Meat price volatility as implications for food security in Indonesia

R P Destiarni1*, A S Jamil2, and F Septya3

1Agribusiness Department, Faculty of Agriculture, University of Trunojoyo Madura, Bangkalan
2Agricultural Training Centre of Jambi, Muara Jambi, Jambi
3Agribusiness Department, Faculty of Agriculture, University of Riau, Pekanbaru

* E-mail: resti.destiarni@trunojoyo.ac.id

Abstract. Indonesian meat consumption has 40 percent deficit which was covered by importing. Meat price in international market tend to fluctuate. The gap between domestic demand and supply meat also the imported price fluctuation causes instability of domestic price. This research is conducted to analyze the volatility of meat price which implicated to food security in Indonesia. ARCH-GARCH model is used to estimate meat price volatility in Indonesia. The Augmented Dickey-Fuller and cointegration test have been used for testing the presence of unit root and cointegration in the series. Langrange multiplier has been utilized to detect the presence of autoregressive conditional effect. Daily meat prices used are national average price which obtained from the Indonesia Ministry of Trade. This study reveals that meat price in Indonesia has high volatility with increasing price over the research period. The empirical model also shows asymetry effect. The results recommend that Indonesia should apply comprehensive managed import such as not only import on fresh meat and ready to cut bovine but also on breeding bovine. By the fulfilling production and stock, meat price can be more stable. By the price stabilization, food security concept will be reached so that every layer society can consume meat.

1. Introduction
Meat is one of the seven main food source commodities that are the focus of the government in realizing food security in Indonesia through self-sufficiency programs. Based on the 2015-2019 Strategic Plan of the Ministry of Agriculture, the seven commodities include rice, corn, soybeans, consumption sugar, beef, fish and salt. The government's focus on the beef commodity is a program to increase beef production to meet household consumption needs [1]. This production increase program is implemented in a self-sufficiency program so that it can meet the needs of consumers from various backgrounds for animal protein. Indonesia's focus on achieving food security is Indonesia's first step towards realizing food sovereignty, which is reflected in the power to overcome problems and fulfill food needs independently [2]. The concept of food security according to Law Number 18 of 2012 is a condition for the fulfillment of food for the state to individuals, which is reflected in the availability of sufficient food, both in quantity and quality, safe, diverse, nutritious, equitable, and affordable and does not conflict with religion, belief, and community culture, to be able to live healthy, active and productive in a sustainable manner. Three important aspects that must be met in order to achieve food security are the availability, access and absorption of food. Beef, which is the product of the livestock sub-sector, is one of the commodities that is the focus for realizing food security.
Changes in the lifestyle of Indonesians who are increasingly aware of the importance of animal protein for body health and hormonal balance have made the demand for beef has an increasing trend every year. The trend of increasing beef consumption in addition to consumers tends to consume beef with consideration of nutrition, social status, culinary, and western cultural influences. Based on data collected by the Center for Agricultural Data and Information Systems, Indonesian beef consumption fluctuates with a tendency to increase annually by 2.89 percent per year with the level of beef consumption in 2017 reaching 2.40 kg / capita / year from various age levels.

2. Methods
Data used in this research are daily observation of meat price. The number of observations was 2737 data observed from September 2010 to January 2017. Data was collected from the Ministry of Trade, Ministry of Agriculture, Kramat Jati Central Market and other sources. This data is used to answer the research objectives, where volatility is analysed using the econometric approach with the ARCH / GARCH model. GARCH ARCH model estimation using Eviews.

ARCH / GARCH model estimation begins with a stationary test. Stationary test was used to prevent spurious regression model. Spurious regression implies that the result of the regression may not be as significant as they seem. In this study, the stationary test was conducted by the augmented Dickey Fuller test. The ADF test is used to detect whether the data being analysed contains unit roots. The data is said to be stationary if it does not contain a unit root. The hypothesis in the ADF test is

- $H_0$: data has a unit root
- $H_1$: data has no unit root

Testing the hypothesis by comparing the t-statistic and the critical value of MacKinnon. If the t-statistic value in the ADF test is smaller than the critical value MacKinnon means the data is not stationary and it needs to be differentiated or differencing. After the data has been stationary, the tentative ARIMA model estimation is then carried out. Determination of the AR (p) and MA (q) orders is based on correlogram (ACF and PACF patterns), while for the determination of the order d is determined based on the level of data stationarity.

Selection of the best ARIMA model based on the smallest value of Akaike Information Criteria (AIC) and Schwartz Criterion (SC). In addition to the smallest AIC and SC criteria, the selected ARIMA model must also meet the following criteria, namely random forecast residuals, parsimonious models, estimated parameters that are significantly different from zero, invertibility and stationarity conditions must be met as indicated by the number of AR and MA coefficients respectively, each is less than one, the iteration process must be convergence, and the model must have a small MSE.

