AGRISOCIONOMICS
Jurnal Sosial Ekonomi dan Kebijakan Pertanian
ISSN 2580-0566; E-ISSN 2621-9778
http://ejournal2.undip.ac.id/index.php/agrisocionomics
Vol 8 (1): 134-146, March 2024

PRICE FLUCTUATIONS AND VOLATILITY OF NATIONAL STRATEGIC FOOD COMMODITIES IN INDONESIA

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Submitted 24 March 2023; Approved 21 June 2023

ABSTRACT

Meeting the food needs of the Indonesian population is a top priority, and national strategic food plays a vital role in achieving this goal. However, the unstable nature of national strategic food prices can have significant implications, particularly for those with low incomes. This volatility can hinder access to healthy and nutritious food, ultimately impacting the nation's food security. In recent times, food prices have risen sharply, which is expected to have far-reaching consequences. Therefore, it is imperative to analyze the volatility of national strategic food prices to comprehend price fluctuations and patterns. This study analyzed the volatility of national strategic food prices in Indonesia from 2018 to 2022, focusing on commodities such as shallots, garlic, red chilies, cooking oil, and rice. The ARCH-GARCH method used to conduct the analysis, revealing that all five commodity prices were volatile at the national level. The red chili and shallot exhibits a distinctive pattern, characterized by an increase volatility during the second quarter of each year. This can be attributed to the rise in demand during the Ramadan. Conversely, garlic volatility was high in early 2019 and 2020, while remaining relatively stable during other periods. Cooking oil volatility remained stable until the end of 2020, but started to increase in early 2021. This closely related to cooking oil crisis that occurred in Indonesia. Lastly, rice price volatility was high in early 2018. Subsequently, exhibited relatively stable volatility until first quarter of 2022, although there were some periods where the volatility exceeded its average.

Keywords: *ARCH-GARH, commodity, food, price, volatility*

BACKGROUND

Volatility is a major issue that has significant impacts on various fields, including the food sector. In its terminology, volatility indicates the speed and quantity of changes over time, one of which is commodity prices. From this terminology, it can be clearly seen that volatility is an object that is difficult to understand and a measurement concept that is vulnerable to its surrounding subjectivity. However, economic theory attempts to classify volatility into two concepts, namely variability, which is an aggregation of movements, and uncertainty, which is a description of unpredictable changes (FAO 2011).

In Indonesia, volatility is a common occurrence in the economic cycle, particularly in the food price cycle. This is mainly due to the country's dependence on imports, which results in unstable global food prices that significantly impact domestic prices. Bourdon (2011) notes that the instability of food prices is one of the consequences of developing countries. While price volatility is essential

ISSN 2580-0566; E-ISSN 2621-9778
http://ejournal2.undip.ac.id/index.php/agrisocionomics
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for a functioning market, it becomes problematic when prices become unpredictable and soar, increasing risks for economic actors, including producers, consumers, and small traders. Furthermore, problems arise when prices do not reflect market performance, creating new issues for Indonesia's economic and social spheres.

Strategic food price volatility is one of the phenomena that often occurs in the global food market. Volatility in food prices can be defined as the fluctuation of food prices over a certain period. Food price volatility can be caused by various factors, such as climate change, currency exchange rate fluctuations, changes in trade policies, and others (Abulai 2018). Volatility in food prices can impact many aspects of people's lives. For example, high food price volatility can make it difficult for people, especially those with low incomes, to meet their daily food needs. Moreover, the increase in national strategic food prices can affect people's purchasing power, causing inflation and triggering a decrease in the nutritional quality of the diets of poorer people (Fiszbein 2014).

In recent years, strategic food prices in Indonesia have shown an increasing trend. The Ministry of Agriculture classifies strategic food commodities as a group of commodities that have a significant contribution to the formation of fluctuating prices that have an impact on inflation levels. Strategic food is also the most frequently consumed group of food, so its availability in the market is always monitored. Strategic food commodities in Indonesia include garlic, chicken meat, beef, chicken eggs, shallots, red chili, cayenne pepper, cooking oil, and sugar (Kementan 2017).

