

# Analysis of Subsidized Fertilizer Sales Forecasting Using the Time Series Decomposition Forecasting Method of PT Pupuk Indonesia Persero

Markus Rivaldo Yulinchton<sup>1</sup>, Alfatih S. Manggabarani<sup>2</sup>, Maria Assumpta Wikantari<sup>3</sup>, Prasetyo Hadi<sup>4</sup>

<sup>1,2,3,4</sup>UPN Veteran Jakarta

Email: markusrivaldo1@gmail.com , alfatih@upnvj.ac.id , maria.an@upnvj.ac.id , prasetyohadi@upnvj.ac.id

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## **Abstract**

### **Keywords:**

Forecasting; MAPE; WMA.

*The purpose of this study is to provide the best forecasting solution related to subsidized fertilizers at PT Pupuk Indonesia. This research is quantitative in nature, using secondary data from the Annual Report of PT Pupuk Indonesia (Persero). The study employs the Weighted Moving Average (WMA) calculation method with weights of 3, 5, and 7, and uses the Mean Absolute Percentage Error (MAPE) index to measure the accuracy of the generated data. The analysis results indicate that the sales forecasting using the WMA method with weights of 3, 5, and 7 can be recommended, as the MAPE values fall within the range of 10%-20%, which is categorized as having good predictive capability.*

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## **INTRODUCTION**

Marketing activities in a business are the spearhead that determines its continued success. The right strategy will make a product or service known to the public, increase sales volume, and ultimately generate high profits. However, marketing mistakes often arise from ignorance or lack of experience in conducting marketing activities. (Yulia & Setianingsih, 2020).

One marketing activity, namely marketing planning, is generally carried out early on, even before the production of goods or services begins. This activity includes sales forecasting, which will ultimately influence the quantity of goods produced and the amount of inventory. This series of activities is part of the marketing supply chain process.

Fertilizer plays a crucial role in agricultural production, contributing to increased crop yields and ensuring food security. Accurate fertilizer demand forecasting is crucial for producers, distributors, and farmers to optimize production planning, inventory management, and supply chain operations. However, fertilizer demand forecasting often presents significant challenges due to the mismatch between estimated quantities and actual market demand.

Inaccurate estimates of fertilizer needs can have negative consequences for all stakeholders involved. Overestimating demand can result in excess inventory, leading to increased storage and financing costs, and financial losses. On the other hand, underestimating demand can result in

supply shortages, delayed deliveries, dissatisfied customers, and lost market opportunities. (Seyedan & Mafakheri, 2020).

Based on their distribution in Indonesia, there are two types of fertilizer: subsidized and non-subsidized. Subsidized fertilizers are those whose procurement and distribution receive subsidies from the government to meet the needs of farmers. This subsidy is provided based on a government program outlined in Regulation of the Minister of Agriculture of the Republic of Indonesia Number 771 of 2021 and its amendment Number 8 of 2022, which regulates the allocation and retail price of subsidized fertilizers for the agricultural sector for the 2022 fiscal year. Furthermore, Regulation of the Minister of Trade Number 15 of 2013 also regulates the procurement and distribution of subsidized fertilizers for the agricultural sector.

The government, represented by the Ministry of Agriculture, has entered into a contract with PT Pupuk Indonesia as a producer to provide and distribute subsidized fertilizer to farmers at a predetermined price. Any gap between COGS and the price sold to farmers will be reimbursed/subsidized by the government. In providing subsidized fertilizer, based on the Minister of Trade Regulation No. 15 of 2013, PT Pupuk Indonesia is required to meet the minimum stock requirements in the warehouse as needed. Farmers are subject to a maximum allocation limit as stipulated in the Minister of Agriculture Regulation.

