

APPLICATION OF ARCH/GARCH MODELS IN ANALYSIS OF PRICE VOLATILITIES LOCAL, IMPORTS (USA), AND WORLD

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ABSTRACT

Soybeans are one of Indonesia's strategic agricultural commodities. Soybean prices fluctuate due to high demand and low stock of soybeans. This study was conducted to determine the behavior of local soybean prices in Indonesia, imported soybeans from the USA, and world soybeans. This study uses monthly soybean price time series data from January 2017 to March 2022 for local and world soybean price data and for imported soybean price data (USA) from January 2018 to March 2022. The data is obtained from the Kementerian Perdagangan, UN Comtrade, and the World Bank. The research method used is the ARCH/GARCH analysis method. The result of this study is the estimation of the GARCH model on the volatility of local soybean prices in Indonesia, imported soybeans (USA), and world soybeans obtained the GARCH (1,1) model. Based on the GARCH (1,1) model, the price of local soybeans in Indonesia is more volatile than the price of imported soybeans (USA) and the price of world soybeans is more volatile than the price of imported soybeans (USA). The prices of local soybeans in Indonesia, imported soybeans, and world soybeans are more volatile after the Covid-19 pandemic than before the Covid-19 pandemic. Future forecasts of local soybean prices in Indonesia, imported soybeans, and world soybeans are predicted to increase with the highest price in December 2024 of IDR 15,391.21 for local soybeans, IDR 11,303.92 for imported soybeans, and IDR 12,069.11 for world soybeans. This price forecast can be used as a reference by the government in planning soybean import policies.

Key words: ARCH/GARCH; Soybean; Volatility

INTRODUCTION

Soybean is one of the strategic agricultural commodities owned by Indonesia. Strategic commodities are commodities that have high economic value to maintain food stability, especially on price stability indicators to avoid inflation. A very high level of consumption of soy crops can also maintain food sustainability. Soya consumption per capita per year from 2016–2020 has increased by 12%. According to [15], soya commodity production tends to decline from year to year due to a lack of cultivation techniques. That could threaten food security in Indonesia. The high consumption of soybeans has led to an increase in demand for soybeans in Indonesia, not accompanied by soybean production, thus causing the government to undertake import activities. [2] soya imports are carried out to the United States, Canada, Argentina, Brazil, Malaysia, France, India, and other countries [6].

Indonesia is still dependent on imports of soybeans because its own local soybean production decreases every year and is unable to meet domestic needs. The government imports mostly from the United States, which is the world's largest soybean producer. The uncertainty about domestic soybean production leads to fluctuating demand, thus implicating unstable local soybean prices. Local soybean demand fluctuations are often accompanied by a phenomenon of inability to meet market demand, which is a factor in price fluctuation [14]. The failure to satisfy market demands is

due to the limited availability of local soybeans. This is caused by the small desire of farmers to expand the soya cultivation area because the soybean prices are no longer profitable as a result of the fact that the producers, who are the largest consumers of soya commodities (about 60%), are not interested in local soya and prefer imported soya for raw materials [10]. The volatile amount of soy imports is due to the uncertain availability of soy on the export market, so the quantity of soy exported is uncertain. The import of soy to Indonesia is also a factor causing the price fluctuations that occur in local soy as a result of the price competition between local soy and soy imported in Indonesia [19].

Imported soybean prices also fluctuate frequently, owing to a declining supply of soybeans in the world markets, rising distribution costs, and weakened rupee exchange rates against the U.S. dollar [3]. The declining supply of soybeans in the world market may be caused by climate conditions in the country of origin that could potentially lead to harvest failures. Besides, the prices of soybeans in the world markets are also fluctuating. This is because the availability of the world's soybeans is heavily dependent on the supply of the central world's soybean producer, namely the United States (USA). The phenomenon has led to a gap in the price of local soybeans in Indonesia, with world prices widening. The study uses import soy prices (USA) because the US itself is the center of soy production in the world. The study aims to find out the behavior of local soy prices in Indonesia, imported soy from the US, and world soya, comparing the three behaviors of these prices and comparing price behavior before and after the COVID-19 pandemic. The existence of price behavior analysis will also provide information for the government to determine the policy in determining the price of soybeans in Indonesia to remain stable and the policy in increasing soybean cultivation in the swasembada.