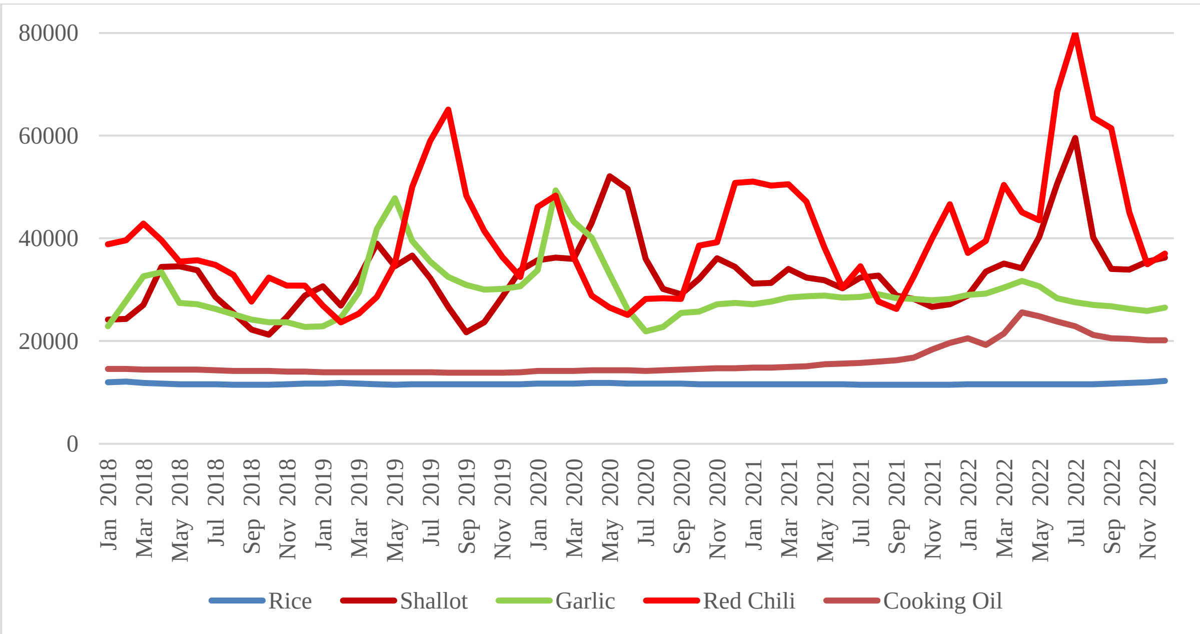

Figure 1. Prices of Strategic Food Commodities 2018-2022

The increase in prices of strategic food can be observed through the strategic food inflation proxy. The commodity with the highest inflation in the first half of 2022 was cooking oil, which reached a year-on-year inflation rate of 35.6%, followed by red chili, shallots, garlic, and cooking oil (BI 2022). Cooking oil prices remained relatively stable from 2017 to the end of 2020. However, an increase started to occur from the beginning of 2021. From March 2021 to January 2022, cooking oil prices rose every month with an average increase of 4.15% per month. Red chili prices also showed an increasing trend throughout 2021 to 2022, although in previous periods, the price of red chili was quite fluctuating. Throughout 2021, the price of shallots was relatively stable, ranging between Rp

ISSN 2580-0566; E-ISSN 2621-9778
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28,000-35,000 per kilogram, but in the following months, there was a relatively significant price increase, reaching up to Rp 62,000 in mid-2022. The opposite happened to garlic prices. Garlic prices were relatively fluctuating from July 2019 to June 2020, and since July 2020 to December 2022, garlic prices were not as fluctuating as in previous periods. Meanwhile, rice prices were relatively stable from 2018 to 2021, but there was an average increase in rice prices in 2022 (PIHPS 2022).

Analyzing the volatility of national strategic food prices is essential in helping the government plan and implement appropriate policies to reduce price fluctuations that impact food availability, accessibility, and security. For example, analyzing volatility can aid the government in planning sufficient strategic food reserves and effectively regulating their distribution during significant price fluctuations (Gaiha et al., 2017). Moreover, analyzing national strategic food price volatility can also assist the private sector in making business and investment decisions. Entrepreneurs can take steps to minimize price fluctuation risks, such as diversifying their supply of raw materials or considering alternative markets (Rosyadi 2017). This study aims to analyze the level of volatility in national strategic food prices, including shallots, garlic, red chili, cooking oil, and rice from 2018 to 2022.

RESEARCH METHODS

This research utilized time series data with a period ranging from January 2018 to Desember 2022. The data used are national average price data for commodities such as shallots, garlic, red chili peppers, cooking oil, and rice in traditional markets to analyze their volatility. All price data were obtained from the Strategic Food Price Information Center (PIHPS). The variables used in this study are presented in Table 1.

Table 1. The Price Variables

Variables	Units
Cooking Oil Price	Rupiah/Kg
Red Chili Price	Rupiah/Kg
Shallots Price	Rupiah/Kg
Garlic Price	Rupiah/Kg
Rice Price	Rupiah/Kg

Modeling of ARCH-GARCH

The main objective of ARCH-GARCH modeling is to analyze the magnitude of volatility. Initially, the Autoregressive Conditional Heteroscedasticity (ARCH) model was developed by Engel (1982) to address the issue of volatility in economic, business, and financial data. This volatility is reflected in the error variance that does not meet the assumption of homoscedasticity, in other words, it contains heteroscedasticity (Firdaus 2011). Heteroscedasticity occurs because time series data show elements of volatility. Therefore, the variance of the model will depend heavily on the volatility of the variable in the previous period. In conclusion, the equation of the residual variance in the ARCH model can be written as follows:

$$\sigma^2_t = \alpha_0 + \alpha_1 e^2_{t-1} + \alpha_2 e^2_{t-2} + \ldots + \alpha_p e^2_{t-p}$$

