Price volatility of maize and animal protein commodities in Indonesia during the Covid-19 season

Nur Baladina\textsuperscript{1, 2*}, Arifin Noor Sugiharto\textsuperscript{2}, Ratya Anindita\textsuperscript{1}, and Fitrotul Laili\textsuperscript{1}

\textsuperscript{1} Department of Social Economy, Faculty of Agriculture, Brawijaya University, Malang
\textsuperscript{2} Maize Research Centre, Institute of Research and Community Services, Brawijaya University, Malang

E-mail: baladina.fp@ub.ac.id

Abstract. The demand for corn in Indonesia is dominated as raw material for animal feed, so the high and low price of corn will have a big impact on the price of livestock products such as chicken and chicken eggs. The Covid-19 gives an impact on the uncertainty of food commodity prices. As we know, food price stability is one of the supports for maintaining a balance of production and consumer buying power. This study aims to analyze the price volatility of corn, chicken meat, and chicken eggs in Indonesia during the Covid-19 pandemic. The ARCH / GARCH model was used as an approach to analyzing volatility in the monthly prices of corn, chicken meat, and chicken eggs at the consumer level during the January 2011-June 2020 period. This research showed that the price of corn and chicken is categorized as high volatility category, while chicken eggs are a low volatility category with the form is asymmetric. It can be concluded that the price uncertainty faced by consumers in the future for corn and chicken meat will be bigger, while chicken eggs will be decreased. Therefore, it is expected that the government will make policies for maintaining the stability of food supply and prices.

Keywords: Price Volatility, Corn, Chicken, Chicken Eggs, ARCH / GARCH, Covid-19

1. Introduction

Food is an important thing for poor and developing countries. If food prices increase, other foods will increase and will impact inflation. The Covid-19 that spread since the end of 2019 in the way of resulting the crisis and recession due to reducing the workforces on the economic sectors, workers, and buying power [1] [2]. On the other hand, some consumer classes increase the demand for buying the products due to panic-buying and stockpiling [1]. This condition will ultimately impact the uncertainty of food commodity prices leading to price volatility [3].

Volatility is a statistical measurement method to determine the uncertainty price movement of a commodity during a certain period [4]. The volatility is a complex issue that impacts various fields including food security, financial markets, and trade flows [5]. The volatility is also one of the indicators of market performance indicating the degree of variation of the fluctuations price of agricultural commodities and the strategic animal protein that have related to each other such as corn as animal feed, chicken and eggs as livestock products that used corn as feed.

Consumption of corn in Indonesia is more than 58% used as raw material for animal feed [6]. The composition of corn in animal feed rations, especially poultry farm is about 50% of the total feed composition, and the feed is the largest component (70%) of production costs [7] [8]. Chicken is the...
highest meat consumption in a month by Indonesian rural and urban communities, while the chicken eggs are the highest animal protein consumption per capita in a month by Indonesian rural and urban communities[9]. If corn price as raw material for poultry feed fluctuates, the livestock products’ price such as chicken and chicken eggs will fluctuate too. The corn, chicken, and eggs include in strategic food commodities which interrelated to each other, so the high volatility of the three commodities will affect the food security during the Covid-19 in Indonesia. Therefore, this study aimed to analyze the price volatility of the corn and strategic animal protein commodities (chicken and chicken eggs) during the Covid-19 in Indonesia.

2. Materials and Methods
The research used monthly nominal price at the Indonesian consumer level of corn, chicken, and chicken eggs commodities from January 2010 to June 2020 (126 observations). The data source in this study came from the Indonesian Rural Consumer Price Statistics published by the Central Bureau Statistics (BPS). The volatility measurement method applied the ARCH / GARCH method approach. The steps for taking the data were stationarity test, ARMA order testing, ARCH effect testing, and ARCH / GARCH estimation.