MATERIALS AND METHODS

Data Collection Method

The data used are time series data on monthly soybean prices (Rp/kg) from January 2017 to March 2022 for local, imported (USA), and world soybean price data. Local soybean price data is obtained from Kemendag, US imported soybean price data from UN Comtrade, and world soybean price data from the World Bank.

Analysis Method

Excel 2016 and Eviews 7 software data processing. The analytical method used to solve the behavior of local, imported, and world soy prices is the ARCH/GARCH method. The ARCH/GARCH model is used to look at fluctuations, where fluctuation will describe the risks that occur. The GARCH model equations (p,q) are generally mathematically as follows for the prices of local soya, exported soya, and world soybeans :

$$\sigma_t^2 = a_0 + a_1 \varepsilon_t^2 + a_2 \varepsilon_{t-1}^2 + \dots + a_p \varepsilon_{t-p}^2 + \beta_1 \sigma_{t-1}^2 + \dots + \beta_q \sigma_{t-q}^2 = a_0 + a_1 \varepsilon_t^2 + a_2 \varepsilon_{t-1}^2 + \dots + a_p \varepsilon_{t-p}^2 + \beta_1 \sigma_{t-1}^2 + \dots + \beta_q \sigma_{t-q}^2$$

with

$$a_0 > 0, \beta_q \geq \beta_q \geq 0, \text{ dan } a_p \geq a_p \geq 0$$

Description:

σ_t^2 = Soybean price variation in the t-period

a_0 = Constanta

ε_{t-p}^2 = Price behavior in previous periods

σ_{t-q}^2 = Varieties in previous periods

Based on [16], there are some test stages of the ARCH/GARCH model among them as follows:

1. Unit root testing with the Augmented Dickey Fuller (ADF) method with the following criteria:
 - a. If the Augmented Dickey Fuller (ADF) test statistic > Mackinnon critical, then H0 is rejected.
 - b. If the Augmented Dickey Fuller (ADF) test statistic < Mackinnon critical, then H0 is approved.
2. The determination of the ARMA model is best done by looking at the PACF and ACF patterns first on the data correlograms that have been stationary. Selection is done on the lag of the P ACF and the ACF that pass through the dividing line. Next, select an order candidate based on the selected lag. An estimate of the ARMA model is performed on each chosen order candidate. Next is the selection of the best ARMA model, with the criteria used as a measure of the accuracy of the ARMA models as follows:

$$\text{Akaike Information Criterion (AIC)} = T \log |\Sigma||\Sigma| + 2 N$$

$$\text{Schwarz Criteion (SBC)} = T \log |\Sigma||\Sigma| + N \log (T)$$

Description:

T = Observation Total

$|\Sigma||\Sigma|$ = Determination of the variance/kovarians matrix of the sequence

N = Number of estimated parameters

The best ARMA model is the one with the Akaike Information Criterion (AIC) and the smallest Schwarz Criteria (SC), among other ARMA models.

3. Identify the ARCH effect and determine the best ARCH/GARCH model. Identification of heterosexuality was done on the best ARMA model at local, import, and world soya prices. If the probability value is $F < 0,05$ (prob. $F < 0.05$) and the Chi Square probability value is $< 0,05$, it can be construed that there is an ARCH effect. Next, determine the ARCH/GARCH model using the selected ARMA model that has been tested for heterosexuality. Estimates of ARCH/GARCH models were made on ARCH (1), ARCH (2), GARCH (1,1), GAR CH (1,2), and GARC (2,2). The best ARCH and GARCH models were those with the smallest AIC and SC values compared to other models and no longer had an ARCH effect. If the value of the error coefficient is less than 1, it means that the soya price volatility is not responding to or following the changes in the market.
4. The model evaluation stage is used to ensure the suitability of a model by passing the residual freedom analysis. There is no autocorrelation in the selected model that can be tested with the statistical test Ljung-Box. The model is said to be unqualified when the Q-Stat value is greater than the P-value value in the Chi Square table at a level of 5% (Q-State > P-Value). In addition, the presence of autocorrelation is determined by a probability value less than 0.05 (prob. < 0.05). An adequate model at this stage of evaluation is one that does not have an autocorrelation.
5. The calculation of the value of price behavior can be seen based on the standard graph of conditional deviation, or conditional standard deviation. The graph will show the patterns of volatility that occurred in local soy prices in Indonesia, imported soy prices (USA), and world soy prices. The more volatile or volatil the chart of price behavioral values, then there is a possibility that soy prices fluctuate increasingly extreme and bigger.

