Statistical Analysis of Strategic Food Commodity Pricing Trends

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Abstract. Strategic food commodities are commodities that have a significant impact on inflation. Their prices can fluctuate considerably due to various factors, including weather conditions, production levels, and demand. Understanding the pricing trends of strategic food commodities is essential for multiple stakeholders, including farmers, traders, consumers, and policymakers. Pricing trend analysis is essential for farmers to make informed production decisions, traders to make informed trading decisions, consumers to make informed purchasing decisions, and policymakers to make informed policy decisions. This research uses statistical analysis to comprehensively overview the pricing trend analysis of ten strategic agricultural commodities in Yogyakarta. The ten commodities are rice, purebred chicken meat, purebred chicken eggs, beef, shallots, garlic, red chili, cayenne pepper, cooking oil, and sugar. The projection information on the best statistical approach can then be used to predict future prices and develop strategies for managing risk.

Keywords: food price, strategic food commodity**,** trend analysis

1 Introduction

Food commodity prices have seen substantial volatility over time, influenced by a multifaceted interaction of factors such as climatic patterns, supply and demand dynamics, global economic circumstances, trade regulations, and geopolitical conflicts [1]. The price volatility has substantially influenced food security, especially in emerging nations where a considerable proportion of household earnings are allocated to food expenses. Exorbitant price surges can result in food instability, malnutrition, and social unrest [2][3]. In contrast, extended periods of low pricing might impede agricultural investments and diminish productivity, thus jeopardizing long-term food availability.

Therefore, due to the significant impact on the global economy and the well-being of billions of individuals, it is imperative to closely monitor the prices of essential food commodities that are crucial for human nutrition and serve as necessary inputs in industrial production. Furthermore, the unpredictability of food costs is a significant worry for governments, businesses, and consumers. Abrupt price increases can result in food instability, malnutrition, and societal unrest. Therefore, comprehending the variables that impact food prices is crucial for formulating efficient strategies to tackle food security and instability.

Various statistical techniques, such as trend analysis [4][5][6], time series analysis [7][8], and regression analysis [9][10][11], can be employed to study the volatility of food prices. Trend analysis is employed to detect enduring patterns in food prices, and time series analysis is utilized to find recurring cycles and seasonal variations. Regression analysis is a statistical

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technique that can be employed to create models that forecast forthcoming food prices by considering past data and other relevant aspects.

Various regression models, such as linear, polynomial, quadratic, and logarithmic, can be employed to predict food commodity prices. The optimal model selection relies on the particular commodity under examination and the specific characteristics that are perceived to impact its pricing. Considerable scholarly research has focused on the subject of food commodity pricing, investigating many elements, such as the factors that determine prices, methodologies for predicting prices, and the effects of different pricing schemes. Preliminary research primarily examined the influence of supply and demand fundamentals on commodity pricing [12][13]. Recent studies have explored the intricacies of price formation in worldwide markets, considering aspects such as speculation, information asymmetry, and herd behavior [14][15].

Moreover, statistical modeling, such as regression analysis, has been extensively studied for assessing food commodity prices. The use of linear regression, which presupposes a direct relationship between the dependent variable (price) and independent variables (time, economic indicators, market indices, etc.), has been extensively utilized. Nevertheless, the complex and unpredictable patterns in price changes have necessitated the creation of increasingly sophisticated regression methods, including multiple linear, quadratic, and exponential regression.

This research aims to analyze the trend of strategic food commodity pricing in Yogyakarta, Indonesia. We will assess the efficacy of various regression models in predicting food prices in Yogyakarta. This study's results will apply to politicians, businesses, and consumers interested in the food market in Yogyakarta.

2 Research Methodology

This study assesses the price trend of ten crucial national strategic food commodities: rice, purebred chicken meat, purebred chicken eggs, beef, shallots, garlic, red chili, cayenne pepper, cooking oil, and sugar. Based on the available data, the best appropriate model for predicting is recommended for future forecasting study. A trend refers to a consistent and gradual movement upwards or downwards over a significant period. This movement is determined by calculating the average change over time, resulting in a reasonably smooth figure. Periodic trend data exhibits a continuous and alternating pattern of rising and downward trends. An ascending trajectory is referred to as a positive trend, whereas a descending trajectory is referred to as a negative trend. The trends exhibit rather prolonged and consistent temporal fluctuations. Multiple trend analysis and forecasting approaches are examined:

1. Model Linear: $Y = b_0 + b_1t$
2. Model Logarithmic: $Y = b_0 + b_1 \ln t$
3. Model Quadratic: $Y = b_0 + b_1t + b_2t^2$
4. Model Cubic: $Y = b_0 + b_1t + b_2t^2 + b_3t^3$
5. Model Compound: $Y = b_0b_1^t$ atau $\ln Y = \ln b_0 + \ln b_1 t$
6. Model S: $Y = e^{(b0+b1/t)}$ atau $\ln Y = b_0 + b_1/t$
7. Model Growth: $y = e^{(b0+b1t)}$ atau $\ln Y = b_0 + b_1t$
8. Model Exponential: $Y = b_0e^{(b1t)}$ atau $\ln Y = \ln b_0 + b_1t$