2. 1. Testing Data Stationarity
The stationary test equation with ADF (Augmented Dickey Fuller) in this study written as follows:

\[ \Delta YPKJ_i = \alpha_0 + \gamma \Delta PKJ_{i-2} + \beta \sum_{i=1}^{p} \Delta PKJ_{i-1} + \epsilon_i \] ..............................(1)

\[ \Delta YPKD_i = \alpha_0 + \gamma \Delta PKD_{i-2} + \beta \sum_{i=1}^{p} \Delta PKD_{i-1} + \epsilon_i \] ..............................(2)

\[ \Delta YPKT_i = \alpha_0 + \gamma \Delta PKT_{i-2} + \beta \sum_{i=1}^{p} \Delta PKT_{i-1} + \epsilon_i \] ..............................(3)

Where:
\[ \Delta YPKJ_i \] : is second difference form for corn price at consumer level
\[ \Delta YPKD_i \] : is second difference form for chicken price at consumer level
\[ \Delta YPKT_i \] : is second difference form for chicken eggs price at consumer level
\[ \alpha_0 \] : Intercept
\[ \gamma \] : The coefficient of variable being stationarity tested
\[ PKJ \] : Price of corn (Rp/kg)
\[ PKD \] : Price of chicken (Rp/Kg)
\[ PKT \] : Price of chicken eggs (Rp/kg)
\[ \beta \] : Coefficient
\[ p \] : the lag length used in the model
\[ \epsilon \] : Error term

In the test, the hypothesis used is: \( H_0 : \delta = 0 \), meaning that there is a unit root so the data is not stationarity. \( H_0 \) is accepted if the probability value of ADF is bigger than the critical value that has been determined in the study (\( \alpha = 5\% \)).

2. 2. Testing ARMA Order
The general form of the ARMA model (p, q) is the autoregressive order p and the moving average q order written in the following general equation:

\[ X_t = \mu + \sum_{i=1}^{p} \phi_i X_{t-i} + \epsilon_t + \sum_{i=1}^{q} \theta_j \epsilon_{t-j} \] ..............................(4)

2. 3. Testing the ARCH Effect
The testing to prove the existence of the ARCH effects was carried out by heteroscedasticity testing. This test was done to see that the variance of the error does not have the same variance. The assumption is if \( \text{var}(\mu_t) = \sigma^2 \), then the variance of the error is constant (homoscedasticity), so the error variance value will be heteroscedastic if \( \text{var}(\mu_t) \neq \sigma^2 \). The test considers several summary statistics in order to determine the presence of heteroscedasticity, one is
the value of kurtosis (tapering), if the value is more than three, it can be assumed as an early symptom of heteroscedasticity.

2.4. ARCH / GARCH estimation

To describe a data series with changing volatility, the ARCH model allows the variant of the error term to change over time. Engle (1982) in [10] defined $\varepsilon_t$ from the general form equation of the ARMA model (equation 4) as a process of autoregressive conditional heteroscedastic, in which all $\varepsilon_t$-shaped:

$$
\varepsilon_t = z_t \sigma_t 
$$

$$
\sigma_t^2 = \omega + \sum_{i=1}^{p} \alpha_i \varepsilon_{t-i}^2 + \sum_{j=1}^{q} \beta_j \sigma_{t-j}^2 
$$

Where:

$z_t$: Independent variable distributed at zero mean and unit variance

$\sigma_t^2$: Conditional variance

$\varepsilon_{t-i}^2$: Volatility in the previous period

$\omega$: Constanta

$\alpha_i$: The coefficient of volatility in the previous period

Although $\varepsilon_t$ is not serially correlated in the ARCH model, but the conditional variance of $\sigma_t^2$ can change over time. The ARCH model (p) considered as a short process which the current residual $\sigma_t$ value has impact on the variance in the future.

By using the GARCH model (Bollerslev, 1986 in [11]), the ARMA model assumed for error variance. The GARCH (p, q) model expressed in the same form as ARCH except for the variance equation written as follows:

$$
\sigma_t^2 = \omega + \sum_{i=1}^{p} \alpha_i \varepsilon_{t-i}^2 + \sum_{j=1}^{q} \beta_j \sigma_{t-j}^2 
$$

Where:

$\sigma_t^2$: Conditional variance

$\varepsilon_{t-i}^2$: Volatility in the previous period

$\omega$: Constanta

$\alpha_i$: Coefficient of volatility in the previous period

$\beta_j \sigma_{t-j}^2$: Variance of the previous period

If all coefficients $\beta_j$ are zero, then the GARCH (p,q) model will be reduced to the ARCH (p) model. The GARCH (p,q) model allowed all previous residuals to impact the current variance either directly or indirectly via the lag variance. The GARCH estimation used to identify periods of high volatility and classifications of volatility. The amount $\alpha_i + \beta_j$ showed the level of volatility in the price series. If the amount of $\alpha_i + \beta_j$ gets closer to one, then the tendency of the power of volatility is greater over a longer period of time (Lepetit, 2011).

