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Implementation the Pegel's Classification to Forecast Rice Prices Based on Quality at The Milling Level

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Abstract

Rice is the primary food of the Indonesian people and plays an important role in various aspects. In fact, the increase rice prices in Indonesia has occurred from 2014 until now. The burden on society continues to occur when the discourse of increasing PPN issue by 12% in 2025 is delivered by the government. Business actors, especially food and consumers, are very influenced by this policy. Against this background, this study analyzes the average prediction of rice prices at the milling level according to quality. The Pegel's Classification is the technique employed in this research. The data used in this study from *Badan Pusat Statistik (BPS)*. The predicted price of premium or medium rice less than IDR 14,000 with a difference of no more than IDR 700 for each quality. February 2025 is the predicted highest average price for rice for each quality, with a decrease in March. Pegel's B-2 model is an best effective model because it has a Mean Absolute Percentage Error (MAPE) value of 2.02%.

Keywords: Forecasting, pegel's classification, rice prices

1. Introduction

In Indonesia, the primary food of the public is rice. Rice plays an important role in the economic, environmental, and socio-political (Kusumawardani et al., 2021). Mr. Joko Widodo stated that all countries (not only Indonesia) have experienced an increace in rice prices caused by climate change, resulting in many crop failures. In Indonesia, rice consumption has not changed but production has decreased, so supply has decreased and prices have increased (McCulloch & Peter, 2008). Thus, the major challenge faced in rice price management is uncertainty. Where the factors that caused price increases include supply and demand, government policies, weather conditions, and other external factors.

The increase in rice prices applies to all types of rice. According to quality, rice is divided into three, namely premium, medium, and special/other rice (Pratiwi & Damayanti, 2023). Medium rice has a minimum milling degree specification of 95% with a maximum water content of 14% and a maximum of 25% broken grains, while premium rice has a higher quality with a minimum milling degree of 95%, a maximum water content of 14%, and a maximum of 15% broken grains (Pratiwi & Damayanti, 2023). The degree of polishing is the percentage of the degree of removal of the water skin and the skin covering the rice grains. The low degree of rice milling will interfere with the consumption process. Based on the content in each type of rice, premium rice is superior to medium rice, as is the case with the names of the two types of rice. Another difference lies in the quality of the appearance of the rice, such as the color or brightness of the appearance of the rice, and also whether the rice is whole or broken.

Before rice is distributed to the market, it has gone through several stages of the distribution process. Starting from the grain purchased from farmers directly by the middlemen until it reaches the sales location in various locations. The further the location, the more expensive it will be and vice versa. The distribution route for rice to reach consumers can go through four to six distribution points (Hermawan et al., 2023). First, farmers sell their harvest to middlemen or rice cutters who will dry the rice and sell it to the rice mill owners, which is the second point of rice distribution. Then the third point is large-scale wholesale traders who have storage warehouse. The wholesaler will sell to small-scale wholesalers who become the fourth point, for example, the Main Market. Then the last point is sold to retailers and purchased by consumers.

The wholesaler will sell to small-scale wholesalers who become the fourth point, for example, the Main Market. Then the last point is sold to retailers and purchased by consumers. Decisions that can be taken include the production,

distribution, and consumption of rice. Although the basic price does not have a value-added tax (PPN) rate as explained by Prabowo Subianto, mister president in Indonesia. However, increase in basic prices can occur due to other factors, so rice price forecasting remains important and can be analysed like other basic commodities.

2. Literature Review

Research on rice predictions has previously been conducted by Minten et al. (2013), who concluded that the average price of premium quality rice at the milling level tends to be stable and only experiences a gradual increase. However, the price of rice commodities in 2022 is not expected to reach IDR 10,000. Another study on rice price predictions using Monte Carlo Simulations was able to produce rice price predictions with a high level of accuracy, with an average accuracy level of 97.60% for 2022 and 94.27% for 2023 (Pasaribu & Karo, 2024). From this study, it can be seen that the Monte Carlo prediction error is 2.4% for 2022 and 5.73% for 2023.