6. The forecasting phase of the ARCH model is carried out to predict the future prices of local, imported, and world soya. Forecasts on local soya prices in Indonesia, exported soya (USA), and global soya were made from January 2018 to December 2024. The forecasts of local soja prices, imports (USA), and world prices used the best model of ARCH/GARCH.

RESULTS AND DISCUSSION

The ARCH/GARCH analysis was carried out on local soybean price data in Indonesia, world soybean prices from January 2017 to March 2022, and imported soybean price data (USA) from January 2018 to March 2022. There was a difference in the amount of data released. Imported soybean prices (United States) were conducted starting in January 2018 due to data from a previous year, namely 2017, containing heterosthesity (Prob. > 0.05), causing the equation model to be inaccurate and efficient and causing model estimates to be disturbed. Table 1 shows local soy price data, imports (USA), and the world has been stationary, with no ARCH effect and no autocorrelation.

Table 1. Data stationarity test, best ARIMA model, ARCH effect identification, best ARCH/GARCH model, and autocorrelation test.

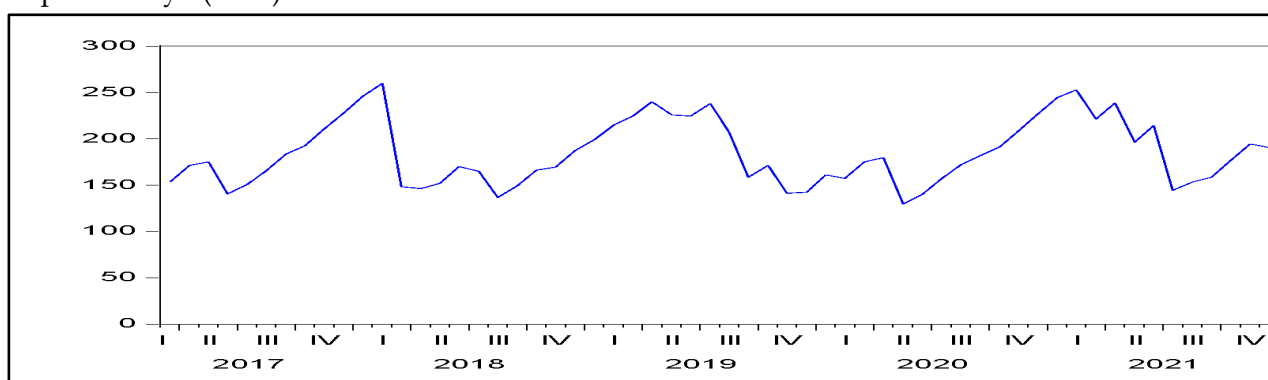
Variable	ADF t-statistic	Critical Value (5%)	Prob.	Best ARIMA Model	ARCH Effect	Best ARCH/GARCH Model	Autocorellation
Local price Soybean	-6.398329	-2.910019	0.000	ARIMA (1,1,1)	No Exists	GARCH (1,1)	No Exists
Import Price Soybean (USA)	-7.532404	-3.506374	0.000	ARMA (0,2,1)	No Exists	GARCH (1,1)	No Exists
World Price Soybean	-12.88806	-2.910860	0.000	ARMA (1,2,0)	No Exists	GARCH (1,1)	No Exists