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Then, Bollerslev (1986) developed the ARCH model into the Generalized Autoregressive Conditional Heteroscedasticity (GARCH) model. Bollerslev stated that the residual variance not only depends on the previous period residual but also on the previous residual variance. Therefore, the equation for the GARCH model can be expressed as follows:

$$ht=k+\lambda_1\sigma^2_{t-1}+\lambda_2\sigma^2_{t-2}+\ldots+\lambda_p\sigma^2_{tp}+\alpha_1e^2_{t-1}+\alpha_2e^2_{t-2}+\ldots+\alpha_qe^2_{t-q}$$

According to Juanda (2013), there are several stages to determine the ARCH-GARCH model, namely:

1. ARCH Effect Identification. To test or determine whether there is an ARCH effect, it can be done in two ways: (1) Observing the correlation coefficient value of residual data squared through a correlogram. If the value of the Autocorrelation Function (ACF) and Partial Autocorrelation Function (PACF) is zero at all levels of lag or not statistically significant, then there is no ARCH effect. (2) Conducting an ARCH-LM test. If the p-value is smaller at a certain significance level, such as 5% (α = 5%), then the conclusion is to reject the null hypothesis, in other words, there is an ARCH effect in the model.
2. Model Estimation. In the estimation stage, a number of simulations are performed iteratively on several variance equation models. The best model is selected by considering the significance of the estimation parameters, goodness of fit, and using the smallest Akaike Information Criterion (AIC) and Schwartz Information Criterion (SIC).
3. Model Evaluation. The model evaluation stage involves performing a Jarque Bera test of normality on the standardized residual model. This stage is also done to ensure that the model used is the best model. This test examines the kurtosis and skewness. The Jarque Bera test equation is as follows:

$$JB = \frac{N-K}{6}\left[S^2 + \frac{1}{4}(k-3)^2\right]$$

Information:
K : Kurtois
N : Number of Observations
S : Skewness
k : Number of Estimated Coefficients

Volatility Measurement

Volatility is calculated after obtaining the best ARCH-GARCH model. The model can be used to project future volatility values. ($\zeta_{t=1}$). Where $\zeta_t = \sqrt{ht}$. The forecast of variance for the next period is formulated as follows:

$$h_t = \zeta^2+\alpha_1e^2_{t-1}+\alpha_2e^2_{t-2}+\ldots+\alpha_pe^2_{t-p} \text{ (for ARCH(m))}$$

$$ht=k+\lambda_1\sigma^2_{t1}+\lambda_2\sigma^2_{t2}+\ldots+\lambda_p\sigma^2_{tp}+\alpha_1e^2_{t-1}+\alpha_2e^2_{t-2}+\ldots+\alpha_qe^2_{t-q} \text{ (for GARCH(r,m))}$$

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Information:

h_t	: Variance t-period
e	: Residual
k	: Constanta
α_p and α_q	: Parameters

RESULT AND DISCUSSION

Volatility Calculation

In this study, the level of volatility of national strategic food commodity prices, namely garlic, shallots, red chili, cooking oil, and rice, was analyzed using the ARCH-GARCH analysis method. The ARCH-GARCH model can be formed through several estimation stages. The first stage involves testing whether the price data used is stationary at the level or requires differencing. The next step is to identify and determine the Box-Jenkins model (AR, MA, and ARIMA) while considering the results of the stationarity test. Furthermore, the Box-Jenkins model selected based on the established statistical criteria will be tested with an ARCH test to determine whether the model contains ARCH/GARCH elements. The fourth step is to tentatively select the best ARCH-GARCH model. The final step involves conducting an LM Test to test whether the selected ARCH-GARCH model still contains ARCH effects (Hardjanto 2014).

Stationarity Test and Best Arima Modeling

The stationarity test was conducted on the strategic food commodity prices used in the analysis to obtain stationary data. In this study, the stationarity test performed was the unit root test using the Augmented Dickey Fuller Test (ADF Test) with a significant level of 5%. The data is considered stationary if the absolute value of the ADF statistics is greater than the critical value of MacKinnon; if not, differencing is necessary. (Firdaus 2011). Additionally, the stationarity of the data can also be assessed through the probability value. If the probability value is less than the significance level of 5%, the data is considered stationary. After obtaining the degree of stationarity of the strategic food commodity prices data, the next step is to tentatively model the ARIMA. The best model is selected based on the criteria of the largest R-squared and the smallest AIC and SIC. The results of the stationarity test and ARIMA best model are presented in Table 2.