The right prediction method is one of the factors to obtain the smallest possible prediction error. Of the several prediction methods used by several researchers for time series data, the one that attracts the attention of researchers is the Pegel classification method. This is because several forecasting studies using this can be effectively used to predict time series data. For example, research (Wiyanti & Siregar, 2023) which uses the Pegel's method compared to the artificial intelligence product, namely GPT-3, concluded that GPT-3 cannot predict the DBD time series and Pegel's predicts with a forecast error approaching 0%. Pegel's classification is a prediction method that utilizes information from the characteristics of time series data. For example, if time series data has a linear pattern and trend and is not seasonal, then the type of Pegel's classification used is Holt's Linear. As a research (Evania & Wiyanti, 2024). Holt's linear method is used to predict the number of deaths from diabetes mellitus in Indonesia, with a prediction error value of 0.546%. Pegel's classification is also used to predict dengue fever data with seasonal or cyclical data characteristics (Wiyanti & Siregar, 2023). In addition, the use of Pegel's classification with SES, ARRSES, and Holt's types to predict data with trend and seasonal characteristics obtained a very small prediction error value of 0%-0.66% (Wiyanti & Siregar, 2023). Even Pegel's classification has also been applied in the financial sector, namely for stock price predictions with prediction errors ranging from 4% to 6.6% (Oral, 2019).

Based on the background above, this study aims to apply the pegel's classification to predict the average price of rice at the milling level to obtain visualization and the level of forecast error. The selection of the Pegel's classification method is due to several reasons mentioned above, namely that the forecast error used is close to 0%. The benefit of conducting this research is that researchers can implement the Pegel's method that they have learned in college to be applied directly to time series data. In addition, it can expand knowledge and insight into the results of predicting the average price of rice at the milling level based on variations in quality each year. It is hoped that this research will not only be useful for researchers, but also for food business actors and customers so that it can help in understanding the pattern of changes and continuation of the average price of rice at the milling level based on variations in quality.

3. Materials and Methods

3.1. Materials

The data used in this study is secondary data obtained from the BPS website, namely the average monthly rice price data at the milling level according to quality (rupiah/kg) from 2021 to December 2024. The quality of rice in question is medium and premium. The method of data analysis for this research uses a quantitative method, namely Pegel's classification. The data processing process for this research can be seen in Figure 1, which is a flow diagram for this for this research.

Figure 2 is a plot of average data on premium and medium rice prices at the milling level from 2021 to December 2024. The average price of premium and medium rice is not much different. Both began to increase in mid-2022 and peaked in 2024. Then, data began to decline and stabilize until the end of 2024. An increase in the average price of rice could occur in the future, so forecasting is needed to estimate the average price of rice in the following month.