Pupuk Indonesia provides a one-year sales forecast to meet farmer needs. The comparison of this forecast to actual demand in the field can be seen in the figure below:

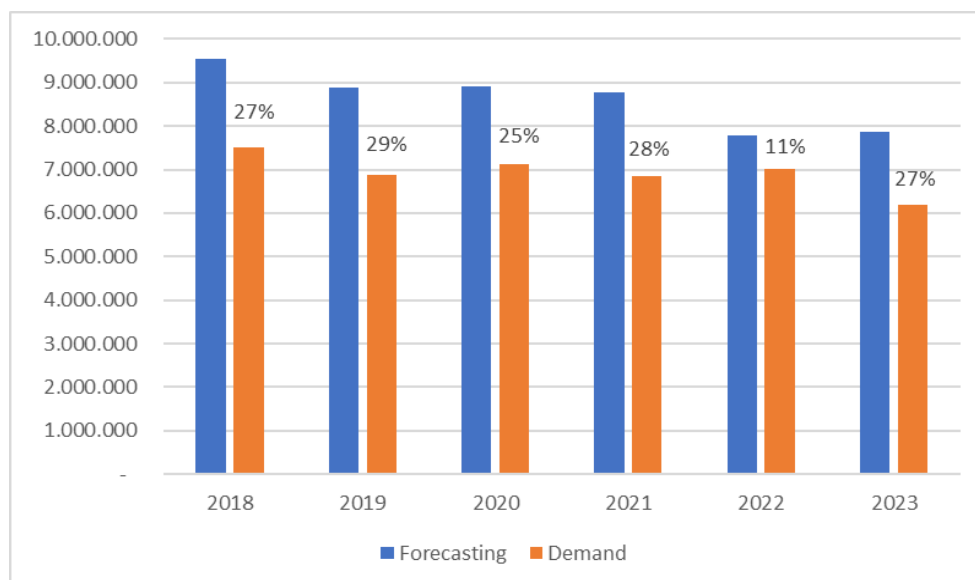


Figure 1. Forecasting and Demand for Subsidized Urea Fertilizer 2018 - 2023

The figure above displays monthly data for 2018 – 2023 on the X-axis, and the amount of subsidized urea fertilizer in tons on the Y-axis. From these figures, the demand for subsidized fertilizers is always fluctuating and forecasting is immature, resulting in a striking difference

between forecasting and demand. On average, the gap from 2018 – 2023 is 24% or 10,159,963 tons. In 2018, the gap was 27%, with forecasts of 9,550,000 tons and demand of 7,500,725 tons. In 2019, the gap was 29%, with forecasts of 8,874,000 tons and demand of 6,886,843 tons. In 2020, the gap was 25%, with forecasts of 8,900,467 tons and demand of 7,135,844 tons. In 2021, the gap was 28%, with forecasts of 8,776,847 tons and demand of 6,846,188 tons. In 2022, the gap was 11%, with forecasts of 7,776,281 tons and demand of 7,018,214 tons. In 2023, the gap was 27%, with forecasts of 7,856,951 tons and demand of 6,186,769 tons.

This gap is due to the uncertainty of demand from end users/farmers in the distribution of subsidized fertilizer, which is influenced by government regulations and natural factors such as rainfall. The current method involves regional sales sending forecasts to their respective regions and summarizing them into a total sales plan, taking into account allocations, sales history, and field conditions.

This condition is in line with the statement that companies are more interested in making forecasts based on sales data from previous periods, with the assumption that what happened in the past will be repeated now. (Taylor & Letham, 2017) Forecasting itself can be defined as the process of estimating the magnitude of future needs/events. These needs include the dimensions of quantity, quality, time, and location required to achieve predetermined targets. (Azman, 2019).

This situation contradicts the statement that forecasting activities require the application of methods aimed at minimizing forecast errors. Some utilize time series data for analysis and generate future forecasts based on a synthesis of past data patterns using forecasting methods, including ARIMA and Moving Average. (Ngantung et al., 2019). Demand forecasting carried out by companies can use the Linear Exponential Smoothing calculation method with MAPE (Moving Average Percentage Error) values to predict sales more accurately. (Kusumawardani, Afandi, & Riani, 2019) This is in line with the use of the Exponential Smoothing method in forecasting by using time series data with seasonal data patterns to predict sales. (Nisa Ayunda, Faizah, & Sujarwo, 2021).

Based on the explanation above, the researcher found a phenomenon and research gap between the results of previous studies and the results of the latest research. Given the current conditions, there is a high possibility of differences in the results of previous studies on Time Series Decomposition Forecasting Analysis. Therefore, the author wants to conduct a study with the title "Analysis of Subsidized Fertilizer Sales Forecasting Using the Time Series Decomposition Forecasting Method of PT. Pupuk Indonesia Persero".

