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Comparison of Farmer Exchange Rate Index Forecasting with Decomposition and Single Exponential Smoothing Method

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ABSTRACT

NTP forecasting is crucial for supporting appropriate policy-making. Therefore, this study aims to address the problem of selecting the most accurate forecasting method for predicting the Farmers' Terms of Trade Index (FTTI). Specifically, the objective is to compare the accuracy of two time series forecasting methods, namely Decomposition and Single Exponential Smoothing (SES), in forecasting the price index received by food crop farmers for the period 2020 to 2024. Both methods were evaluated using Root Mean Square Error (RMSE) as a measure of forecasting accuracy. The results show that the Decomposition method provides better forecasting accuracy, as indicated by lower RMSE values (RMSE = 1.846) than the SES method, both with α = 0.1 (RMSE = 7.37) and α = 0.6 (RMSE = 3.23). This finding suggests that the Decomposition method is better at capturing seasonal patterns and trends in the FTTI data than the SES method, which tends to produce larger errors.

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A. INTRODUCTION

The government has issued various policies to maintain economic balance, including the food price stabilization policy. This policy is closely related to the nature of food products that tend to have volatile prices and seasonal production (Rozi et al., 2025). This condition makes food commodities vulnerable to sharp price changes, which can, in turn, trigger economic instability. This policy aims to ensure that strategic food price increases can be managed properly and remain stable, and reduce their impact on inflation (Wibowo et al., 2025). One indicator of the welfare of food crop farmers is the Food Crop Farmer Exchange Rate (NTPP). This indicator compares farmers' purchasing power from their earned income with their expenditures on consumption and production inputs. Given the importance of the Farmer Exchange Rate (NTP) as a measure of farmers' welfare, maintaining the stability of the factors that influence it is crucial. Farmers' welfare can potentially improve if the NTP stabilizes above 100 (Erekalo et al., 2025). To achieve this, a deep understanding of the NTP pattern is needed as a basis for accurate forecasting. In this study, data on the price index received by food crop farmers from 2020 to 2024 are used to analyze monthly price fluctuations, with rice as the main component (Ahmed et al., 2025). The data shows a consistent fluctuation pattern from year to year, with significant increases in 2023 and 2024. In 2024, the price index received by farmers reached an annual figure of 133.83, with the paddy index at 135,99. To further analyze this pattern, an appropriate forecasting method is needed to predict future price trends and help formulate policies that support the agricultural sector. The Farmer Exchange Rate (NTP) index primarily serves as a comparative measurement tool for comparing the value of goods and services needed by farmers to produce and fulfill household needs with the value of the products they sell (Van Asseldonk et al., 2021). Since NTP is the ratio of the prices received by farmers to the prices they must pay, this index is an important indicator for assessing farmers' welfare in Indonesia (Elfira et al., 2022). NTP is dynamic and continues to change according to the latest conditions of the value of products enjoyed by farmers (It) and products paid by farmers (Ib). NTP will increase if the percentage increase in the prices of products produced by farmers exceeds the percentage increase in the prices of products purchased by farmers, indicating an increase in farmers' income. Therefore, in general, there is a close relationship between an increase in farmer income and NTP. Usually, there is a positive correlation between farmers' income and their welfare, so NTP is considered an accurate indicator of improvements in farmers' welfare (Akbar et al., 2019).

Exponential Smoothing is a time-series forecasting method that uses exponential weighting of past data. In this case, the Exponential Smoothing method is divided into three, namely Single Exponential Smoothing, which is used for smoothing data that is stationary, has no trend, and seasonal variations, so it only uses one parameter, (α) (Wasono et al., 2024). Double Exponential Smoothing is used to smooth data that has a trend but does not show seasonal variations, with two smoothing parameters, namely (α) and (β). Meanwhile, Triple Exponential Smoothing is used to smooth data that has a trend and seasonal variations, using three smoothing parameters, namely (α), (β), and (γ) (Cantarella et al., 2025). Single Exponential Smoothing is used for short-term forecasts without any trends or growth patterns. Single Exponential Smoothing applies a smoothing constant. This model assumes that data fluctuate around a fixed or near-horizontal mean, with a weight between 0 and 1 for the current and previous observed values. A weight closer to 1 indicates greater emphasis on the current value, while a weight closer to 0 indicates greater emphasis on past data (Zhao et al., 2022). There are two types of decomposition models: additive and multiplicative. The additive model is used when seasonal or cyclical variations are relatively stable and do not depend on the series' level.