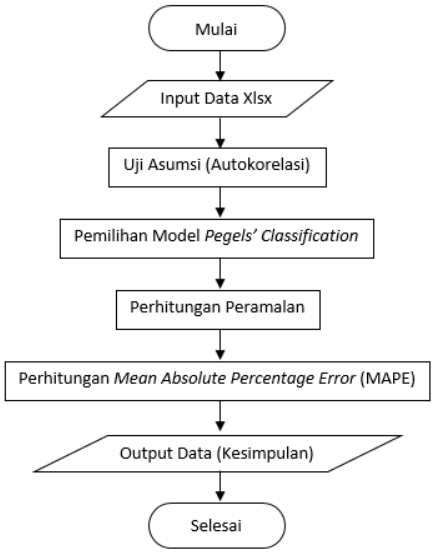

Figure 1: Research data analysis process

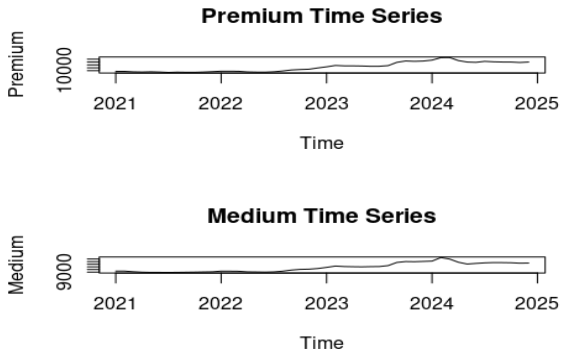

Figure 2: The mean cost of medium and premium rice

3.2. Methods

3.2.1. Exponential Smoothing: Pegel's Classification

Pegels classification is one of the exponential smoothing forecasting methods by looking at whether the time series data contains a trend and/or the data includes seasonal data (Makridakis & Wheelwright, 1997). These two components produce nine smoothing models in Table 1. The formulas used in the nine smoothing models can be summarized by equations (1), (2), and (3). (Makridakis & Wheelwright, 1997)

$$L_t = \alpha P_t + (1-\alpha)Q_t \tag{1}$$

$$b_t = \beta R_t + (1-\beta)b_{t-1} \tag{2}$$

$$S_t = \gamma T_t + (1-\gamma)S_{t-s} \tag{3}$$

Where are,

L_t : Estimate of series level of time t.
P_t : Actual value of time t.
Q_t : Estimate of series level of time t.
b_t : Trend at time t.
R_t : Actual trend's value at the time t.
S_t : Seasonal's component at time t.
T_t : Seasonal's actual value at time t.

Table 1: Pegel's Classification's Model

Trend Component	Seasonal Component		
	1 (none)	2 (additive)	3 (multiplicative)
A (none)	A-1	A-2	A-3
B (additive)	B-1	B-2	B-3
C (multiplicative)	C-1	C-2	C-3

Table 2: Nine Formula of Pegel's Classification

Trend Component	Seasonal Component		
	1 (none)	2 (additive)	3 (multiplicative)
A (none)	$P_t = Y_t$ $Q_t = L_{t-1}$ $F_{t+m} = L_t$	$P_t = Y_t - S_{t-s}$ $Q_t = L_{t-1}$ $T_t = Y_t - L_t$ $F_{t+m} = L_t + S_{t+m-s}$	$P_t = Y_t / S_{t-s}$ $Q_t = L_{t-1}$ $T_t = Y_t / L_t$ $F_{t+m} = L_t S_{t+m-s}$
B (additive)	$P_t = Y_t$ $Q_t = L_{t-1} + b_{t-1}$ $R_t = L_t - L_{t-1}$ $F_{t+m} = L_t + mb_t$	$P_t = Y_t - S_{t-s}$ $Q_t = L_{t-1} + b_{t-1}$ $R_t = L_t - L_{t-1}$ $F_{t+m} = L_t + mb_t + S_{t+m-s}$	$P_t = Y_t / S_{t-s}$ $Q_t = L_{t-1} + b_{t-1}$ $R_t = L_t - L_{t-1}$ $F_{t+m} = (L_t + mb_t) S_{t+m-s}$
C (multiplicative)	$P_t = Y_t$ $Q_t = L_{t-1} b_{t-1}$ $R_t = L_t / L_{t-1}$ $F_{t+m} = L_t b_t^m$	$P_t = Y_t - S_{t-s}$ $Q_t = L_{t-1} b_{t-1}$ $R_t = L_t / L_{t-1}$ $F_{t+m} = L_t b_t^m + S_{t+m-s}$	$P_t = Y_t / S_{t-s}$ $Q_t = L_{t-1} b_{t-1}$ $R_t = L_t / L_{t-1}$ $F_{t+m} = L_t b_t^m S_{t+m-s}$

The parameters used in exponential smoothing adjust for seasonal components and variations. Three parameters used in the pegel's classification are (Maçaira et al., 2015):

1. Alpha (α) : The alpha parameter is a relative weighting control in the forecasting method. Its value ranges from 0 to 1. Alpha is used consistently in all models to optimize forecast accuracy.
2. Beta (β): The beta parameter controls the relative weighting of new observations to estimate the emergence of a trend in the data series. Its value ranges from 0 to 1, with higher values indicating a higher weighting of observations. Beta is used in models that have a linear trend component or do not have seasonal variation.
3. Gamma (γ) : The gamma parameter controls the relative weighting of new observations to account for the presence of seasonal variation in the data. Its values range from 0 to 1. Gamma is used in models that have a seasonal variation component.