## METHODS

The population used in this study is the Annual Report of PT Pupuk Indonesia Holding Company. The population used in this study is Fertilizer Sales Data from 2018 to 2023. Meanwhile, the sample taken uses a purposive sampling technique, meaning sample selection is based on determining certain characteristics that are in line with the research objectives so that the samples taken can answer the problems in this study.

The type of data used is quantitative data that is numerical or numbers that can be analyzed using statistics, with the aim of proving the established hypothesis. Data sources in this study were obtained from internal and external sources. Secondary data is internal and obtained through the Annual Report of PT Pupuk Indonesia Holding Company. Then the data collection technique used is secondary data such as the Annual Report of PT Pupuk Indonesia Holding Company, journals, books and websites that support this research. The dependent variable is the level of accuracy of PT Pupuk Indonesia's sales forecasting with the independent variable being the sales forecasting method using the Weighted Moving Average (WMA) method. The data analysis technique used is the classical assumption test consisting of the normality test, Weighted Moving Average (WMA) and in the Error Rate Analysis method using the MAPE (Mean Absolute Percent Error) model. The steps that can be taken in the Weighted Moving Average (WMA) weighting method are as follows:

1. Determine the weight for each period, the closer to the present, the greater the weight.
2. Calculate the forecast for fertilizer sales for the next period using the following formula:

$$F_t = \frac{\sum ((\text{Bobot untuk periode } n)(\text{Penjualan Pupuk dalam periode } n))}{\sum \text{Bobot}}$$

Meanwhile, MAPE (Mean Absolute Percent Error) is calculated as the average absolute difference between the forecasted and actual values, expressed as a percentage of the actual value. If there are forecasted and actual values for  $n$  periods, the steps in calculating the MAPE error are as follows:

1. Rounding alpha to 0.1 and 0.5 against the actual Fertilizer sales data for the previous period and its forecast
2. Make the absolute value positive by calculating the difference between the actual data and the forecast.
3. Then calculate the error value, using the following formula:

$$A = \frac{\sum \text{Kesalahan persen absolut}}{n}$$

## RESULTS AND DISCUSSION

## Research Data Description

In this study, the author used secondary data for 72 months from 2018 – 2023 which was forecasting data and realization of subsidized fertilizer distribution using non-probability sampling with the sampling method taken being purposive sampling.

| Bulan  | Realisasi |
|--------|-----------|
| Jun-23 | 433.454   |
| Jul-23 | 440.442   |
| Aug-23 | 422.194   |
| Sep-23 | 405.582   |
| Oct-23 | 472.250   |
| Nov-23 | 560.826   |
| Dec-23 | 479.594   |
| Jan-24 | 367.801   |
| Feb-24 | 506.391   |
| Mar-24 | 456.644   |
| Apr-24 | 400.584   |
| May-24 | 705.763   |
| Jun-24 | 677.360   |
| Jul-24 | 711.244   |
| Aug-24 | 592.594   |
| Sep-24 | 632.932   |
| Oct-24 | 806.628   |
| Nov-24 | 790.521   |

Figure 2. Realization of Subsidized Fertilizer Sales

## Classical Assumption Test

Table 1. Classical Assumption Test

|             | Kolmogorov-Smirnova |    |      | Shapiro-Wilk |    |      |
|-------------|---------------------|----|------|--------------|----|------|
|             | Statistic           | df | Sig. | Statistic    | df | Sig. |
| realization | .186                | 18 | .100 | .907         | 18 | .078 |

a. Lilliefors Significance Correction

The significance value of Kolmogorov Smirnov is 0.1 and with Shapiro Wilk is 0.078 so because both are above 0.05 then the data is normally distributed.