R Square metric evaluation is chosen to analyze the significance of attribute contributions to the data trend to select the best model. The data is collected from the Central Bank of Indonesia's published direct survey findings of market prices in each city/district (https://www.bi.go.id/hargapangan). The acquired data has solely two attributes: the timeframe and pricing. The commodity price data was collected from August 26, 2021, to August 26, 2023.

Detailed information about the ten chosen national strategic food prices analyzed are provided in the following details:

1. Rice: The data for this commodity comprises six different grades of rice based on their price level, including two categories of regular/lower quality rice, two categories of medium quality rice, and two categories of premium quality rice. The selection of rice varieties was based on the predominant type commonly consumed by the community in the city or district of the sampled area. Rason / rastra rice is excluded from regular / inferior rice pricing. The indicated price is the cost for each kilogram. The price used for further analysis is the mean of all available pricing data.
2. Shallots: The data for this commodity comprises solely of one type of shallots, which is sourced locally and is of average quality. The indicated price corresponds to the cost for each kilogram.
3. Garlic: The data for this product includes only one type of garlic, which is of medium quality and may contain weevils. The indicated price is the cost for each kilogram.
4. Red chili: The data for this commodity includes huge red chili and fresh-curly red chili. The indicated price is the cost for each kilogram. The price used for further analysis is the mean of all available pricing data. The price used for further investigation is the mean of all the available pricing data.
5. Cayenne pepper: This commodity's data includes red cayenne pepper and green cayenne pepper, both in fresh condition. The indicated price is the cost for each kilogram. The price used for further analysis is the mean of all the available pricing data.
6. Beef: This product's data comprises two characteristics: meat is fresh outside and inside. The indicated price is the cost for each kilogram. The price used for further analysis is the mean of all available pricing data.
7. Purebred chicken meat (chicken): The data for this product refers explicitly to high-quality chicken meat from purebred chickens, excluding any offal, and in a fresh state. The indicated price is the cost for each kilogram.
8. Purebred chicken eggs (eggs): The data for purebred chicken eggs (eggs) pertains exclusively to fresh chicken eggs of high quality. The indicated price is the cost for each kilogram.

9. Granulated sugar (sugar): Granulated sugar, often known as sugar, is categorized into two types based on quality: local/bulk quality with a yellow hue and premium grade. The indicated price is the cost for each kilogram. The cost for further analysis is calculated as the mean of all the available pricing data.
10. Cooking oil: The data for this product includes three different qualities: one for local/bulk purchases and two for refill packing. The indicated price is the cost for each liter. The price used for further analysis is the mean of all the available pricing data.

3 Result and Discussion

This section will use eight regression equation models to explain the analytical results of the average price trend of ten strategic food items in the Yogyakarta area. Additionally, the optimum model for projecting the price of each commodity will be identified.

3.1 Rice

The cubic model is the most suitable model for rice commodities due to its highly significant value of 0.000, which indicates that it is very close to zero. Additionally, it has the highest R square value of 0.678. Given its R square value compared to other models, the cubic model regression method is the most suitable forecasting technique for predicting rice prices in Yogyakarta at the retail trader level. The R square value indicates that 67.8% of the variation in Yogyakarta's rice prices can be attributed to the influence of time series and other factors included in the research model. The remaining 32.2% is influenced by variables not accounted for in the model.

3.2 Shallots

The cubic model is the most suitable model for shallots commodities due to its highly significant value of 0.000, which is near to zero, and its highest R square value of 0.227. Due to its notably higher R square value compared to other models, the cubic model regression method is deemed appropriate for predicting shallot prices in Yogyakarta at the retail trader level. The R square value indicates that 22.7% of the variation in Yogyakarta's shallots prices can be attributed to the influence of time series and other factors considered in the research model. The remaining 77.3% of the variation is driven by other variables not included in the model.

3.3 Garlic

The cubic model is the most suitable for garlic commodities due to its substantial value of 0.001, which is close to zero, and the highest R square value of 0.072. Given its R square value compared to other models, the cubic model regression method is deemed the most suitable forecasting technique for predicting garlic prices at the retail trader level in Yogyakarta. The R square value indicates that the combined influence of time series and garlic prices in Yogyakarta accounts for 7.2% of the total variation in the dependent variable. The remaining 92.8% of the variation is attributed to other variables that not considered in the this research.

