

ARCH/GARCH Analysis: Estimating Beef Price Volatility in Indonesia

*Price Volatility
Analysis of Beef in
Indonesia*

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ABSTRACT

This study analyses the volatility of beef prices in Indonesia, a strategic commodity that significantly impacts the welfare of producers and consumers. The sustained and erratic price fluctuations pose an economic risk to producers and threaten farmers' economic stability. ARCH / GARCH models were used to analyze daily beef price data from 10 July 2017 to 31 December 2023, obtained from the National Strategic Food Price Information Centre of Bank Indonesia. The GARCH (2,2) model is the most suitable for estimating the volatility of beef prices in Indonesia, with low and sustainable volatility in the long run. Factors that affect this volatility include feeder cattle and beef imports, exchange rates, livestock diseases, the COVID-19 pandemic, and government policies such as PPKM and PSBB during the new normal era. Important events such as Ramadan, Eid al-Fitr, Christmas, and New Year also influence price volatility of beef. This research aims to assist the government to design more effective market stabilization policies in the short, medium, and long term period.

Keywords: *beef, ARCH/GARCH, price volatility, fluctuation*

ABSTRAK

Penelitian ini mengkaji volatilitas harga daging sapi di Indonesia, yang sebagai komoditas strategis berdampak signifikan terhadap kesejahteraan produsen dan konsumen. Fluktuasi harga yang berkelanjutan dan tidak menentu ini menimbulkan risiko ekonomi bagi produsen dan mengancam stabilitas ekonomi peternak. Dengan menggunakan model ARCH/GARCH, penelitian ini menganalisis data harga harian daging sapi dari tanggal 10 Juli 2017 hingga 31 Desember 2023 yang diperoleh dari Pusat Informasi Harga Pangan Strategis Nasional Bank Indonesia. Hasil penelitian menunjukkan model GARCH (2,2) sebagai model terbaik untuk mengestimasi volatilitas harga daging sapi di Indonesia, dengan volatilitas yang cenderung rendah dan berkelanjutan dalam jangka panjang. Faktor-faktor yang mempengaruhi volatilitas ini termasuk impor sapi bakalan dan daging sapi, nilai tukar, penyakit hewan ternak, pandemi COVID-19, kebijakan pemerintah seperti PPKM dan PSBB selama era normal baru. Peristiwa penting seperti Ramadan, Idul Fitri, Natal, dan Tahun Baru juga mempengaruhi volatilitas harga daging sapi. Diharapkan penelitian ini dapat membantu pemerintah dalam merancang kebijakan stabilisasi pasar dalam jangka pendek, menengah, dan panjang.

Kata kunci: *daging sapi, ARCH/GARCH, volatilitas harga, fluktuasi*

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INTRODUCTION

Indonesia's beef market dynamics have been a significant concern in recent years. The demand for beef is increasing due to population growth and changing consumption patterns, as described by Arifin et al. (2019), Magalhaes et al. (2023), Tambi & Maina (2003). However, domestic production is insufficient to meet this demand. According to data from the Ministry of Agriculture (2022), national beef production in 2022 was approximately 413,669 tons, while consumption reached 627,952 tons. Indonesia's domestic beef production falls short by 214,283 tons, which accounts for 51.80% of the total production. Consequently, the country has to rely on imports to meet its demand for beef.

As (Nurlaela, 2021) noted, this dependence on imports makes domestic beef prices susceptible to price fluctuations in the international market. Continued efforts to import alone cannot ensure local price stability due to the existing deficit between high production and consumption (Heatubun & Matatula, 2023).

The beef industry in Indonesia faces a significant challenge in the form of price volatility. According to data from the Central Bureau of Statistics, beef prices increased by 6.6% in just one year, from October 2021 to October 2022 (Bank Indonesia, 2023). These erratic and unpredictable price changes indicate instability in beef commodity prices. Although volatility is expected in the market, it poses significant risks for stakeholders in the beef supply chain (Dewi et al., 2017; Uchezuba & Mbai, 2016).