Source : Secondary data processed by researchers, 2023

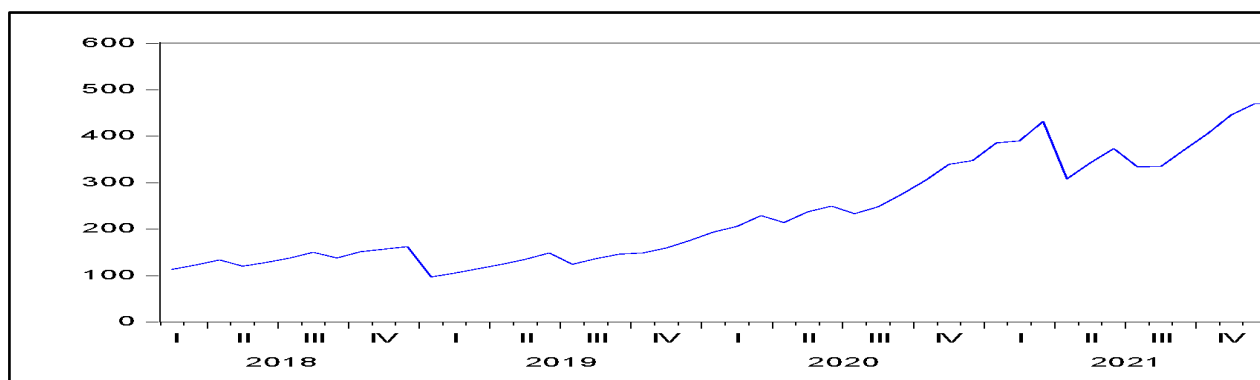
The quantity equation obtained is (1) the price of local soybeans in Indonesia. $\sigma_t^2 = -584,8743 - 0,157149\varepsilon_{t-1}^2 + 1,240637\sigma_{t-1}^2$, (2) the price of import soybeans (USA) $\sigma_t^2 = -584,8743 - 0,157149\varepsilon_{t-1}^2 + 1,240637\sigma_{t-1}^2$, and (3) the price of world soybeans $\sigma_t^2 = -33,86769 - 0,109883\varepsilon_{t-1}^2 + 1,148187\sigma_{t-1}^2$. Based on the equation, information was obtained that the variance of error size in the GARCH model (1,1) was influenced by the square of the size of the disturbance in the previous month (and affected by the coefficient of variance error in the preceding month). So, the value of the error size factor in the prices of local soy, imports (USA), and the world is away from the value 1, that is. It means local soy price volatility in Indonesia, imports (USA), and the world is not responding to or following market changes. Based on the above equation, it indicates that there was no influence on soy price behavior in the previous period.

Estimates of local soy price volatility, import soy price (USA), and world soy price indicate that there were variations in soy price between January 2017 and March 2022 for local and global soy and between January 2018 and March 2022 for imported soy (USA), as shown in Figure 2.

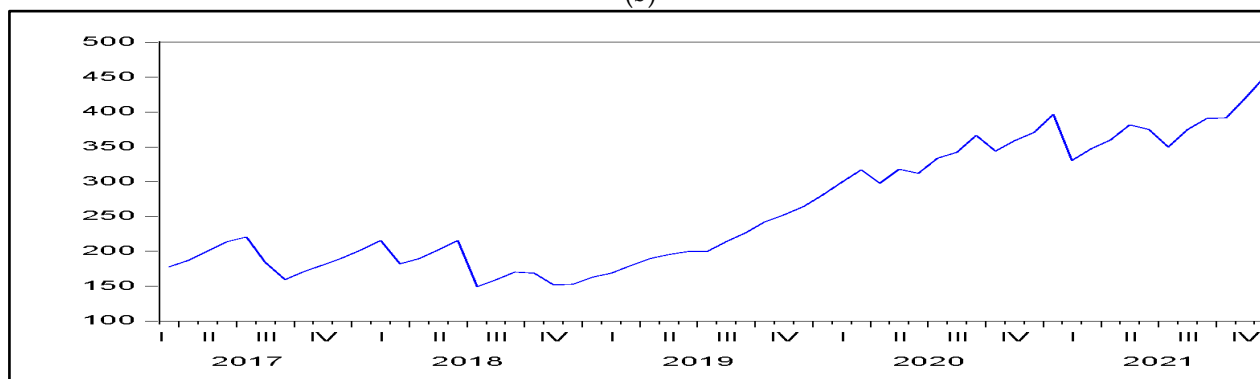
Extreme volatility occurred between May 2020 and March 2022, exactly after the COVID-19 pandemic in Indonesia. This is supported by the [12] that states that the conditions of soya volatility before the COVID-19 pandemic were more stable compared to the post-COVID-19 period. In Figure 2(b), the pattern of imported soya price volatility (USA) tends to be more steady compared with local soya prices. This is in line with research carried out by [19]. [9] and [12] that says that the price of local soybeans in Indonesia is more volatile compared to the prices of imported soya. [12] said that in 2020, precisely after the COVID-19 pandemic, the volatility of the price of imported soybeans increased due to restrictions on the territory's entry and exit that hampered import activity. Figure 2(c) shows a world soya price volatility pattern that is fluctuating and more volatile compared to imported soya (USA).