Table 2. Stationarity Test and ARIMA Best Model

Variables	ADF T-Statistic	Critical Value	Prob	Best ARIMA Model
Shallots	-3.5773	-3.4272	0.0037	ARIMA (1,0,3)
Garlic	-3.5773	-3.4272	0.0037	ARIMA (2,0,2)
Red Chili	-3,0627	-2,8724	0.0307	ARIMA (4,0,2)
Cooking Oil	-4,4016	-2,8728	0.0003*	ARIMA (0,1,2)
Rice	7.6482	-3.4274	0.0000*	ARIMA (3,1,0)

*Stationary at first difference

After analyzing the stationarity test results presented in Table 2, it can be concluded that the variables for shallot price, red chili price, and garlic price are stationary at the level. This conclusion is based on the ADF t-statistic value, which is higher than the critical value of MacKinnon at a significant level of 5%, and the probability value is smaller than the alpha value (α = 5%). However,

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the variables for cooking oil price and rice price are found not to be stationary at the level level in some sample areas, requiring differencing at the first difference level. We have used the previously mentioned criteria to obtain the best ARIMA model for each food price.

The next step involves conducting a heteroscedasticity test to determine the presence of an ARCH element in the established ARIMA model. The estimation results of the ARIMA modelling are said to not contain ARCH/GARCH elements if there is at least one significant Q-statistic value, and ACF and PACF values that differ significantly from zero at a certain lag (Juanda 2013). Moreover, the selection of a model with heteroskedasticity elements can be done by examining the residual values based on the significant chi-square probability value at a significant level of 5%. If the Probability value is below 0.05, the conclusion is that H0 is accepted (there is an ARCH effect) in the model. Our test results indicate that all prices have ARCH in their ARIMA models, and we must find the optimal model by conducting the estimation and selection process of ARCH/GARCH models. The method for selecting this model is the same as the previous step used to choose the best ARMA/ARIMA model. Table 3 presents the estimation results of the best ARCH/GARCH model.

Table 3. Heteroscedasticity Test and ARCH/GARCH Best Model

Variables	Best Arima Model	Heteroskedasticity Test Prob	Best ARCH/GARCH Model
Shallots	ARIMA (1,0,3)	-3.4272	GARCH (1,1)
Garlic	ARIMA (2,0,2)	-3.4272	GARCH (1,1)
Red Chili	ARIMA (4,0,2)	-2,8724	ARCH (2,0)
Cooking Oil	ARIMA (0,1,2)	-2,8728	ARCH (1,0)
Rice	ARIMA (3,1,0)	-3.4274	ARCH (1,0)

After identifying the best ARCH/GARCH model, the next step is to assess its adequacy by conducting a normality test using the Jarque-Bera statistical analysis. The results of the test indicate that the model errors are not normally distributed, which is also true for all ARCH-GARCH models tested. However, despite the non-normality of the errors, the ARCH-GARCH models presented in Table 4 are still considered the best models. To address the non-normality issue, the Heteroscedasticity Consistent Covariance Boolerslev-Wooldrige method can be applied (Hardjanto 2014). The final step is to perform an ARCH-LM test to evaluate whether the estimated model is free from ARCH effects or not. If the obtained Probability value is greater than α (5%), the model is considered free from ARCH effects. The results of the test, presented in Table 4, show that all of the estimated models have been freed from ARCH effects.

Table 4. ARCH/GARCH Model Evaluation

Variables	Best ARCH/GARCH Model	Normality Test Prob	ARCH-LM Test Prob
Shallots	GARCH (1,1)	0.0038	0.4980
Garlic	GARCH (1,1)	0.0000	0.5875
Red Chili	ARCH (2,0)	0.0000	0.8710
Cooking Oil	ARCH (1,0)	0.0000	0.2023
Rice	ARCH (1,0)	0.0000	0.1304

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Volatility Value

After obtaining the best ARCH/GARCH model and meeting the evaluation criteria, the next step is to analyze the value of national strategic food price volatility. The volatility value is reflected in the conditional variance of the estimated ARCH/GARCH model (Bahmani 2011). The value of volatility of strategic food prices varies for each commodity and region analyzed. The volatility values are presented in the form of a graph.

Shallots Price Volatility

From January 2018 to February 2019, the national shallots prices remained relatively stable, but after that period, there was an increase in price fluctuations as indicated by the volatility values that surpassed the mean and standard deviation in subsequent periods, as depicted in Figure 22. The highest volatility values of national shallots prices occurred in the second quarters of 2020 and 2022, where the values even exceeded 2 and 4 standard deviations, respectively, resulting in a price surge from Rp 41,500 to Rp 61,600 per kilogram. According to Aurelia et al. (2022), the spike in shallots price fluctuations in the second quarter of 2020 was due to the spread of the Covid-19 pandemic in Indonesia, which caused a shock in the market. In contrast, the rise in volatility during the second and third quarters of 2022 was due to a lack of stock caused by unfavourable weather conditions that affected rainfall and pest attacks. There is a discernible pattern of increasing shallots price fluctuations in the second and third quarters of each year. Krisnamurthi (2013) attributed this pattern to the growing demand during the Ramadan and Eid al-Fitr for shallots.