Price increases directly impact farmers, who are the primary producers. The rise in production costs, including those for feed and livestock care, as noted by Bozma et al., (2023), has resulted in a significant decrease in profit margins and has put the farm's sustainability at risk. Additionally, wholesalers and retailers are affected by the increase in beef prices, as they may have to pay more when purchasing beef from farmers or distributors. Purchasing beef from farmers or distributors may become more expensive, potentially increasing the selling price for end consumers (Ijaz et al., 2021; Priyanti & Inounu, 2018). This price increase could have a negative impact on consumer purchasing power and sales volumes. It is important to note that price changes can also affect consumers' ability to afford their nutritional needs.

Beef price volatility significantly impacts various aspects of people's lives. Farmers struggle to keep their businesses afloat, while traders and retailers must adapt to price changes to maintain business continuity. However, consumers encounter challenges meeting their fundamental nutritional requirements because of beef availability and price fluctuations.

The stability of the beef market has been questioned due to the considerable impact of price volatility on different stakeholders. Price fluctuations are influenced by various factors, including the availability of supply, consumer demand, climatic conditions, government policies, and external factors such as global market dynamics, as identified by Arifin et al. (2019), Paksi et al. (2023), Zulmaneri et al. (2021). According to Kusumaningrum & Soeyatno (2021), special events such as religious holidays like Eid al-Fitr or Eid al-Adha and the period leading up to Christmas and New Year often trigger price spikes. Meanwhile, sudden disruptions to the supply chain can also cause unexpected price volatility.

This article analyses the volatility of beef prices in Indonesia by examining the factors that influence it. The research aims to provide a comprehensive understanding of market dynamics and propose strategic measures that can be implemented to improve beef price stability in Indonesia.

METHODS

The study utilizes secondary data from the National Strategic Food Price Information Centre (PIHPS) of the Bank of Indonesia. The data consists of daily beef prices at the consumer level, collected from 10 July 2017 to 31 December 2023. Data collection was carried out from December 2023 to January 2024. This research focuses on DKI Jakarta

due to its significance as a market center and price reference for other markets across Indonesia (Pramita & Ruslan, 2022).

The study employed the ARCH/GARCH model to estimate the volatility of beef prices in Indonesia. The analysis was conducted in several stages. Firstly, the stationarity of the data was tested using the ADF Test (Augmented Dickey-Fuller Test) to prevent unreliable estimates in direction. The ADF Test (Augmented Dickey-Fuller Test) was used to test the root unit. If the initial data is non-stationary, the differentiation process will be applied until the data reaches stationary properties to avoid including biased data in the analysis.

The second step is identifying the mean equations; the ARIMA model was used. The ARIMA model (p,d,q) can consist of an Autoregressive (AR) model with order p, Moving Averages (MA) with order 1, or an ARMA combination (p,q). The letter 'd' represents the number of differentiations to produce stationary data. When selecting the optimal model, it is crucial to take into account both a high determination coefficient (R-square) and the smallest value of the AIC (Akaike Information Criterion) and SIC (Schwarz Information Criterion). The ARIMA model with heteroskedasticity or the effect of ARCH can be further tested with the ARCH/GARCH model.

The third step involves ARCH/GARCH modelling using Engle's (1982) introduced and formulated model.

$$\sigma_t^2 = \alpha_0 + \alpha_1 \varepsilon_{t-1}^2 + \alpha_2 \varepsilon_{t-2}^2 + \dots + \alpha_p \varepsilon_{t-p}^2 \dots \dots \dots (1)$$

where σ_t^2 is the period t conditional variance, α is the squared residual parameter coefficient, ε_{t-1}^2 is the period t-1 squared residual, ε_{t-2}^2 is the period t-2 squared residual, and ε_{t-p}^2 is the period t-p squared residual.

The GARCH model by Bollerslev (1986) is formulated as follows.