### Weighted Moving Average (WMA)

This study used the Weighted Moving Average method, with weights of 3, 5, and 7, to calculate PT Pupuk Indonesia's sales forecast. The WMA calculation yielded the following values:

| Bulan  | WMA Bobot 3 | WMA Bobot 5 | WMA Bobot 7 |
|--------|-------------|-------------|-------------|
| Jan-25 | 505.447     | 486.092     | 474.522     |
| Feb-25 | 437.236     | 452.663     | 451.674     |
| Mar-25 | 455.728     | 469.056     | 465.819     |
| Apr-25 | 458.419     | 462.147     | 465.171     |
| May-25 | 436.905     | 437.591     | 449.278     |
| Jun-25 | 562.517     | 525.444     | 509.859     |
| Jul-25 | 640.698     | 588.752     | 554.999     |
| Aug-25 | 699.035     | 642.717     | 604.447     |
| Sep-25 | 646.271     | 643.476     | 615.961     |
| Oct-25 | 632.538     | 648.617     | 629.530     |
| Nov-25 | 713.057     | 696.167     | 682.004     |
| Dec-25 | 786.573     | 742.922     | 726.426     |

Figure 3 WMA Calculation Results

The 2025 forecast calculation data can be said to fluctuate every month where in WMA Weight 3 for the highest value in December 2025 amounted to 786,573 tons and the lowest value in May 2025 amounted to 436,905 with a total sales forecast of 6,974,426 tons and an average of 581,202. In WMA Weight 5 for the highest value in December 2025 amounted to 742,922 tons and the lowest value in May 2025 amounted to 437,591 with a total sales forecast of 6,795,642 tons and an average of 566,303. In WMA Weight 7, the highest value in December 2025 was 726,426 tons and the lowest value in May 2025 was 449,278 with a total sales forecast of 6,629,690 tons and an average of 552,474.

### Mean Absolute Percent Error (MAPE)

This study uses the Mean Absolute Percent Error (MAPE) method to calculate the percentage error using weights 3, 5, and 7 to calculate PT Pupuk Indonesia's sales forecast. The MAPE calculation values are as follows:

| Bulan  | PE Bobot 3 | PE Bobot 5 | PE Bobot 7 |
|--------|------------|------------|------------|
| Jan-25 | 37%        | 32%        | 29%        |
| Feb-25 | 14%        | 11%        | 11%        |
| Mar-25 | 0,20%      | 3%         | 2%         |
| Apr-25 | 14%        | 15%        | 16%        |
| May-25 | 38%        | 38%        | 36%        |
| Jun-25 | 17%        | 22%        | 25%        |
| Jul-25 | 10%        | 17%        | 22%        |
| Aug-25 | 18%        | 8%         | 2%         |
| Sep-25 | 2%         | 2%         | 3%         |
| Oct-25 | 22%        | 20%        | 22%        |
| Nov-25 | 14%        | 16%        | 17%        |

Figure 4. Calculation of Forecast Percentage Error

The Percentage Error calculation data for 2025 can be said to fluctuate every month where the Percentage Error Weight 3 for the highest value in May 2025 was 38% and the lowest value in March 2025 was 0.20%. Percentage Error Weight 5 for the highest percentage value in May 2025 was 38% and the lowest percentage value in September 2025 was 2%. Percentage Error Weight 7 for the highest percentage value in May 2025 was 36% and the lowest percentage value in August 2025 was 2%.

After calculating the percentage error, the author can calculate the MAPE (Mean Absolute Percent Error) from the predetermined weight values. The MAPE (Mean Absolute Percent Error) calculation is as follows:

| Bobot | Nilai MAPE | Persentase Keberhasilan |
|-------|------------|-------------------------|
| 3     | 15,87%     | 84,13%                  |
| 5     | 16,14%     | 83,86%                  |
| 7     | 16,40%     | 83,60%                  |

Figure 5. MAPE Value of WMA Weight

From the table above, we can see the MAPE value and success percentage for each weight. At weight 3, the prediction value can be said to be good with the MAPE Indicator being between 10% - 20%, which is 15.87% and the success percentage value is 84.13%. At weight 5, the prediction value can be said to be good with the MAPE Indicator being between 10% - 20%, which is 16.14% and the success percentage value is 83.86% and at weight 5, the prediction value can be said to be good with the MAPE Indicator being between 10% - 20%, which is 16.40% and the success percentage value is 83.60%.

## DISCUSSION

Currently, PT Pupuk Indonesia uses forecasting methods, which refer to techniques or approaches used to predict future fertilizer needs. This involves analyzing historical data, trends, and patterns to create projections about future sales or demand. The choice of forecasting

method can significantly impact the accuracy of the predictions.