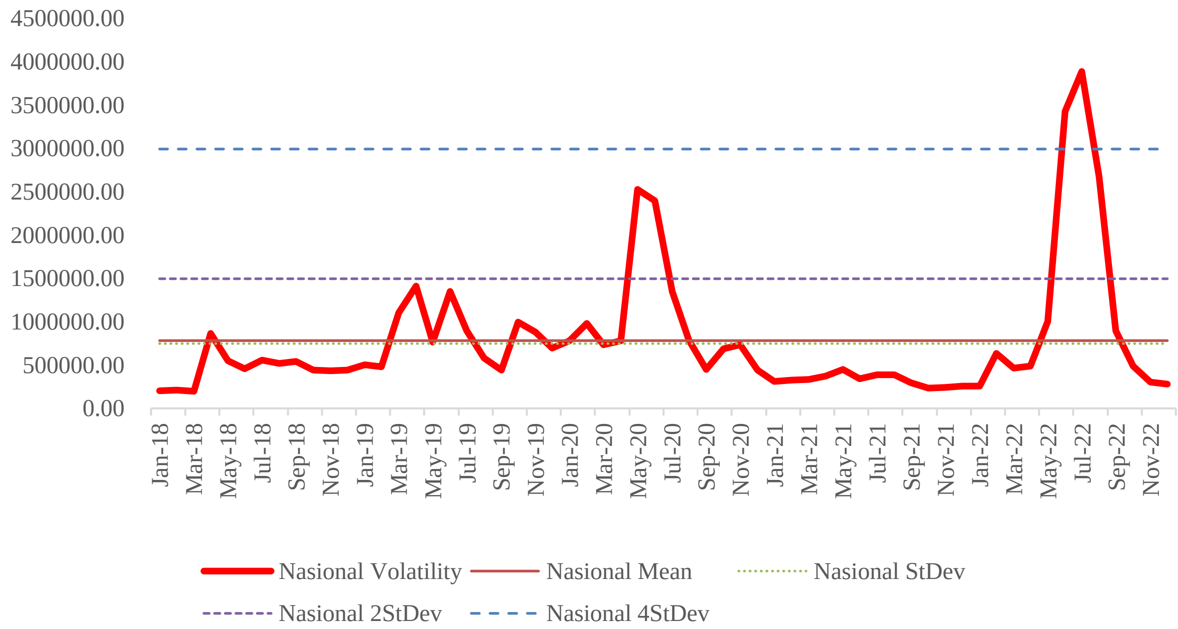

Figure 2. Shallots Price Volatility

Other factors contributing to shallots price volatility include limited availability of production inputs such as seeds, which was evident in the incident that occurred in June 2022, where shallots prices reached Rp 50,000 per kilogram due to the scarcity of seeds among farmers and the exorbitant seed prices at Rp 65,000 per kilogram. Shallots seeds are vital as they are directly linked to production. Good quality seeds will improve the quality and quantity of shallots production (Syam'un 2017). The volatility of shallots commodities is a crucial concern for the government as the policy

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holder and producer of legal products that promote collective welfare. The government should establish buffer stocks to regulate the cultivation pattern of staple food commodities, so that the existing commodities can be stored and not affected by the volatile weather conditions in Indonesia.

Garlic Price Volatility

Garlic commodity stocks in Indonesia are primarily imported due to limited domestic production, which fails to meet the annual demand. In 2017, domestic production only satisfied 3.4% of the national demand, but there was a notable increase in 2018 when Indonesia produced 39,302 tons of garlic, and a subsequent 225% increase in 2019 to 88,816 tons. However, domestic production sharply declined to 45,091 tons in 2021, representing a 45% drop in production (BPS 2022). Despite the government's numerous attempts to promote self-sufficiency in garlic, these programs have failed to boost domestic garlic production. Achieving self-sufficiency in garlic is critical for Indonesia. Studying successful countries such as China, which has achieved self-sufficiency in garlic, may be an effective approach. China is one of the largest garlic exporters globally, with a production share of 73.83% in 2021 (Tridge 2022).

Several factors contribute to high garlic production in China. Firstly, China innovated by producing garlic that can produce seeds for cultivation, whereas garlic cultivation in Indonesia still relies on bulbs that are more susceptible to disease. Secondly, the Chinese government provides adequate road infrastructure to facilitate the transport of harvested garlic. Thirdly, modern cold storage facilities are also provided by the Chinese government, which can keep Chinese garlic fresh for up to two years, while storage in Indonesia is still done traditionally. Lastly, there is a subsidized insurance program for garlic farmers to ensure the sustainability of garlic cultivation in China. These factors have made China the world's largest garlic producer (Ayuningtyas 2021).