The selected ARIMA model was tested using the Lagrange Multiplier test to see the presence of the ARCH effect. The ARCH-LM effect test is based on the null hypothesis (Ho), that is, there is no ARCH error. The existence of the ARCH effect is a requirement for estimating the ARCH / GARCH model. After ascertaining that there is an ARCH effect, the process continues by estimating several variance models using the ARIMA model. Several alternative ARCH / GARCH models that have been estimated were then selected based on AIC and SC.

After obtaining the ARCH / GARCH model, the model evaluation is carried out by checking the adequacy of the model. If the model is inadequate, then return to the identification stage to get a better model. Model diagnosis is done by analysing the standardized residuals that include

1. Residual normality
   The residual normality test was carried out to test whether the residuals spread normally. Residual normality was checked by using the Jarque-Bera test. The Jarque-Bera test measures the difference between skewness (protruding) and kurtosis (tapering) data from a normal distribution, and includes a measure of variability.

2. Residual freedom
   The residual freedom test is carried out to test whether there is autocorrelation in the analyzed data. ARCH-GARCH model shows good performance if it can eliminate the existing autocorrelation in the data, that is, when the residuals are random (white noise). The test was
carried out by examining the residual squared autocorrelation coefficient with the Ljung-Box statistical test.

3. The presence of the ARCH-GARCH effect or the presence of heteroscedasticity.

A test for the presence of the ARCH effect is carried out to test whether there is still an ARCH effect on the selected ARCH-GARCH model. The presence of the ARCH effect can be detected by the Lagrange Multiplier (ARCH-LM) test.

The ARCH / GARCH model that has been evaluated is then used to estimate the value of beef price volatility. The volatility value of the beef price is described by the standard deviation value which is the square root of the various ARCH / GARCH models estimated.

3. Results and discussion

Figure shows daily beef price trend over the past six years. This figure also shows that the development of meat prices has increased. Meat price growth increased by 66.75% from the beginning of the period to the end of the data period. This significant increase is partly due to the increasing trend of middle-income communities in Indonesia. In addition, according to Nugroho (2016), the increase in population and purchasing power and driven by changes in consumption patterns has an impact on increasing demand for meat.

![Figure 1. The development of meat price data](image)

An increasing trend in meat prices indicates that there is a change in the average or in other words, the data is not stationary on the average. Based on the Augmented Dicky Fuller test, it shows that at the data level, the p-value is greater than alpha (0.8695 > 0.05). This means that the data is not stationary and requires differencing. The 1st differencing shows that the p-value is either tested using intercept or intercept and the trend is stationary.

| Variables | Intercept | Intercept and Trend |
|-----------|-----------|---------------------|
|           | t-statistic | Prob | t-statistic | Prob |

Tabel 1. The result of Augmented Dicky Fuller test on meat price data
After the data is stationary, the tentative ARIMA model is identified. The formation of the tentative ARIMA model is carried out by determining the AR order (p) and the MA order (q) [3]. The best ARIMA model selected has met the selection criteria, namely having the smallest Akaike Information Criteria (AIC) and Schwarz Criterion (SC) values [4], [5]. Each tentative ARIMA model is presented in Table 2. Based on the SIC, SC and R-squared criteria, it shows that ARIMA (3,1,1) is the best model.

**Table 2. The result of tentative ARIMA models**

| ARIMA         | AIC      | SC        | R-squared |
|---------------|----------|-----------|-----------|
| ARIMA (1,0)   | 15.09488 | 15.09975  | 2.5455    |
| ARIMA (2,0)   | 15.10316 | 15.10803  | 1.7527    |
| ARIMA (3,0)   | 15.08591 | 15.09078  | 3.4663    |
| ARIMA (0,1,1) | 15.08683 | 15.09170  | 3.2860    |
| ARIMA (0,1,3) | 15.08650 | 15.09137  | 3.3176    |
| ARIMA (1,1)   | 15.09137 | 15.08999  | 3.4566    |
| ARIMA (1,1,1) | 15.07739 | 15.08005  | 4.3327    |
| ARIMA (3,1,1) | 15.06788 | 15.06323  | 5.9607    |
| ARIMA (1,1,2) | 15.07681 | 15.07947  | 4.3708    |
| ARIMA (1,1,3) | 15.06673 | 15.07404  | 5.3301    |
| ARIMA (2,1,2) | 15.10237 | 15.10503  | 1.9128    |
| ARIMA (3,1,3) | 15.09045 | 15.08940  | 3.4673    |

The ARCH-LM test and the ACF and PACF behaviour patterns were then used to identify the presence of heteroscedasticity elements in the best ARIMA model. Based on the identification of the correlogram pattern, it shows that the autocorrelation value of the squared data analysed is significant in the first 15 lags. This shows the existence of the ARCH effect on the model [3], [6], [7]. In addition, the ARCH-LM test also shows that the p-value is less than alpha, so it can be concluded that there is an ACH effect on the model.