(a)



(b)



(c)

Figure 1. Volatility patterns (a) Indigenous Soybeans Prices in Indonesia, (b) Imported Soybeans (USA) Prices, and (c) World Soybeans Price

Source: Processed by researchers, 2023

This is supported by studies by [19], [9] and [12], which say that the volatility of the world soy price is more volatile than the price of imported soybeans. The pattern of volatility of the global soybean price also experienced extreme volatility after the COVID-19 pandemic took place. According to [12], who stated that in January 2020 there was a shortage of soya in the world market due to the massive demand of China that was justified to secure its domestic stocks, so the price on the Chicago Stock Exchange continued to rise and only the United States has sufficient stocks of soy beans to be exported.

Local soy prices in Indonesia are highly volatile or have high volatility. High volatility occurs every middle of the year towards the beginning of the next year. Every mid-year, the prices of local soybeans in Indonesia tend to have high volatility. In addition to being influenced by the season, the production of soybeans in Indonesia is also affected by the time of planting and the location of the plant [13]. The melting season is from April to September, while the rainy season lasts from October to March. Usually, farmers plant soy around June or July each year [5]. The local soy season is usually planted in the melt season, just after the peach harvest season is over [8]. By the middle of the year, the supply of local soybeans in Indonesia has been shrinking while the demand for soya continues to rise. This led to high volatility in local soy prices in Indonesia in the middle of the year. At the turn of the year, exactly after the local soy harvest season, volatilities tend to decrease as local soy supplies in Indonesia return to normal. This is in line with [14] study, where high volatility occurs in the period before the growing season until the coming growing season, whereas volatility tends to be stable at the time the harvest season arrives until after the growth season. High volatility also occurred during 2019, in addition to being influenced by the planting time and the local harvest time of soybeans in Indonesia. This high volatility is due to the increased volume of imported soybeans in 2019 from the previous year of 2.677,000 tons. For the past five years, the highest volume of imports was in 2019. The amount of imported soybeans in Indonesia affects the prices of local soybeans in Indonesia because of price competition [7]. Extreme volatility occurred between 2021 and 2022 as a result of the COVID-19 pandemic that occurred in Indonesia.

Based on the estimated results of the ARCH/GARCH model on imported soy price data (USA), we obtained a more stable pattern of volatility compared to local soy prices in Indonesia and the world soy. This is because import activities are generally carried out in large quantities and the stock of imported soya (US) can be stored in the storage warehouse owned by the importer, so this can cause the price of soya imported to be higher than the price of local soy in Indonesia [19]. In addition, the stability of imported soybean prices can also be caused by the stronger US dollar exchange rate, so that the prices of goods in America are much cheaper. As a result, Indonesia is interested in importing soy products from the United States. Low and tendingly stable volatility in imported soy prices (USA) is due to import activities with the contract system. This contract system has a fairly long duration because of the distribution gap of soya, which takes a long time, so that when soya prices rise in the world market, it will not directly affect the price of imported soya. In addition, the fluctuation in the price of imported soybeans can be suppressed by a policy from the United States that facilitates export subsidies to U.S. soybean importers in Indonesia in the form of export credit subsidies [18]. The export credit subsidiary called GSM-102 consists of credit guarantees, export credit insurance, low interest rates, and longer payment periods [4]. In addition,

there is a Facility Guarantee Program (FGP) policy designed for sales to countries with limitations in inadequate storage, processing, handling, and distribution, so these credit guarantees are made to facilitate the financing of US goods and services to enhance agricultural facilities in the importing country market. The volatility of imported soybeans (USA) is very important for industry actors to know and understand in Indonesia. This is done to reduce the percentage of risk involved in conducting the business.