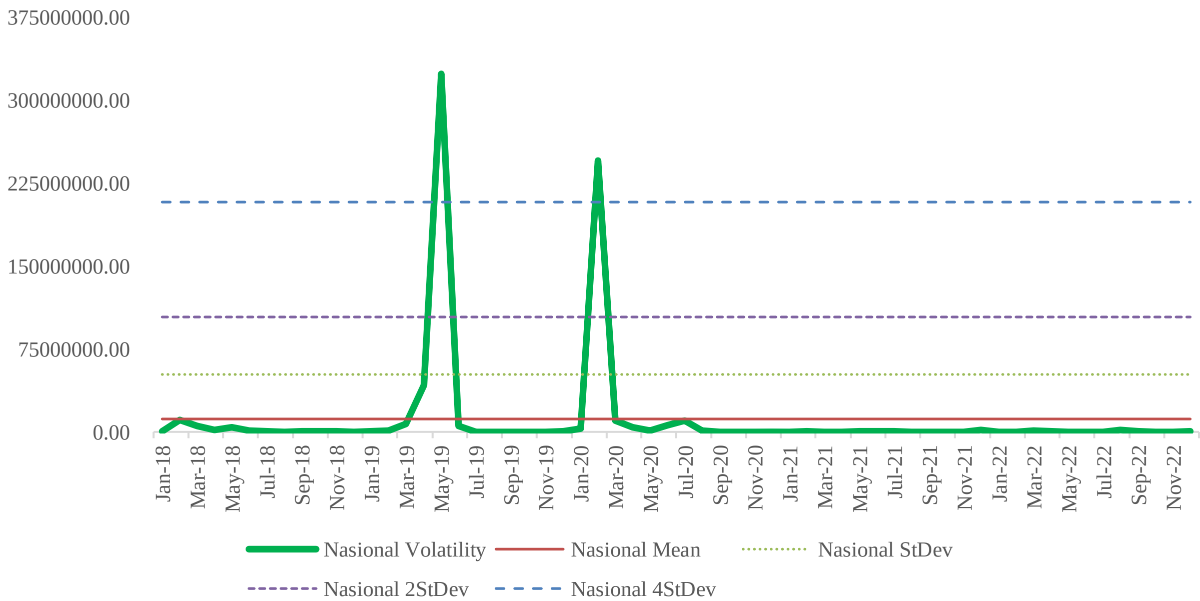

Figure 3. Garlic Price Volatility

The national garlic price volatility remained relatively stable from 2018 to 2022, with most values below the average. There were two extreme increases in volatility, exceeding four standard deviations in April 2019 and February 2020. In April 2019, there was a significant price increase of 41.3% from March. Similarly, in February 2020, the price of garlic increased from Rp 34,859 to Rp

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50,454 per kilogram. From mid-2020 to the end of 2022, garlic price volatility remained stable below the average. The relatively stable garlic price from mid-2020 to the end of 2022 was due to the stable garlic import price from China, which is the main source of garlic imports for Indonesia, ranging from 800 to 1,000 USD per ton. COVID-19 did not have a significant impact on garlic prices in China, as China has a reserve stock of 3 million tons of garlic (Zhang 2022).

Red Chili Price Volatility

Red chili prices exhibit high volatility during the second and third quarters of each year, while the first and fourth quarters are characterized by low volatility. This cyclic pattern can be predicted, with the timing and trend of price changes being forecasted (Amalia 2018). The seasonality of red chili is the main cause of this trend, with production decreasing during each rainy season and increasing during the dry season. Gilbert and Morgan (2010) support this view, indicating that weather patterns impact agricultural yields and are a major factor in price variability. Additionally, price differences exist between regions due to centralized production in certain areas, leading to varying prices. Furthermore, there is an increase in red chili price volatility during the month of Ramadan and Eid al-Fitr. Public demand for spicy dishes during Eid al-Fitr shifts from cooking a variety of dishes during Ramadan. This causes an increase in chili prices.