**Table 3. The result of heteroscedasticity test**

| Heteroscedasticity Test | P-value | Conclusion |
|-------------------------|---------|------------|
| Correlogram test        | Signifikan | Heteroscedasticity |
| ARCH-LM                 | 0.0000  | Heteroscedasticity |

The result of tentative ARCH / GARCH model estimation are showed in Table 4. All six models show significant autoregressive and moving average behaviour in the meat price so that the ARIMA model specification is maintained for all models to keep the residuals free from the serial autocorrelation. In addition, the selection of the best model is determined by taking into account the significance of the parameters, the criteria for the smallest AIC and SC [5], [8], [9]. Based on the indicators in Table 4, it can be concluded that the best model is the TARCH model.

**Table 4. The result of ARCH/GARCH model estimations**

| Model      | Estimation Parameter Significance | Log Likelihood | AIC  | SC    |
|------------|----------------------------------|----------------|------|-------|
| AR (3)     | V                                | -17374.81      | 14.6727 | 14.68488 |
| AR (2)     | V                                | -17207.88      | 14.53261 | 14.54723 |
| GARCH (1,1)| V                                | -16628.47      | 14.04345 | 14.05807 |
| EGARCH     | V                                | -16571.44      | 13.99615 | 14.01321 |
| TARCH      | V                                | -16543.69      | 13.97272 | 13.98977 |
The TARCH model is then evaluated for model normality and residual randomness. Testing for normality of errors is done by doing Jarque-Bera. It is concluded that the error is normally distributed if the Jarque-Bera is not statistically significant. Based on the normality test, it shows that the error model is not normally distributed. Although the TARCH model does not spread normally, other ARCH / GARCH models are also not normally distributed. Therefore, the TARCH model remains the best model in this case. In addition, based on the ARCH-LM test, it was found that the model was free from the ARCH effect.

The optimal result of TARCH estimation is shown in equation below:

\[
 h = 947.7806 + 0.272505 \sigma^2_{t-1} - 0.257075 d_{t-1} + 0.882690 \sigma_{t-1} \\
(35.059) \quad (0.008)^{***} \quad (0.009)^{***} \quad (0.001)^{***} 
\]

The residual and volatility of the previous period have a positive effect on future volatility.

The ARCH coefficient value in the meat variant model is 0.272505. This value is relatively low, so it indicates that the volatility is low. Meanwhile, the value of the GARCH coefficient is 0.882690. This value is relatively high (close to 1) so that the shock to the price variant occurs for a relatively long time (persistence).

The effect of asymmetry on the model is -0.257075, this indicates that the occurrence of a negative shock has a greater effect than a positive shock. Basically, the dt-1 variable is a dummy variable, where when the dummy coefficient is positive, the effect on volatility is 0.272505. Then, if the dummy coefficient is negative the effect on volatility is 0.01543 (0.272505 + (- 0.257075)) [10]. In other words, a negative shock event will change the value of future volatility to a greater extent than if a positive shock event occurs. Figure 2 also shows development of the conditional variance over the years. The meat price met the highest conditional variance on 2015 compare to other years.

![Figure 2. Conditional variance of meat price](image-url)
4. Conclusion
Meat is one of the main food source commodities which becomes focus on government self-sufficiency program which is written on The Ministry of Agriculture Strategic Planning on 2015 – 2019. Focus on this program is increasing meat production as one of the animal protein sources so that it could fulfill all demand and affordable for all Indonesian. This is related to achievement of food security in Indonesia. Food security concept based on Undang-Undang No. 18 of 2012 have three aspects which should be realized, there are availability, access, and food absorption. Change of lifestyle which is increasingly aware about the importance of animal protein for body healthy and hormonal balance make the meat demand has an increasing trend every year. Based on data from The Ministry of Agriculture, Indonesian meat consumption fluctuates with increasing trend around 2.89 percent per year by the consumption rate of meat on 2017 reaches 2.40 kg/capita/year from various age levels so that meat production still has deficit around 40 percent. That deficit was covered by doing meat importing to keep domestic meat stock. However, meat price in international market tend to fluctuate in increasing trend. The gap availability between demand and supply of domestic meat and the imported price fluctuation causes instability price of domestic meat. That causes price volatility which is a risk to face on meat commodity. Price volatility on meat commodity become fundamental issue especially for Indonesia related to food security. The research about price volatility will increase food security and price problem awareness so that this research is conducted to analyze the volatility of meat price which implicated to food security in Indonesia on meat commodity. The autoregressive conditional heteroscedasticity/generalised autoregressive conditional heteroscedasticity (ARCH-GARCH) regression model is used to estimate meat price volatility in Indonesia. The Augmented Dickey-Fuller (ADF) and cointegration test have been used for testing the presence of unit root and cointegration in the series. Langrange multiplier has been utilized to detect the presence of autoregressive conditional (ARCH) effect. Daily meat prices used are national average price which obtained from the Indonesia Ministry of Trade. This study reveals that meat price in Indonesia has high volatility with increasing price over the research period. The empirical model also shows asymmetry effect. The results recommend that Indonesia should prevent effect of high volatility with applying comprehensive managed import such as not only import on fresh meat and ready to cut bovine but also on breeding bovine which can be bred in Indonesia. Government must be consistent on program implementation to increase domestic production like SIWAB (Sapi Indukan Wajib Bunting), livestock distribution from densely populated to biomass abundant areas but empty cattle, increasing cattle productivity, preventing productive female cattle slaughter, preventing and controlling disease to decrease mortality rate, and also improving genetic quality through selection and crossing. By the fulfilling production and stock, meat price can be more stable. By the price stabilization, food security concept about availability, access, and food absorption will be reached so that every layer society can consume meat.