This research uses two forecasting methods, namely decomposition and single exponential smoothing. These two methods have different approaches in processing time series data. The decomposition method aims to identify seasonal patterns that recur regularly. This method is suitable for seasonal data that exhibits a consistent pattern over a specific time period. Meanwhile, the exponential smoothing method assigns decreasing weights to older observation values. When forecasting time series data, it's necessary to compare various methods to find the most appropriate approach (Kumar et al., 2024). The author will use the Mean Absolute Percentage Error (MAPE) to evaluate the accuracy of the forecasting method. This MAPE helps the author assess how closely the prediction results match the actual data as a percentage, making it easier to compare the accuracy of various methods and determine the most suitable method for predicting data (Tadayonrad & Ndiaye, 2023).

The study by Chicco et al. (2021) highlighted the importance of selecting appropriate evaluation metrics, where R-squared was considered more informative and reliable than other metrics, while Wasono et al. (2024) demonstrated that the Holt-Winters exponential smoothing method was capable of capturing both trend and seasonal patterns with minimal forecasting errors. Based on these findings, this research formulates the problem as how to compare the accuracy of the Decomposition and Single Exponential Smoothing methods in forecasting the Farmers' Terms of Trade (FTT) for the period 2020–2024, and to determine the most appropriate evaluation metric to assess forecasting accuracy.

B. RESEARCH METHOD

The data used in this study are secondary data obtained from the official website of Badan Pusat Statistik (BPS). The dataset consists of the Price Index Received by Farmers (INTP) for rice commodities covering the period 2020–2024. The data are structured as a monthly time series, providing a comprehensive description of price fluctuations over the observed period. To conduct forecasting, this study applies two time-series analysis methods: the Decomposition Method and Single Exponential Smoothing (SES). Both methods are employed in parallel to evaluate and compare their performance in predicting the price index received by farmers. The steps undertaken in the data analysis are as follows:

1. Retrieve data from the official website of the Badan Pusat Statistika.
2. Preprocessing data to ensure data completeness and validity.
3. Performing the data stationarity test. If the data is not stationary, differencing is performed to make it stationary.

4. Perform forecasting using the decomposition method:
   a. Perform time series decomposition to separate trend, seasonal, and residual components in Equation (1) (Qian et al., 2019).

$$Z_t = S_t + T_t + R_t \tag{1}$$

   b. Handle missing values in the trend and seasonal components.
   c. Creating a trend forecasting model using ARIMA in Equation (2) (Nusrang et al., 2025):

$$\phi_t(B)(1-B)^d Y_t = \theta_0 + \theta_q(B)\alpha_t \tag{2}$$

   d. Combining the trend and seasonal components to get the final forecasting results.
5. Perform forecasting using the Single Exponential Smoothing (SES) method:
   a. Determine inputs and outputs based on monthly time series data of the Farmer Exchange Rate Index (NTP).
   b. Determining the alpha parameter for SES, using the optimal value based on the Grid Search Optimization method.
   c. Perform SES modeling on training data in Equation (4) (Aziz et al., 2025):

$$F_t = \alpha \times X_t + (1-\alpha) \times F_{t-1} \tag{3}$$

   d. Implementing the SES model on testing data to measure forecasting accuracy.
   e. Perform forecasting predictions for the next 12 months using the best SES model.
6. Determine the best model using Root Mean Square Error (RMSE) in Equation (4) (Wang & Lu, 2018):

$$\text{RMSE} = \frac{r\Sigma\,(x-y)^2}{n} \tag{4}$$

7. Make interpretations and conclusions based on the results of data processing. The flow diagram shown in Figure 1 is as follows.