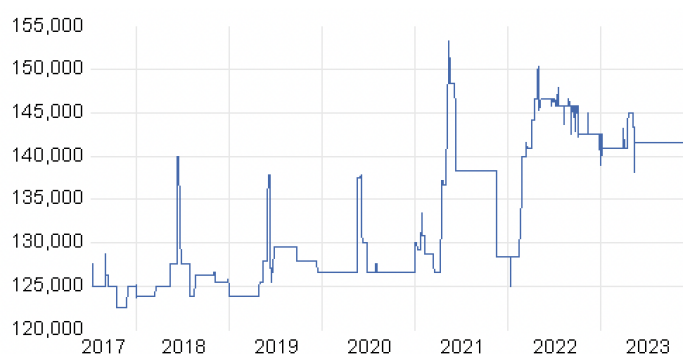
$$\sigma_t^2 = \alpha_0 + \alpha_1 \varepsilon_{t-1}^2 + \dots + \alpha_p \varepsilon_{t-p}^2 + \beta_1 \sigma_{t-1}^2 + \dots + \beta_q \sigma_{t-q}^2 \dots \dots \dots (2)$$

where β is the parameter coefficient of σ_{t-p}^2 . The model is selected based on the significance parameter, the largest log-likelihood value and the smallest AIC and SIC value. The essential criterion for the ARCH/GARCH model is the importance of having a significant coefficient, and the total number of coefficients must not exceed 1 ($\alpha + \beta < 1$), with all coefficients being positive ($\alpha_0 > 0, \alpha > 0, \beta > 0$). The value α or the ARCH coefficient identifies the level of price volatility. A value of $\alpha + \beta$ approaching one indicates a persistence in long-term volatilities.

The fourth step involves ARCH-LM testing. If no ARCH effect is detected, it can be concluded that the model has been adequately specified.

RESULTS

This analysis utilizes daily beef price data at the consumer level from 10 July 2017 to 31 December 2023. The survey of price trends reveals fluctuations that indicate price volatility, as illustrated in Figure 1.



Source: National Strategic Food Price Information Centre (PIHPS)

Figure 1. Daily beef price in Indonesia from 10 July 2017 to 31 December 2023

Figure 1 illustrates the daily trends in beef prices, highlighting fluctuations that indicate unstable price patterns.

Unit Root Test

The daily beef price data has been transformed into natural logarithms to remove the impact of trends, inflation effects, and seasonal variability. This transformation enables a more focused analysis of unexpected price volatility. When testing hypotheses, the null hypothesis (H0) assumes that the data is stationary or has a unit root, while the alternative hypothesis (H1) suggests that the data is non-stationary or lacks a unit root. If the statistical value of the Augmented Dickey-Fuller (ADF) test is smaller than the critical value set by McKinnon, then the data is considered stationary. On the other hand, if the statistical ADF value is greater than the critical value set by McKinnon, the data is considered non-stationary.

Table 1. Result of Unit Root Test

Level	ADF statistic	Prob	Critical Value 1%	Critical value 5%
Level	-2,209	0,203	-3,433	-2,863
1 st different	-27,901***	0,000	-3,433	-2,863

Note: *** : significant at 1%

The root unit testing conducted on Indonesia's daily beef price data, which has been transformed into natural logarithms, has provided evidence that the data is stationary at the level. This stationarity is demonstrated by Augmented Dickey-Fuller (ADF) statistical values that are smaller than the critical threshold at the significance level of 1%. More specifically, the probability resulting from the test is 0.000, significantly lower than the threshold of 1%, indicating that the data does not have a unit root and is therefore stationary.

Determination of Average Equation

To determine the average equation, the first step was to set the number of lags on the ARIMA model and estimate the AR and MA parameter coefficients based on the Autocorrelation Function (ACF) and Partial Autocorrelation Functions (PACF). The optimal ARIMA models were selected based on several criteria, including the maximum Adjusted R-squared value and the minimum Akaike Information Criteria (AIC) and Schwartz Criterion (SIC).

