods provide a fairly high accuracy value seen from the fairly low MAPE value, so the author provides suggestions/recommendations that the best forecasting method is the exponential smoothing method with α = 0.2 which has the smallest MAPE value of 3.23% and the smallest MAD of 97, to be applied as a forecasting method for bottled drinking water products at PT. ARSINUM. MAPE and MAD results from exponential.

References

Baykal, T. M., Colak, H. E., & Kılınc, C. (2022). Forecasting future climate boundary maps (2021–2060) using exponential smoothing method and GIS. *Science of The Total Environment*, *848*, 157633. https://doi.org/10.1016/j.scitotenv.2022.157633

Davydenko, A., & Fildes, R. (2013). Measuring forecasting accuracy: The case of judgmental adjustments to SKU-level demand forecasts. *International Journal of Forecasting*, *29*(3), 510–522. https://doi.org/10.1016/j.ijforecast.2012.09.002

Flores, B. E. (1986). A pragmatic view of accuracy measurement in forecasting. *Omega*, *14*(2), 93–98. https://doi.org/10.1016/0305-0483(86)90013-7

Houshmand, N., Esmaeili, K., Goodfellow, S., & Carlos Ordóñez-Calderón, J. (2023). Predicting rock hardness using Gaussian weighted moving average filter on borehole data and machine learning. *Minerals Engineering*, *204*, 108448. https://doi.org/10.1016/j.mineng.2023.108448

Kim, S., & Kim, H. (2016). A new metric of absolute percentage error for intermittent demand forecasts. *International Journal of Forecasting*, *32*(3), 669–679. https://doi.org/10.1016/j.ijforecast.2015.12.003

Klimberg, R. K., & Ratick, S. (2017). Development of a Practical and Effective Forecasting Performance Measure. In K. D. Lawrence & R. K. Klimberg (Eds.), *Advances in Business and Management Forecasting* (Vol. 12, pp. 103–118). Emerald Publishing Limited. https://doi.org/10.1108/S1477-407020170000012007

Liu, L., Zhou, S., Jie, Q., Du, P., Xu, Y., & Wang, J. (2024). A robust time-varying weight combined model for crude oil price forecasting. *Energy*, *299*, 131352. https://doi.org/10.1016/j.energy.2024.131352

Rahman, H., Hidayat, N., Arifin, F., & Al Aziz, M. S. K. (2025). AI-Driven Insights into the Determinants of Leadership, Compensation, and Organizational Culture on Employee Work Discipline: A Case Study of NU Gapura Supermarket, Sumenep. Jurnal Bina Manajemen, 13(2), 73-84. https://doi.org/10.52859/jbm.v13i2.745

Rusdiana, S., Syarifah Meurah Yuni, & Delia Khairunnisa. (2020). Comparison of Rainfall Forecasting in Simple Moving Average (SMA) and Weighted Moving Average (WMA) Methods (Case Study at Village of Gampong Blang Bintang, Big Aceh District-Sumatera-Indonesia. *Journal of Research in Mathematics Trends and Technology*, *2*(1), 21–27. https://doi.org/10.32734/jormtt.v2i1.3753

Shahani, N. M., Sajid, M. J., Zheng, X., Brohi, M. A., & Mallah, N. B. (2021). Statistical and exponential triple smoothing approach to estimate the current and future deaths of Pakistani coal miners from 2010 to 2050. *International Journal of Mining and Mineral Engineering*, *12*(1), 34. https://doi.org/10.1504/IJMME.2021.114908

Siti Sa'adah, Dewi Bela Safitri, H. R. (2024). Implementation of Service Based Business Model Application in Tobacco Products Industrial Area Management in Sumenep Regency. *Indonesian Interdisciplinary Journal of Sharia Economics (IIJSE)*, *7*(3). https://doi.org/10.31538/iijse.v7i3.5580

Song, X., Xu, H., & Bai, Y. (2024). An integrated SWJ-LSTM-ETS modeling strategy for investigating upper morphology dynamics of a stochastic laboratory delta with environmental changes. *Geomorphology*, *445*, 108977. https://doi.org/10.1016/j.geomorph.2023.108977

Yang, D., Sharma, V., Ye, Z., Lim, L. I., Zhao, L., & Aryaputera, A. W. (2015). Forecasting of global horizontal irradiance by exponential smoothing, using decompositions. *Energy*, *81*, 111–119. https://doi.org/10.1016/j.energy.2014.11.082