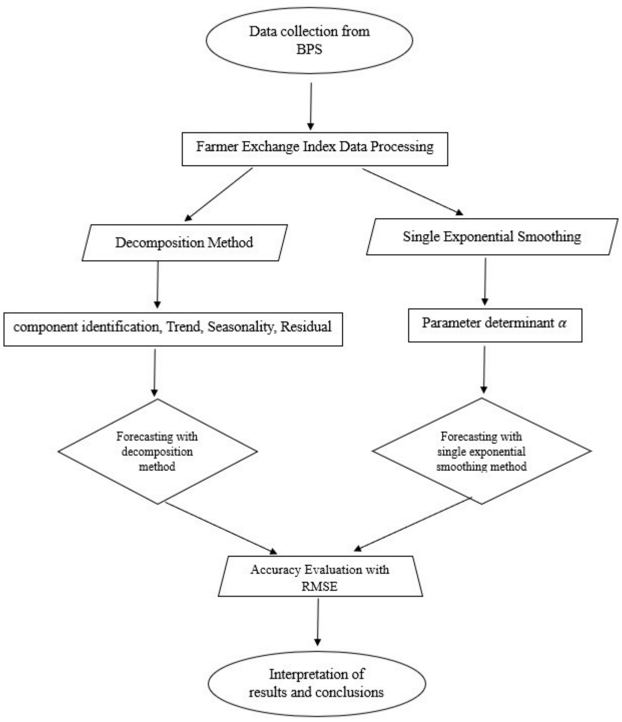

Figure 1. Flow Diagram

C. RESULT AND DISCUSSION

1. Descriptive Analysis

Descriptive analysis provides an overview of the research data. The data used in this study is the Farmer Exchange Rate Index (NTP) data from January 2020 to December 2024. The data was obtained from the Central Statistics Agency (BPS)

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website. The following is a graph and explanation of the data displayed in Figure 2.

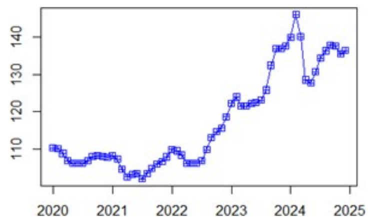

Figure 2. Plot of Farmer Price Index

From Figure 2, it can be concluded that in 2020, the Farmer Exchange Rate Index (NTP) showed a relatively stable movement with fluctuations. During the first 2 years of 2020 and 2021, the Farmer Exchange Rate Index (NTP) fluctuated little, with a slight decrease at the beginning of 2021, followed by an insignificant increase in 2022. The Farmer Exchange Rate Index (NTP) continued to rise throughout 2023, peaking in early 2024. This data is fluctuating or irregular conditions, and the plot on the Farmer Exchange Rate Index (NTP) data does not form a straight line, so the data studied is non-linear data displayed in Table 1.

Table 1. Descriptive Statistics

Variable	Speed (rpm)
Min	102
Max	146.1
Median	110
Mean	117.3
Standar Deviasi	12.9

In Table 1, the minimum value for the Farmers' Terms of Trade Index data was 102 in July 2021, and the maximum value was 146.1 in February 2024. The standard deviation, or the dispersion of the data from the mean, was 12.959. The median value of the data was 110, and the average value of the Farmers' Terms of Trade Index was 117.3.

2. Forecasting Method Evaluation

This study applies two forecasting methods, namely the decomposition method and Single Exponential Smoothing (SES). The performance of each method is evaluated by calculating the prediction error, with a particular focus on the Root Mean Square Error (RMSE) as the accuracy measure. The RMSE provides a quantitative measure of the difference between predicted and actual values, enabling direct comparison of forecasting performance. Through this approach, the study aims to identify the method that yields the most accurate predictions.

3. Decomposition Method

In the descriptive analysis, a plot of the Farmers' Terms of Trade Index from 2020 to 2024 is presented. Subsequently, a decomposition analysis is performed to examine the forecasting results for future periods. The forecasting results are shown in Figure 3.

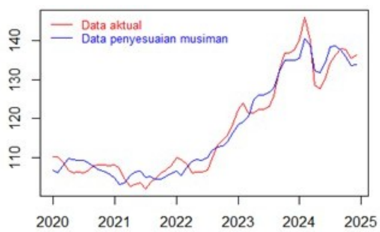

Figure 3. Farmers' Price Index Plot Using the Decomposition Method

Figure 3 presents the results of the decomposition-based forecasting of the Farmers' Terms of Trade Index, illustrating the application of seasonal adjustment. The red line depicts the actual data, whereas the blue line represents the seasonally adjusted data, as shown in Table 2.