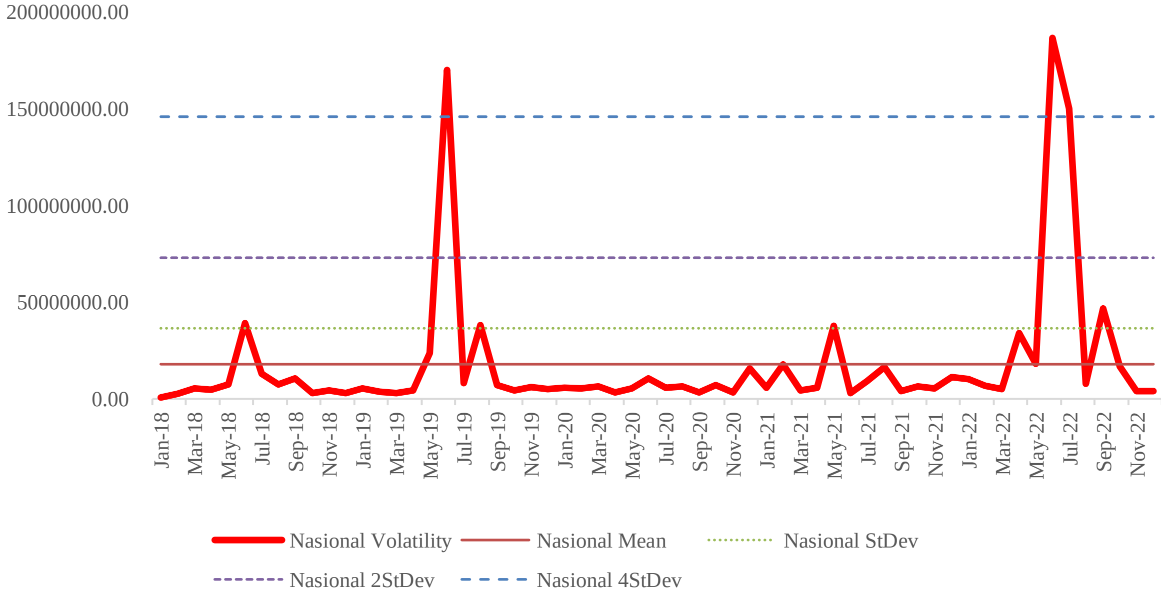

Figure 4. Red Chili Price Volatility

In 2018, the national volatility value of red chili was relatively stable, exceeding the mean value only in the second quarter when the price of red chili rose from Rp 38,700 to Rp 43,450 per kilogram in May. In 2019, red chili prices experienced high fluctuations, with its volatility value exceeding 4 standard deviations in the second quarter. The price of red chili increased from Rp 37,606 to Rp 51,813 in June. Red chili prices remained relatively stable throughout 2020 and 2021, despite an increase in average prices from the previous year. However, in 2022, the volatility of red chili prices increased again in the second and third quarters. The price of red chili surged from Rp 45,503 to Rp 68,450 in June, and it reached its highest price in five years in July, at Rp 80,005 per kilogram.

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Cooking Oil Price Volatility

Cooking oil prices remained stable with volatility values below the mean from 2018 until the end of 2021. However, as the transition to 2022 began, the volatility of cooking oil prices saw a drastic increase, surpassing 4 standard deviations due to the cooking oil crisis in the country. According to Abdulah et al. (2022) in the INDEF (Institute for Development of Economics and Finance) policy brief, there are four factors that caused the increase in cooking oil prices. First, major world producers such as Malaysia and Indonesia experienced a decrease in CPO production. Second, demand increased in both domestic and export markets. Third, the increase in fossil fuel prices, which is a substitute commodity for biofuel, caused a significant transition in demand. Fourth, CPO became one of the supercycle commodities after the Covid-19 pandemic crisis subsided.

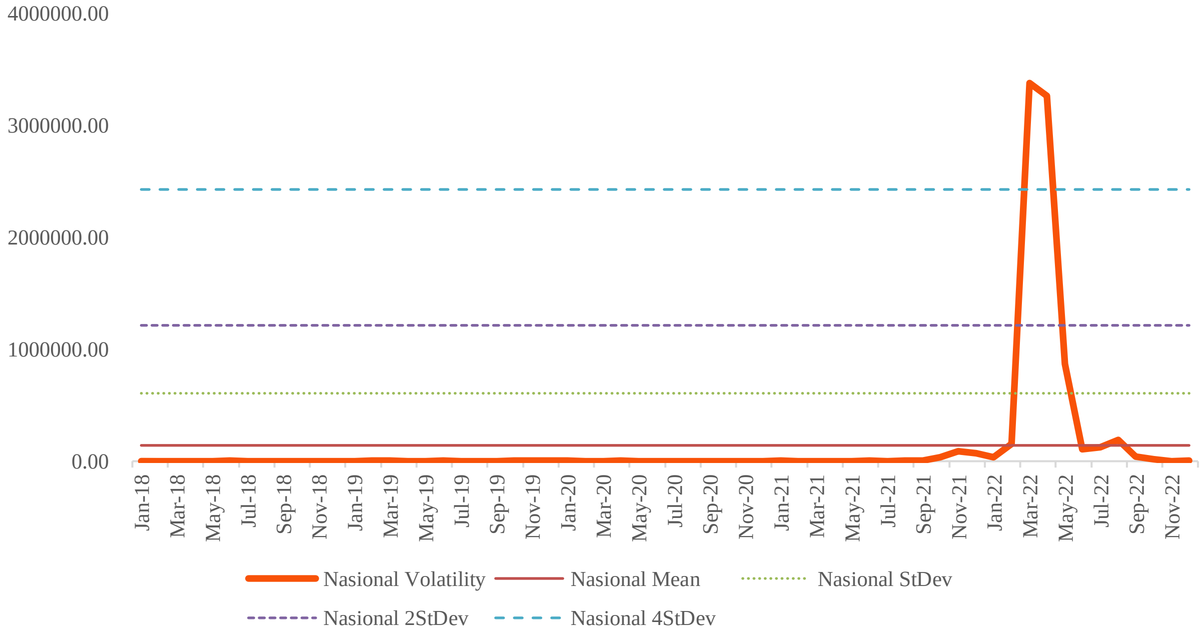

Figure 5. Cooking Oil Price Volatility

The government took various steps to address the cooking oil crisis, including setting the highest retail price (HET) of Rp 14,000 per litter, effective January 19, 2022, and limiting purchases to two liters per person. However, this policy was not able to address the problem optimally as cooking oil stocks remained scarce. After the policy was lifted, cooking oil reappeared in the market and retail stores (Cut 2022). The volatility of cooking oil prices has been decreasing since June 2022 until it returns below the mean by the end of the year. Nonetheless, the price of cooking oil is still relatively high, ranging from Rp 19,000 to Rp 20,000 per kilogram, much higher than the previous year's range of Rp 14,000 to Rp 15,000