The results recommend that Indonesia should prevent effect of high volatility with applying comprehensive managed import. Indonesia’s Import activity is not only done in one time as the fastest way to stabilize price but also to keep domestic stock. Import is not only on fresh meat and ready to cut bovine but also on breeding bovine which can be bred in Indonesia. Government must be consistent on program implementation to increase domestic production like SIWAB (Sapi Indukan Wajib Bunting), livestock distribution from densely populated to biomass abundant areas but empty cattle, increasing cattle productivity, preventing productive female cattle slaughter, preventing and controlling disease to decrease mortality rate, and also improving genetic quality through selection and crossing. By the fulfilling production and stock, meat price can be more stable. By the price stabilization, food security concept about availability, access, and food absorption will be reached so that every layer society can consume meat.

References
[1] D. P. dan P. Bappenas, “Penyusunan RPJMN 2015-2019 Bidang Pangan dan Pertanian,” 2014, [Online]. Available: https://www.bappenas.go.id/files/1914/4299/8417/Penyusunan_RPJMN_2015-2019_Bidang_Pangan_dan_Pertanian.pdf.
[2] Badan Pengkajian dan Pengembangan Kebijakan Perdagangan, “Peluang Ekspor Indonesia di Pasar Negara-Negara Non Tradisional,” pp. 2014–2015, 2015, [Online]. Available: http://bppp.kemendag.go.id/leaflet_artikel_perdagangan/view/NDA%3D.

[3] Mittal S, Hariharan V K, and Subash S P 2018 Price volatility trends and price transmission for major staples in India Agric. Econ. Res. Rev. 31(1), p. 65, 2018, doi: 10.5958/0974-0279.2018.00006.x.

[4] Radifan F 2014 Faktor-Faktor Yang Mempengaruhi Ekspor Crude Palm Oil Indonesia Dalam Perdagangan Indonesia Econ. Dev. Anal. J. 2(4) 259–267, 2014.

[5] Saghaian S H 2010 The Impact of the Oil Sector on Commodity Prices: Correlation or Causation? J. Agric. Appl. Econ. 42(3) 477–485, 2010, doi: 10.1017/s1074070800003667.

[6] Apergis N and Rezitis A 2011 Food Price Volatility and Macroeconomic Factors: Evidence from GARCH and GARCH-X Estimates J. Agric. Appl. Econ. 43(1) 95–110, 2011, doi: 10.1017/s107407080004077.

[7] Nurliza N 2017 The Nature of Food Commodity Prices Volatility in Driving Inflation and Policy Signifikan J. Ilmu Ekon. 6(1) 103–124, 2017, doi: 10.15408/sjie.v6i1.4523.

[8] Ikudayisi A A and Salman K K 2014 Spatial Integration of Maize Market in Nigeria – a Vector Error Correction Model Int. J. Food Agric. Econ. 2(3) 71–80, 2014, [Online]. Available: http://www.foodandagriculturejournal.com/vol2.no3.pp71.pdf.

[9] Rosa F, Vasciaveo M, and Weaver R D 2014 Agricultural and Oil Commodities: Price Transmission and Market Integration between US and Italy Bio-based Appl. Econ. 3(2) 93–117, 2014, doi: 10.13128/BAE-12944.

[10] Ismail A, Ihsan H, Khan S A, and Jabeen M 2017 Price volatility of food and agricultural commodities: A case study of Pakistan J. Econ. Cooper. Dev. 38(3) 77–120, 2017.