Table 1 is a group form of nine models in Pegel's classification. The nine models have their own formulas as in a Table 2. The calculation of prediction using Pegel's classification is determined from the characteristics of the time series data, then selecting the appropriate model from the nine models in Table 2.

3.2.2. Measuring Accuracy of Forecast Values

To measure the accuracy of the prediction value, several methods can be used, namely mean error, mean square error, and mean absolute percentage error. Before calculating all these values, it is necessary to calculate the error value to calculate the error for each period with equation (4). In this study, the prediction error used MAPE (De Myttenaere et al., 2016).

$$e_t = Y_t - F_t \tag{4}$$

$$MAPE = \frac{1}{n}\sum_{t=1}^{n}|PE_t| \tag{5}$$

$$PE_t = \left(\frac{Y_t - F_t}{Y_t}\right) \times 100 \tag{6}$$

Where are,

e_t : error value per period.
Y_t : actual observations for time period t.
F_t : predicted value for t period.
PE_t : percentage error for t

4. Results and Discussion

The results of data analysis using R software. The first is to check the assumptions that must be met before making a forecast. Based on Figure 3, there are four panels, namely the original data, trend components, seasonal components, and random or residual components. In left of figure, the premium decomposition is on the left, while the medium decomposition is on the right. The top panel is the original rice price data over time. Premium has an upward pattern with some large fluctuations at the end of the period, as does medium, but its value is slightly lower than premium. The second panel after the observed panel is the trend component panel, which is the general direction of the data in the long term. Both premium and medium show a gradual increase over time, with premium slightly higher than medium. The third panel is the seasonal component that repeats consistently in each period. Based on the image on the right in Figure 3, the quality of rice prices from 2021 to the end of 2024 shows the same seasonal pattern, namely the data value fluctuates regularly in the short term. The data pattern in certain months tends to be higher or lower each year. The last panel is the random or residual component, which shows the part of the data that cannot be explained by trend or seasonality.

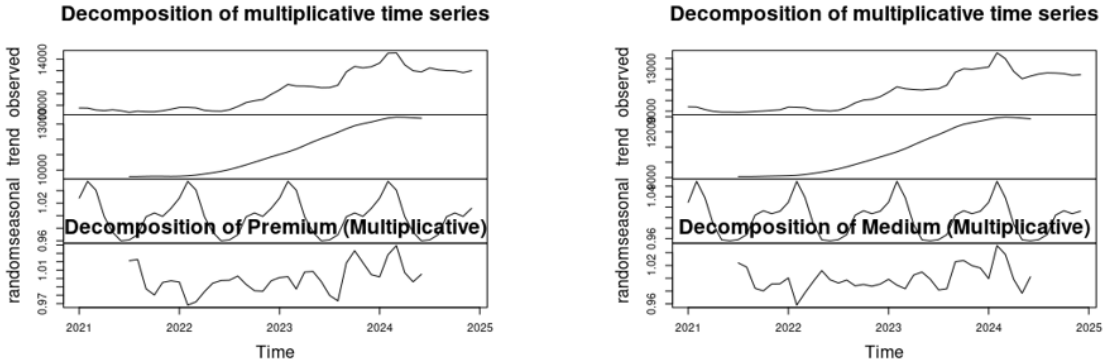

Figure 3: Premium and Medium Rice Price Decomposition Plot

Both graphs in Figure 3, show more volatile random components and have no clear pattern. This reflects uncertainty or unexpected external factors. It can be concluded that the main difference between premium and medium is that the premium value level is higher than medium, and there is little difference in random fluctuations.

After decomposition, data stationarity is carried out using the ADF test. Stationarity testing is needed to determine the next model of rice price forecasting, whether using a linear or nonlinear formula. Based on the results of the ADF test, both datasets have a p-value greater than 0.05 with a p-value of 0.60 for premium and 0.64 for medium. So the null hypothesis is accepted, which means that the average data on rice prices, both premium and medium, are not stationary.