Extreme volatility occurred between 2021 and March 2022 (Figure 2(b)). This is one of the consequences of the worldwide pandemic of COVID-19. The COVID-19 pandemic in the United States has caused the government to lock down for the first time in March 2020 to prevent the spread of the virus. Moreover, since the COVID-19 epidemic has occurred in Indonesia, the exchange rate of the rupee against the US dollar has also weakened, so that the purchase price of imported products is higher [22]. A natural catastrophe of drought in the United States could lead to a fall in soybean production, so the price of imported soybeans rises. The United States itself is the country that produces the world's largest emissions of gases that cause climate change [17]. There is an El Niño phenomenon that supports prolonged drought in the United States. In addition to the El Niño phenomenon that causes drought, there is the La Niña phenomenon that can cause natural disasters like flooding. The phenomenon also affected the production of soy that failed to harvest, causing the stockpiles of soybeans in the United States to shrink and prices to rise. This extreme volatility also affects industry players in Indonesia. At the beginning of 2022, there was a production strike carried out by producers in Indonesia, resulting in a temporary cessation of production [1].

Based on the estimates of the ARCH/GARCH model on the world soya price data, the result is that the world's soya prices are fluctuating as the world market stocks are falling. The decline in the supply of soybeans in the world market can be caused by the conditions of the soya supplier countries, which have constraints. According to [1], there are several soy exporting countries in the world: the United States, Brazil, Paraguay, Canada, and Argentina. The United States of America, as a soya producer, is experiencing climate change that has caused a failure to harvest, so it cannot meet the world's soya demand. In the United States (USA), there is also a competition between soy and corn-grown land. This is because soy and corn crops can be grown alternately. Maize crops, as one of the main ingredients for producing food-based alternative energy sources, have made farmers prefer to cultivate maize commodities rather than soybean commodities. The rise in world oil prices will cause the price of world corn to rise as well. According to [9], 1% increase in maize commodity prices will result in a 0.55% increase in the price of finished soybeans. Climate change is also occurring in other soya exporters, as Paraguay has soya production that is highly fluctuating due to climate problems [21]. Extreme volatility has occurred since the COVID-19 pandemic in the middle of 2021. Soya prices on the world market have risen following the COVID-19 epidemic because many countries, as soybean producers, have limited soybean production, so they cannot supply soybeans to the global market in normal quantities. In addition, extreme volatility is also the result of massive purchases by the Chinese state. The Chinese state purchased 60% of the world stock of soybeans, or the equivalent of 100 million tons, to meet the country's needs for both public consumption and pork feeding.

In Figure 2, local soy price forecast results in Indonesia, soy price imports (USA), and world soy prices are predicted to continue to rise until December 2024. Local soybean prices (Rp/kg),

imports (U.S. imports), and the world (Rp/kg) in December 2024 are predicted to reach Rp 15.391,21, Rp. 11.927,73, and Rp. 12.069,11. Local soy prices are forecast to continue to rise due to the government, which has not been able to increase soybean production in Indonesia because of many obstacles. According to [20], there are barriers in production aspects such as relatively low productivity, pest and disease attacks, climate change that farmers can't predict, soya price instability that often doesn't favor farmers, and limited land ownership that makes farmers prefer more economical and low-risk commodities. [2] also said that obstacles also occur across harvest and postharvest aspects, such as the rate of loss of yields being quite high, the implementation of harvesting technology and postharvest is not optimal, there are capital constraints to buy agricultural tools and machinery (Alsintan), and the availability of agricultural equipment and machines (Alsintan) is inadequate.