3. Results and Discussion

The results of the analysis using EViews as presented in Table 1. It shows that the corn price series is not stationary at the level of the level ($p_{ADF} > \alpha : 0.3981 > 0.05$) and stationary in the first difference. Therefore, the price series of chicken and chicken eggs also need to be tested for stationarity in the first difference in order to get the same order of integration.

| Commodity | ADF | PP | ADF | PP | ADF | PP |
|-----------|-----|----|-----|----|-----|----|
| Corn      | -2.360940 | 0.3981 | -2.476490 | 0.3392 | -10.69878 | 0.0000 | -10.51445 | 0.0000 | -9.583910 | 0.0000 | -56.2533 | 0.0000 |
| Chicken   | -6.131669 | 0.3981 | -5.945523 | 0.0000 | -9.508203 | 0.0000 | -28.33494 | 0.0000 | -7.185538 | 0.0000 | -47.87221 | 0.0000 |
| Meat      | -6.131669 | 0.3981 | -5.945523 | 0.0000 | -9.508203 | 0.0000 | -28.33494 | 0.0000 | -7.185538 | 0.0000 | -47.87221 | 0.0000 |
| Chicken   | -3.605989 | 0.0000 | -4.757906 | 0.0000 | -10.34938 | 0.0000 | -20.10676 | 0.0000 | -7.507284 | 0.0000 | -50.65392 | 0.0000 |

Table 1. Unit Root and Stationarity Test
This study used stationarity testing for the second difference because the ARCH effect appeared at that level. Furthermore, after the ARMA order testing stage and an ARCH effect testing through the heteroscedasticity test. The results showed that all price series commodities including corn, chicken, and chicken eggs had ARCH effect which indicated by the p-value of Obs*R-squared and F-statistic value less than 0.05 (Table 2). Therefore, the ARCH / GARCH model can be used to estimate the volatility in all price series.

**Table 2. ARCH Effect Test**

| Commodities  | Heteroscedasticity Test: ARCH                   |
|--------------|------------------------------------------------|
| Corn         | F-Statistic 40.93090  Prob. F (1, 125) 0.0000 |
|              | Obs * R-Squared 31.32764  Prob. Chi-Square (1) 0.0000 |
| Chicken meat | F-statistic 13.04782  Prob. F (1, 123) 0.0004 |
|              | Obs * R-squared 11.98827  Prob. Chi-Square (1) 0.0005 |
| Chicken eggs | F-Statistic 5.958370  Prob. F (1, 117) 0.0160 |
|              | Obs * R-Squared 5.778271  Prob. Chi-Square (1) 0.0162 |

Note: *showed that data is significant at 5%

The volatility value of each commodity is shown in Table 3. The estimation of the volatility value using the ARCH / GARCH model showed that the corn has a residual value and the GARCH close to 1 or \( (\alpha_i + \beta_j = 0.919778) \). It indicated that the level of corn price volatility is in the high category meaning that the corn price in the Indonesian market experiences a high shock (increase/decrease) so that the uncertainty prices faced by the consumers like broiler breeders will bigger in the future. The high volatility of the price at the consumer level is taken to be influenced by the demand and supply fluctuations. The corn supply can fluctuate because of natural factors, pests and diseases, the volume of the corn imports in the domestic market, and the length of the corn marketing channel from farmers (producers) to consumers which makes the calculation of cost-share and marketing margin more complex. The corn demand fluctuates because of the fluctuating demand for animal feed, the food industry, and alternative energy raw materials.

**Table 3. ARCH/GARCH Estimation**

| Commodities | Equation                                      | ARCH/GARCH Estimation: ARCH(1)GARCH(1) |
|-------------|----------------------------------------------|----------------------------------------|
| Corn        | \( PKJG_t = 0.077038 - 0.026324 e^{2}_{PKJG-1} + 0.946102 \sigma^2_{PKJG-1} \) | C 0.077038  GARCH(-1) (\beta) 0.946102 |
|             |                                              | RESID(-1)^2(\alpha) 0.026324 \alpha_i + \beta_j = 0.919778 |
|             |                                              | RESID(-1)^2(\alpha) 0.026324 \alpha_i + \beta_j = 0.919778 |
| Chicken     | \( PKDA_t = 10.09275 + 0.511440 e^{2}_{PKDA-1} + 0.004146 \sigma^2_{PKDA-1} \) | C 10.09275  GARCH(-1) (\beta) 0.004146 |
| Meat        |                                              | RESID(-1)^2(\alpha) 0.511440 \alpha_i + \beta_j = 0.515586 |
|             |                                              | RESID(-1)^2(\alpha) 0.511440 \alpha_i + \beta_j = 0.515586 |
| Chicken     | \( PKTA_t = 4.492220 + 0.085985 e^{2}_{PKTA-1} - 0.442771 \sigma^2_{PKTA-1} \) | C 4.492220  GARCH(-1) (\beta) -0.442771 |
| egg         |                                              | RESID(-1)^2(\alpha) 0.085985 \alpha_i + \beta_j = -0.356786 |