Based on the assumption test, namely decomposition and the ADF test, it is known that the average data on rice prices for each quality is included in seasonal data and has trend but is not stationary. Thus, the Pegels classification model that is suitable for this type of time series data is the B-2 model. By using the equation in Table 2, the average forecast value of rice prices according to quality is obtained.

The predicted average price of premium rice for three months using B-2 is less than IDR14,000. In January 2025, it is predicted that the average price of premium rice is IDR13,180, while medium is IDR12,717, so the difference between the two is IDR463. In February 2025, it is predicted that the average price of premium rice is IDR13,741, while medium is IDR13,323, so the difference between the two is IDR418. In March 2025, it is predicted that the average price of premium rice will be IDR13,693 while medium is IDR13,064, so the difference between the two is IDR629. Both premium and medium experienced an increase in the average price of rice at the milling level in February 2025 but decreased the following month. For three months, it can be said that the average price of rice is stable even though it fluctuates. This is due to the difference each month, which is not more than IDR700, and the same is true for the difference between rice prices each month, which is superior to the average price of premium rice.

Table 3: The predictions results

Time (t)	Premium Price	Medium Price
Jan 2025	IDR13.180	IDR12.717
Feb 2025	IDR13.741	IDR13.323
Mar 2025	IDR13.693	IDR13.064

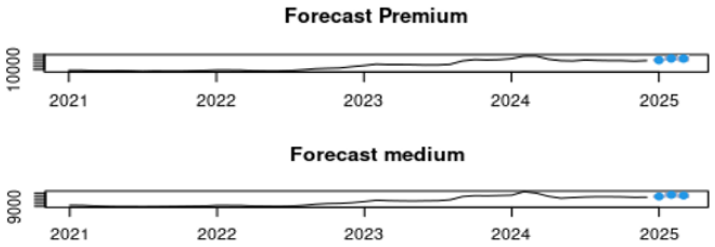

Figure 4: Forecast the Premium and Medium prices with B-2

The results of the forecasting calculations can be visualized into premium and medium forecasts with the B-2 model as in Figure 4. The upper graph is the average forecast of premium rice prices, and the lower graph is the average forecast of medium rice prices. The black line is the original data of the average price of rice for each quality. The blue dots are the average predictions of rice prices for the next 3 months, so there are three dots in each quality. The original data from January 2021 to December 2024 is continued with the prediction of the average price of rice for the next 3 months, namely January, February, and March 2025. The highest price from the prediction for the three months is in February for both qualities so that the point is above January and March. As in the graph, the average price of premium rice is superior to medium. Thus, the better the quality of rice, the higher the selling price at the milling level. When it is in the hands of consumers, this price will be higher because it has gone through several stages of sales.

The Mean Absolute Percentage Error (MAPE) value of the prediction using the B-2 model of the pegels classification is 2.02%. With this value, it can be said that the forecasting model used already has very good accuracy. The average prediction error is only 2.02% of the original data, where the model is able to capture data patterns very well.

5. Conclusion

Forecasting the average price of rice at the milling level for both premium and medium quality shows that it has a consistent trend and seasonal pattern, but the random component does not have a clear pattern. With the same seasonal pattern and trend, the average price of premium rice tends to be higher than medium. In checking stationarity, the data is considered non-stationary with a p-value of more than 0.05. Thus, the suitable pegels classification model is model B-2. Forecasting is done in the next three months, namely January to March 2025. The results of the average rice price prediction, both qualities, increased in February 2025 with a decrease in the next month. The average prediction of premium rice price is higher than the medium, which is similar to the original data and is obtained with less than IDR14,000 predicted value for each quality. The price difference between qualities remains stable with an average of less than IDR700. The B-2 model has best accuracy with a Mean Absolute Percentage Error (MAPE) value of 2.02%. It means that the average prediction error is very small. Thus, it can be concluded that the average price of premium rice is higher due to better quality, and the B-2 model is effective for predicting the average price of rice by providing accurate results for rice price forecasting.

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