3.4 Red chili

After analyzing the results of eight regression equation models used to estimate the average price trend of red chile, it is evident that there is no appropriate model for red chile commodities in the Yogyakarta Traditional Market. This is because none of the models employed can analyze the price fluctuations of red chili in Yogyakarta. In other words, the price of red chili at the Yogyakarta Traditional Market exhibits significant volatility.

3.5 Cayenne pepper

The cubic model is the most suitable for cayenne pepper commodities due to its highly significant value of 0.000, which is very close to 0, and exhibits the highest R square value of 0.124. Due to its R square value compared to other models, the cubic model regression method is deemed the most suitable forecasting technique for predicting the price of cayenne pepper in Yogyakarta at the retail trader level. According to the R square value, it can be inferred that the combined effect of time series and cayenne pepper prices in Yogyakarta accounts for 12.4% of the variation in the dependent variable. The remaining 87.6% is attributable to other variables not considered in this research

3.6 Beef

The cubic model is the most suitable model for beef commodities due to its highly significant value of 0.003, which indicates a close proximity to zero. Additionally, it exhibits the highest R square value of 0.821. Given its R square value compared to other models, the cubic regression method is deemed the most appropriate forecasting technique for predicting beef prices at the retail trader level in Yogyakarta. The R square value indicates that 82.1% of the variation in Yogyakarta's beef prices can be attributed to the influence of time series and beef prices, while the remaining 17.9% is influenced by other variables not considered in the this research.

3.7 Chicken

The cubic model is the most suitable model for chicken commodities because to its highly significant value of 0.000, which is very close to 0. Additionally, it has the highest R square value of 0.151. Given its superior R square value relative to other models, the cubic model regression method is deemed the most suitable forecasting technique for predicting chicken prices at the retail trader level in Yogyakarta. According to the R square value, it can be inferred that the combined effect of time series and chicken prices in Yogyakarta accounts for 15.1% of the total variation in the dependent variable. The remaining 84.9% of the variation is attributed to other variables not considered in the this research.

3.8 Eggs

The quadratic model is the best model for commodity eggs because the significant value of 0.001 is close to 0 and has the greatest R square value of 0.065. Because the regression method of the quadratic model has the largest R square value compared to other models, the quadratic model is the right forecasting method to forecast the price of eggs in Yogyakarta at the retail trader level. Based on the value of R square, it can be concluded that the percentage of contribution of the influence of *time series* and egg prices in Yogyakarta is 6.5%. In comparison, the remaining 93.5% is influenced by other variables that are not included in this research.

3.9 Sugar

The cubic model is the most suitable for sugar commodities due to its highly significant value of 0.003, which is close to zero, and the highest R square value of 0.469. Given its R square value compared to other models, the cubic model regression method is the most appropriate forecasting technique for predicting sugar prices at the retail trader level in Yogyakarta. The analysis of the R square value indicates that 49.6% of the variation in Yogyakarta's Y variable can be attributed to the combined effects of time series and sugar prices. The remaining 50.4% of the variation is impacted by other variables not accounted for in this research.

3.10 Cooking oil

The cubic model is the most suitable for analyzing cooking oil commodities due to its extremely low p-value of 0.001, indicating a strong statistical significance. Additionally, it has the highest R-squared value of 0.93, indicating a strong correlation between the model and the data. Due to its superior R square value compared to other models, the regression approach of the cubic model is deemed the most suitable forecasting technique for predicting the price of cooking oil in Yogyakarta at the retail trader level. The analysis of the R square value indicates that 93.0% of the variation in Yogyakarta's cooking oil prices can be attributed to the combined effects of time series and cooking oil prices. The remaining 7% is impacted by other variables that were not included in this study.

4 Conclusion

The research findings indicate that the cubic regression model is the most accurate method for estimating the average price of ten strategic food commodities in the Yogyakarta area, with the exception of red chili commodities. The cubic model accurately accounts for the degree of influence from time series and rice prices in Yogyakarta. Specifically, it explains that rice contributes 67.8%, chicken meat contributes 15.1%, beef contributes 82.1%, chicken eggs contribute 6.5%, shallots contribute 22.7%, garlic contributes 7.2%, cayenne pepper contributes 12.4%, and cooking oil contributes 93%. 3) The red chili pepper commodity exhibits significant volatility, making finding an appropriate model for estimating its average price challenging.These findings indicate that the cubic regression model is suitable for predicting the average price of ten strategic food commodities in the Yogyakarta area, except red chili commodities. Nevertheless, it is important to note that the R square value generated by the cubic regression model remains very low, indicating that additional factors continue to influence the pricing of these food staples. The factors in question encompass economic, political, social, and environmental aspects. It is advisable to incorporate these variables into the regression model in order to enhance the precision of food commodity price forecasts. Moreover, additional investigation is required to examine the impact of these factors on food commodity pricing.

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