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Table 2. Forecasting Results of the Decomposition Method

Month	Farmer's Terms of Trade Index	Forecast
January	140	138.31
February	146.08	139.24
March	140.14	135.25
April	128.59	130.44
Mei	127.71	130.01
Juni	130.74	130.34

Table 2 presents the actual and forecasted data from the decomposition method for 2025, revealing fluctuations with the highest peak observed in February. Although the predictive model generally follows the overall trend, noticeable discrepancies appear between the actual and forecasted values, particularly at the beginning of the year. The accuracy assessment yields an RMSE of 1.846, indicating that the decomposition method provides relatively accurate forecasts.

4. Single Exponential Smoothing (SES) Method

Single Exponential Smoothing is used for short-term forecasting. This model assumes that the data fluctuates around a fixed average value or is nearly horizontal, with no trends or growth patterns. Single Exponential Smoothing uses a smoothing constant, k, valued between 0 and 1, as a weight for the current and previous observation values, as shown in Figure 4.

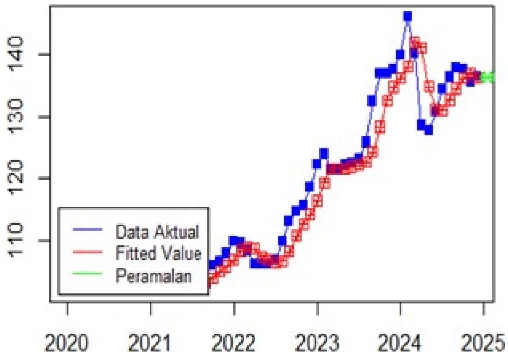

Figure 4. Farmers' Price Index Plot Using the Single Exponential Smoothing (SES) Method

In Figure 4, the forecast plot of the Farmers' Terms of Trade Index shows differences in each symbol along the actual data graph. The blue line represents the actual data, while the green line represents the forecasted values, which do not differ significantly. This indicates that the Single Exponential Smoothing (SES) model performs quite well in capturing the actual data pattern displayed in Table 3.

Table 3. Forecasting Results of the Single Exponential Smoothing (SES) Method

Month	Farmer's Term of Trade Index 2024	Forecast
January	140	136.51
February	146.08	136.51
March	140.14	136.51
April	128.59	136.514
Mei	127.71	136.51
Juni	130.74	136.51

Table 3 shows that the forecast value remains constant because SES does not capture trends or seasonal patterns; it only smooths the average using the most recent data, giving it greater weight. The SES method is applied with two smoothing parameter values (alpha), namely 0,1 and 0,6. The forecast results for the next 10 periods show that the predicted value tends to remain constant when alpha = 0,1, the predicted value is 132,46, and when alpha = 0,6, the predicted value is 136,4. The accuracy evaluation of the SES method shows the following results for $\alpha = 0,1$ with RMSE: 7,37 and $\alpha = 0.6$ with RMSE: 3,23.

5. Comparison of RMSE Values

Based on the RMSE values, the decomposition method shows a lower error rate (RMSE = 1.846) compared to the SES method, both with $\alpha = 0.1$ (RMSE = 7.37) and $\alpha = 0.6$ (RMSE = 3.23). This indicates that the decomposition method has better accuracy in predicting the Farmers' Terms of Trade (FTT) data. The smaller RMSE value from the decomposition method suggests it is better at capturing seasonal patterns and trends than the SES method, which tends to produce constant forecast values.

D. CONCLUSION AND SUGGESTION

This study formulated the problem of comparing the accuracy of the Decomposition and Single Exponential Smoothing (SES) methods in forecasting the Farmers' Terms of Trade Index (FTTI). The results indicate that the Decomposition method achieves higher accuracy than SES, as evidenced by its lower RMSE. The Decomposition method can separate trend and seasonal components, thereby producing forecasts that are closer to the actual data. In contrast, the SES method, although simpler, tends to be less accurate, especially when applied to data with strong seasonal patterns. Thus, this study concludes that the selection of a forecasting method should align with the data's characteristics. The Decomposition method is more appropriate for data with clear trends and seasonal patterns, while SES can serve as an alternative for data with simpler fluctuations.

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AUTHOR CONTIBUTION

All authors contributed to the writing of this article.

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COMPETING INTEREST

The author declares that there is no conflict of interest in publishing this article.

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