The price volatility of chicken was found still in the high volatility category because of the total residual value and GARCH close to 1 \( (\alpha_i + \beta_j = 0.515586) \). This indicated that the level of chicken
price volatility in the Indonesian market is quite volatile, meaning that the price of chicken at the Indonesian consumer level has experienced a high shock (increase/decrease) so the uncertainty of chicken meat prices faced by Indonesian consumers in the future will increase its volatility. The high volatility of chicken prices at the consumer level was taken to be influenced by the demand and supply of chicken fluctuations. As we knew from the supply side, 50% of the raw material composition for animal feed is corn. The animal feed itself is the largest component (70%) of farmers' production costs. If the corn price as raw material for poultry feed fluctuates, the price of livestock products such as chicken and chicken eggs will fluctuate. Besides that, almost all of the important raw materials for the feed must be imported. The fluctuations in the Rupiah (IDR) exchange rate against foreign currencies will give a big impact on the imported materials price which will affect the chicken price. On the other hand, the consumer demand for chicken tends to decrease during the Covid-19 as a result of low income and buying power in the middle and low class but in the high class, the demand increase due to panic-buying and stockpiling of food products. This contradictory condition will give a great impact on the high volatility of chicken prices at the Indonesian consumer level.

In contrast, the total residual value and GARCH of chicken eggs is getting away from 1 and the volatility coefficient value is negative (\( \alpha_i + \beta_j = -0.356786 \)). It is categorized as low with a tendency of decreasing volatility. It meant that the chicken eggs price volatility of the Indonesian consumer market is less volatile because the shock (increase/decrease) in price is getting smaller. The uncertainty of chicken egg prices faced by Indonesian consumers in the future will be decreased. Unfortunately, the supply side showed that the corn is categorized as high volatility which is the raw material for animal feed and some materials for chicken eggs production need to be imported that depend on the Rupiah (IDR) exchange rate. The chicken eggs price categorized as low volatility due to the steady demand for the eggs that easy to get, cheap and affordable for all the classes including the low buying power class. The demands for the eggs not only come from household consumers but also from the food processing industry consumers. SUSENAS 2018 data showed that chicken eggs are the animal protein most consumed per capita per month by rural and urban communities in Indonesia [9]. Therefore the Covid-19 pandemic which generally has an impact on decreasing people's income and purchasing power does not really affect the shock (increase/decrease) of chicken eggs price in the consumer market.

4. Conclusion

Price volatility of corn and chicken at the consumer level in Indonesia belongs to the high category, so the uncertainty of the prices faced by consumers in the coming period will be bigger. However, the price volatility of chicken eggs at the Indonesian consumer-level belongs to the low category with a tendency of decreasing volatility. It means that the uncertainty in the price of chicken eggs faced by consumers in the coming period will be less volatile. The high volatility of the corn prices compared to the price volatility of chicken and eggs at the consumer level indicated that there is a market power that acts as a price maker in the corn consumer market considering the market structure of the animal feed industry in Indonesia is a loose oligopoly [12].

Therefore, the government is expected to implement policies capable of maintaining the stability of food supply and prices. The high volatility will make the price of the corn, chicken, and chicken eggs in the future increasingly unstable and unpredictable that will affect the stability of supply and demand at the national level. The government's policy of providing subsidies or reducing the burden of production costs for the corn farming and broilers (chicken and eggs) are expected to be able to increase the quantity, quality, and continuity of domestic production of the corn, chicken, and chicken eggs so the stability of the food supply side will be achieved. The policy also will support the development of domestic corn and chicken farming, reduce unemployment, and increase people's income and purchasing power in order to make the food demand stable leading to food price stability.
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