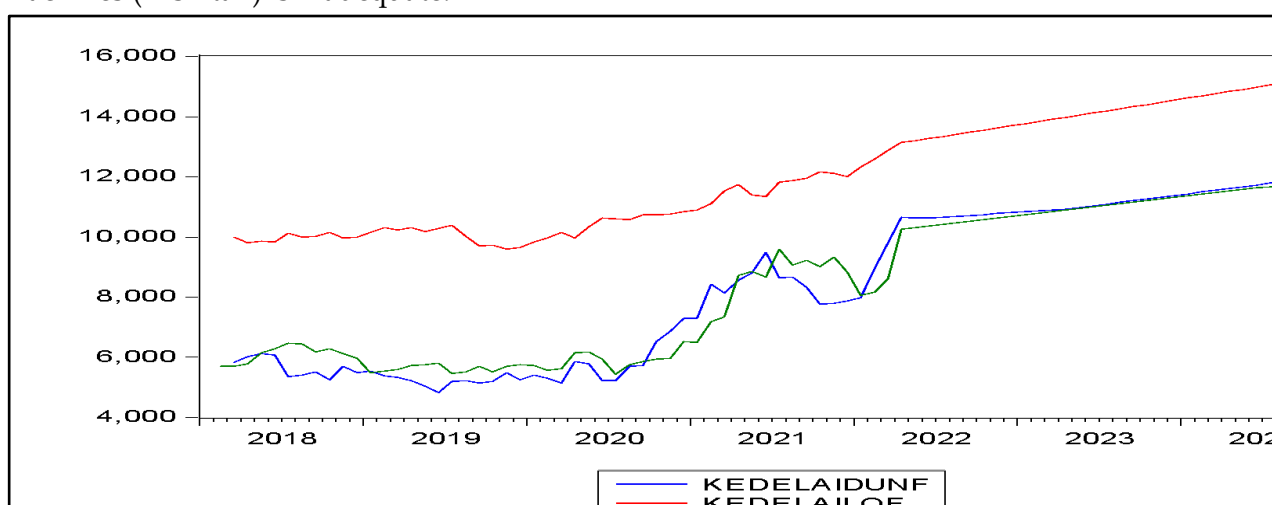


Figure 2. Local, Import (USA) and World Soybean Price Forecast Results

Source: Processed by researchers, 2023

Other challenges in cultivating soybeans are the lack of guaranteed price incentives for quality products, Alsintan's increasing operating cost requirements, the still unmanaged farmers' institutions, and the relatively limited labor force of processors [2]. Indonesian soybean harvests are of low hygienic quality and still contain more water compared to imported soya, so the soya processing industry tends to choose imported soy beans that have a higher level of hygiene and a lower water content. Other factors that hinder the increase in soybean production in Indonesia are not fully using technology and a lack of use of fertile seeds [7]. It requires efforts from the government to attract the attention of farmers to cultivate soybeans, as well as efforts in the development of fertilized seeds with genetic engineering techniques to produce GMO (genetically modified organism) seeds that can be given to farmers for cultivation.

The forecasted price of imported soybeans continues to rise as a result of climate change in the United States, such as the La Nina and El Nino phenomena, thus affecting the decline in soybean production in the US and causing the price of soybean imports to increase in the future. There are forecasts of future imported soya prices (USA) expected to be a matter of consideration for industry levels to reconsider in the selection of importing soya as raw materials (USA), as it is predicted that the import prices of soja will continue to increase. Furthermore, it is expected that the government can consider this in making a policy on the volume of soy beans imported from the US in order to

maintain the price stability of soy imports from the U.S. (USA). The world soya price is also projected to increase continuously due to several factors: (1) failure to harvest in the soya exporting country; (2) the US, as a centrifugal producer of soy, suffered from inflation; and (3) intervention by Ukraine from the beginning of 2022 until now. Ukraine is the largest supplier of vegetable oil derived from corn and sunflower seeds in the world. The rise in world oil prices will cause the price of world corn to rise as well. According to [9], a 1% increase in maize commodity prices will result in a 0.55% increase in the price of finished soybeans.

CONCLUSION

GARCH model estimates on the volatility of local soy prices in Indonesia, imported soy (USA), and world soy are obtained by model GAR CH (1,1). Based on the estimates of the model, the local soy price in Indonesia is more volatile when compared to imported soy prices (US), and the world soy price is more volatile if compared with imported soy prices (USA). Local soy prices are higher after the COVID-19 pandemic than before the COVID-19 pandemic. Local soy price forecasts for Indonesian soya imported (USA) and world soya in the future are predicted to rise to the highest price in December 2024 of Rs 15.391.21 for local soya and Rs 12.069.11 for world soy, and the price of imported seafood (United States) is highest at Rs 11.303.92. The government needs to do something to boost domestic soy productivity by providing superior seed subsidies, improving planting technology, and providing a policy of selling soy at producer-friendly rates for farmers. Further research is needed on the factors that influence the behavior of local soybean prices in Indonesia, imported soybeans (USA), and world soybeans.

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