Rice Price Volatility

The price of rice in Indonesia has remained relatively stable within the range of Rp 11,200 to Rp 12,200 per kilogram. However, as rice is a staple food for the majority of Indonesians, even small changes in the price can have a significant impact on the volatile food inflation proxy (Rachman et al. 2018). In the beginning of 2018, rice price volatility exceeded 4 standard deviations but it remained stable until the first quarter of 2022, although there were periods when it exceeded the average.

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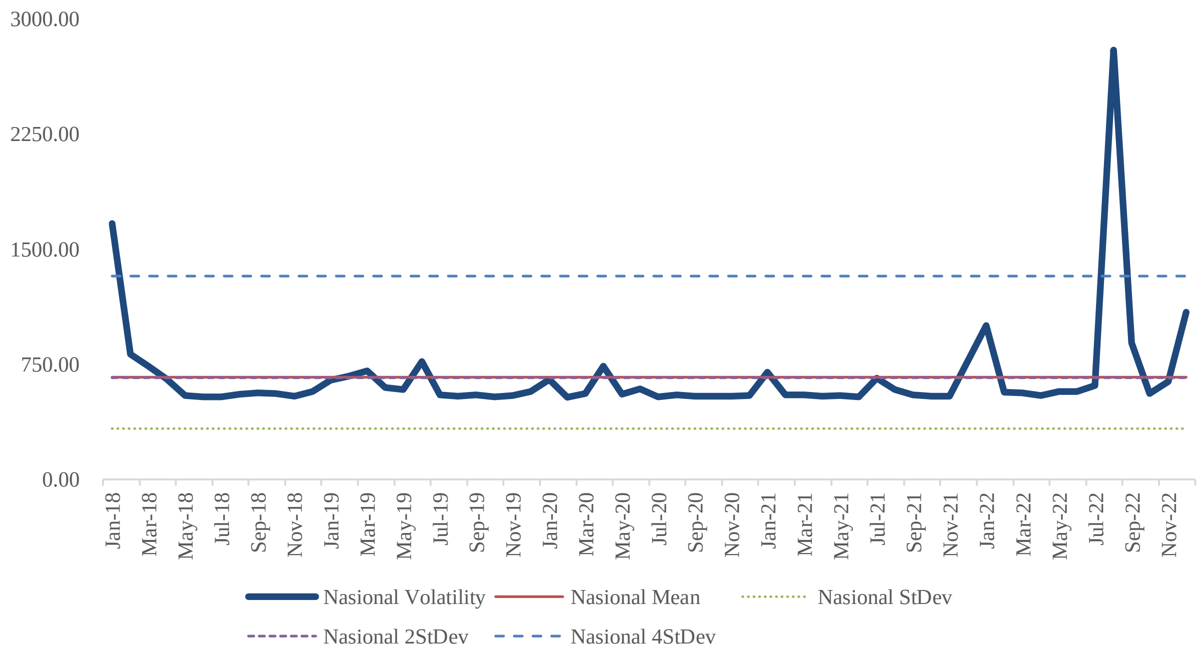

Figure 6. Rice Price Volatility

The Covid-19 pandemic did not have a significant impact on the volatility of rice prices, although Indonesia's food security index decreased due to a reduction in people's income resulting from mobility and activity restrictions (Wijayati, 2022). However, in 2022, the increase in rice price volatility is thought to be due to the rise in subsidized fuel prices, which increased the costs for economic actors such as transportation and production labor wages (Cantika 2022). This led to a 3.3% increase in rice prices, from Rp 11,850 to Rp 12,250 per kilogram.

CONCLUSION AND SUGGESTION

Based on the research findings regarding price volatility in these five commodities, it is recommended that the government focuses on anticipating and mitigating factors that contribute to price instability, while considering the impact on both producers and consumers in the economy. In the case of red chili and shallots, where volatility increases during the month of Ramadan, it is necessary to take technical measures to secure the supply of red chili and shallots to control prices. It is also essential to provide appropriate storage technology for red chili, shallots, and white onions, ensuring that the red onion commodity remains relevant during seasonal transitions and does not cause price fluctuations. To reduce dependence on imported white onions, Indonesia needs to develop strategies for production planning that aligns with market demand and geographical conditions, as well as design well-structured and clear distribution schemes for white onions. The government should also create or strengthen the implementation of regulations related to food to prevent domestic food crises from recurring. Additionally, it is crucial to increase the intensity of research and studies on price stability at the regional level. Suggestions for further research include analyzing the factors that influence price volatility in strategic national food commodities and examining the perspective of farmers as producers.

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