The method used by PT Pupuk Indonesia is irrelevant due to a 25% gap in capturing the complexity of the fertilizer market and the factors influencing demand. It may be outdated, inadequate, or not tailored to the specific characteristics of the fertilizer industry. Inappropriate forecasting methods can lead to inaccurate predictions, resulting in a significant gap between estimated demand and actual fertilizer demand. To improve forecasting accuracy, PT Pupuk Indonesia needs to analyze and address the shortcomings of its current forecasts.

The overall weighted results will be compared. The model with the lowest forecasting error will be proposed as a forecasting method that can be used by the company in the future to improve forecasting accuracy. The error rate will be measured using MAPE (Mean Absolute Percent Error), which is an assessment error in percentage form to be easier to understand and more able to show the weight of the error that occurs without being affected by the size of the data value. The lower the MAPE value, the better the forecasting results obtained. The data obtained in this study are data on subsidized fertilizer sales for the past 5 years.

In this study, the emphasis is on sales forecasting using historical sales realization with the calculation of Weight Moving Average (WMA) weights, namely 3, 5, 7 and MAPE (Mean Absolute Percent Error) values, where in the WMA calculation the MAPE value for Weight 3 is 15.87%, Weight 5 is 16.14% and Weight 7 is 16.40% so that it has a more accurate influence on sales realization in the following year.

### **Results impact on Managerial**

Accurate sales forecasting results enable managers to make data-driven decisions. Forecasting helps project future needs such as product demand, resource allocation, and marketing strategies. Therefore, it can be said that the company's strategic management has an impact on reducing the risk of decisions based on unfounded and unscientific principles and has a long-term impact on increasing the market expansion of subsidized fertilizer sales based on growth projections. It can also plan strategies based on sales forecast figures that have been made to optimize sales efficiency and increase company profits.

### **The results have an impact on Terotics**

The theoretical impact of sales forecasting results (a theory-based approach) encompasses various dimensions, such as theory development in management, predictive model testing, and contributions to theoretical frameworks in marketing and business operations. Further analysis is as follows:

1. Contribution to Management Theory: Sales forecasting tests the relevance and accuracy of theories underlying consumer behavior, markets, and business dynamics. Theories such as demand theory and game theory can be validated or refined based on forecast results.
2. Integrating Theory with Practice: Forecasting results link marketing and operational theory with practical applications, such as supply chain management and pricing strategy.
3. Revision of Theoretical Framework: When Forecasting results do not fit with existing theory, this encourages revision of the conceptual framework or development of new theory to explain more complex phenomena.
4. Contribution to Empirical Literature: Adding new insights to the theory of market behavior through empirical results from forecasting based on big data.

Therefore, it can be concluded that sales forecasting results have a significant impact on theoretical approaches because they can strengthen, validate, or even challenge existing theories. Furthermore, integrating forecasting results with theory helps create a stronger conceptual framework to support strategic decision-making in business.

## CONCLUSION

Sales forecasting is an important tool used by companies to plan for the future based on historical data and market trends. Forecasting aims to improve the accuracy of business decisions, manage risks and optimize resources, diversify techniques and models, improve operational efficiency, and explore the role of technology in forecasting.

The results of sales forecasting using WMA Weights 3, 5, 7 show that the MAPE value falls within the 10% - 20% range category, which is categorized as good predictive ability, but the best forecasting results for 2025 were obtained from Weight 3 with a WMA value of 6,974,426 tons with a MAPE value of 15.87% and an accuracy of 84.13%.

Through a data-driven approach, digital technology, and continuous evaluation, the company is able to develop adaptive, innovative, and sustainable fertilizer marketing plans. With an integrated strategy of demand estimation, distribution, and farmer education, the company is committed to supporting national food security while maintaining business growth in the domestic fertilizer market.

PSO fertilizer sales planning and billing in Indonesia are conducted through a data-driven approach using the RDKK (Regional Development Planning) as the primary basis. This is aligned with government subsidy allocations and agricultural sector policies. This strategy is supported by

close coordination with relevant ministries and the digitalization of systems such as e-RDKK to ensure targeted distribution and transparent distribution of subsidized fertilizer.

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