Table 2. Determine The ARIMA Model

Model	Log Likelihood	AIC	SIC	Prob. F	Prob. Chi-Square
AR(1)	9620	-8,138	-8,135	0,0000	0,0000
MA(1)	9615	-8,131	-8,129	0,0000	0,0000

According to Table 2, the most suitable ARIMA model for beef price data is the AR(1) model. The selection of this model was based on a higher log-likelihood value compared to the MA(1) model, and smaller AIC and SIC values compared to the AR(2) model. The AR(1) model determined also exhibits heteroskedasticity, as evidenced by the Probability F and Chi-Square Probability values below 1%. Therefore, further analysis can be conducted to determine the ARCH/GARCH model.

ARCH/GARCH Modelling

The ARCH/GARCH model selection is adjusted based on the significance of coefficients, the highest log-likelihood value, and the lowest AIC and SIC values.

Table 3. Determine The ARCH/GARCH Model

Model	Significant	Log likelihood	AIC	SIC
GARCH(1,1)	V	10169	-8,601	-8,591
GARCH(2,1)	V	10198	-8,624	-8,612
GARCH(2,2)	V	10235	-8,654	-8,640
GARCH(3,2)	V	10224	-8,644	-8,627

According to the determined parameters, the GARCH(2.2) model is the most suitable for estimating beef price volatility.

ARCH-LM Test

The ARCH-LM test was conducted to identify the heteroscedasticity element or ARCH effect in the ARCH/GARCH model.

Table 4. Estimation Results of Beef Price Volatility in Indonesia

Parameter Coefficient	GARCH(2,2)
Average Equation Model	
AR(1)	-0,340
Variance Model (Conditional Variance)	
Konstanta	7,89E-07
ARCH (α)	0,387
GARCH (β)	0,598
$\alpha + \beta$	0,985
ARCH-LM Test	
Prob. F	0,738
Prob. Chi-Square	0,738

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The F Probability and Chi-square Probability values that exceed the 10% confidence level indicate the absence of heteroscedasticity in the model, which means that the GARCH(2.2) model is the best option for estimating the volatility of beef prices in Indonesia.

The GARCH(2,2) model shows that the volatility of beef prices in Indonesia is influenced by the conditional and residual variance of the previous two square periods. In Indonesia, beef prices are characterized by low volatility, as indicated by the ARCH coefficient of 0.387. The value of $\alpha + \beta$, 0.985, suggests that beef price variability is low and persistent in the long term.

Factors Affecting Beef Price Volatility in Indonesia

Figure 2 displays the volatility of beef prices in Indonesia, represented by the conditional standard deviation or the root of conditional variance.

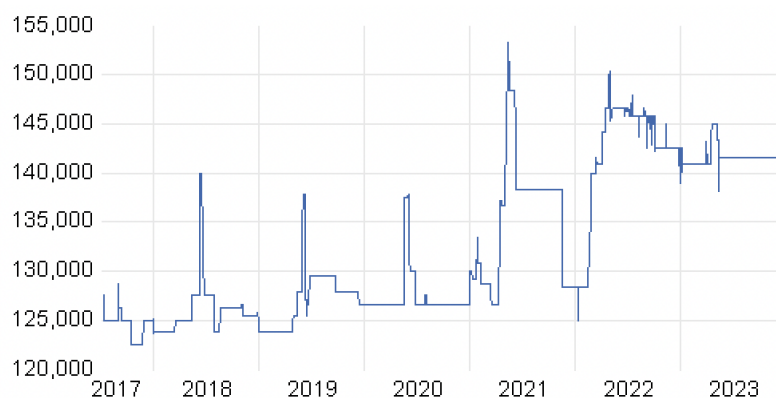


Figure 2. Daily price volatility of beef in Indonesia 10 July 2017 – 31 December 2023

Figure 2 shows the volatility of beef prices in Indonesia from 10 July 2017 to 31 October 2022, represented by the conditional standard deviation or the root of the conditional variance. The graph indicates that price volatility occurs yearly due to Ramadan and Eid. Beef price volatility appears to have peaked more frequently in 2022-2022, which may be attributed to the COVID-19 pandemic and the New Normal policy implemented by the government. Various factors, including the import of feeder cattle, exchange rates, livestock diseases, government policies such as PPKM and PSBB in the new normal era, and religious holidays such as Ramadan, Eid al-Fitr, Christmas, and New Year influence beef price volatility.

DISCUSSION

Beef is an essential agricultural commodity in Indonesia with the potential to increase agricultural gross domestic product (GDP), create production hubs, and provide

livelihoods for farmers in various regions, as confirmed by the Ministry of Agriculture (2020) and (Zainuddin et al., (2015). Additionally, the development of this sector can contribute to increased resilience and food availability in the country.

The interaction between supply and demand determines the price in the market. If demand exceeds supply, it creates pressure that leads to price increases. Conversely, excess supply over demand can decrease prices, as Christianingrum & Syafitri (2019) described. *Price volatility* is a phenomenon that often results from substantial price pressures, causing unstable price fluctuations over a certain period. Various external and internal factors can cause price volatility in commodity markets. Huang et al. (2011) and Nurlita & Naomi (2019) found that political events or corporate performance can trigger price volatility, while Gao et al. (2022) showed market sentiment as another factor influencing price volatility.

Additionally, supply disruptions, government policies, market actors' activities, and demand from developing countries can potentially lead to price volatility, as studied by Brander et al. (2023). It is essential to acknowledge that commodity prices are susceptible to various factors, which can result in increased volatility, risk, and uncertainty for investors and market participants.

The volatility of beef prices significantly impacts various aspects of society and industry. For instance, high price volatility can cause uncertainty in consumer purchases, disrupt budgetary management, and reduce purchasing power, particularly for vulnerable economic groups (Hermawan et al., 2022). Additionally, extreme price fluctuations can threaten market share stability and business sustainability for industry players (Boffo & Patalano, 2020). In conclusion, the volatility of beef prices has economic, social, and industrial impacts.

Since price volatility impacted social economic of the community and industries, it is important for the governments to anticipate the price volatility. There are several policies to be implemented to anticipate the price volatility. As mentioned previously, there are some internal and external factors that could influence price volatility. Since external factors are beyond the government's authority, the government could focus on internal factors. One of internal factors influencing price volatility is caused by the availability of supply during religious days such as Eid Al-Fitr. Therefore, the policy to anticipate the price volatility could be targeted to increase supply of beef. There are several policies can be implemented to meet domestic beef demand. In the short term, importing beef could be one of solution to increase the availability of beef in domestic market. In the medium and long term, policies can be implemented to increase beef production in Indonesia. Importing feeder cattle could be a solution to increase the availability of beef in the medium period since the availability of feeder cattle from local cattle is still insufficient enough. In the long term, the production of local cattle should be enhanced by saving productive female cows or increasing cattle production through artificial insemination. Increasing farmers' capability to improve livestock cultivation, changing farmers' orientation towards commercial, and forming farmer corporations in cattle centres are also a necessity in the long term. The government cannot implement this policy without support from various relevant stakeholders. Collaborative efforts from various parties, including governments, market players, and industry, are required to manage and mitigate the associated risks.

CONCLUSION

The GARCH(2,2) model is the most suitable for estimating beef price volatility in Indonesia. In Indonesia, beef price volatility tends to be low and persistent over time. Beef farmers and retailers may also experience price and supply uncertainty. Factors contributing to beef price volatility include imports of feeder cattle, exchange rates, livestock diseases, the COVID-19 pandemic, and government policies such as PPKM and PSBB in the new normal era, as well as events such as Ramadan, Eid al-Fitr, Christmas, and New Year. The study recommends that the government maintain beef price stability by meeting domestic beef demand. Several policies can be implemented to meet domestic

beef demand, including importing beef and feeder cattle in the short term. In the medium and long term, policies can be implemented to increase beef production in Indonesia, such as importing feeder cattle, empowering farmers' capacity, and developing farmer corporations in cattle centres and providing stricter supervision to save productive female parents.

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