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Climate Change and Milk Price Volatility in Indonesia

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ABSTRACT

The international food crisis from 2007 to 2010 impacts the fluctuation of world's food prices. Indonesia is one of the developing countries that are vulnerable to volatility in food prices because food is a necessity that is still partly imported and hence impactingdomestic prices. This problem has been excerbated by tthe fact that domestic fresh milk production made a relatively small contribution to the availability of milk to meet Indonesia's consumption. This study aims to analyze the volatility of fresh milk prices in three largest milk producer regions in Indonesia, namely East Java, West Java, and Central Java, from June 2015 to December 2018. The study used autoregressive conditional heteroscedasticity-generalized autoregressive conditional heteroscedasticity model. The results of this study shown that fresh milk prices in West Java was volatile and it was influenced by the volatility of the previous period. Climate change and feed prices yielded positive responses on the volatility of fresh milk price in West Java. Subsequently, it achieved a stable price level in the long run. In the short run, the highest response of the milk price volatility shock was shown by the West Java's fresh milk price volatility itself.

Keywords: Autoregressive Conditional Heteroscedasticity-Generalized Autoregressive Conditional Heteroscedasticity, Fresh Milk Prices, Vector Error Correction Model, Volatility
JEL Classifications: Q54, O13

1. INTRODUCTION

Since 2008, food and financial crisis has drawn a significant attention in policy making, particularly due its impacts on political stability and economic development ([FAO] World Food and Agriculture Organization, 2013). The short run food price fluctuations has lead to a high food price volatility (Gilbert and Morgan, 2010), affecting the state of the food security, financial markets and trade flows (Miguez and Michelena, 2011). The food price volatility has been empirically found to be more volatile than the manufacturing products as the demand characteristics of the food is inelastic and highly dependent on external forces such as climate, pest and other factors (Anindita, 2004).

Indonesia, as a net importing country of milk and dairy products, has been facing substantial risks of international price volatility. Increase in the international milk prices increase was transmitted to domestic prices (Hardjanto, 2014). The price transmission risk occurs due to the fact that the domestic fresh milk production made a relatively small contribution to meet Indonesia's demand.

Table 1 shown increasement of Indonesian imported milk, while domestic fresh milk decreased during the period 2012-2015. In addition, the local content requirement to limit the import of milk with ratio 1:1.6 compared to local milk was eliminated since the enactment of Inpres No.4/1998. The abolishment of the regulation has been attributed to the significant increase in import. The latest development of milk imports, acccording to Bureau of Central Statistics data, shows that Indonesian milk imports reached $55 million in August 2018, representing a significant 73.3% rise compared to the previous month of US $31.7 million. The condition of the increase in milk imports is due to a decrease in the availability of domestic milk in Indonesia, which can be seen in Table 2. The table also shows the percentage of domestic milk

Table 1: Indonesia fresh milk production and its contribution to national demand in 2012-2015

Year	Production (tons)	Contribution to total national demand	
		Fresh milk (%)	Imported milk (%)
2012	959 731.00	20.88	79.12
2013	786 849.00	20.79	79.21
2014	800 749.00	19.02	80.98
2015	835 124.60	19.37	80.63

Source: Ministry of Agriculture 2017, processed

Table 2: The availability of milk in Indonesia in 2012-2015

Year	Availability of mil (Kg/Kap/Tahun)			Presentase pada Total (%)	
	Domestic milk	Imported milk	Indonesia	Domestic milk	Imported milk
2012	3.03	11.48	14.51	20.88	79.12
2013	2.67	10.17	12.84	20.79	79.21
2014	2.68	11.41	14.09	19.02	80.98
2015	2.76	11.49	14.25	19.37	80.63

Source: Bureau of Central Statistics 2017

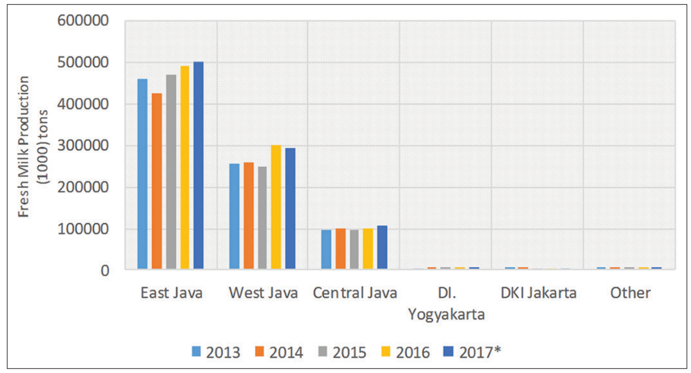
and imported milk to the overall availability of milk in Indonesia in 2012-2015.

Based on these condition, it is imperative to further analyze the response of the milk domestic prices. This study focuses to examine the current condition of fresh milk producer prices in three top producing regions in Indonesia, namely East Java, West Java, and Central Java. On average, East Java contributed 54.25% to national production, whilst the production share of West Java and Central Java was 31.97% and 11.71%, respectively (Figure 1). According to data from the Directorate General of Animal Husbandry and Health, fresh milk production in the three provinces of fresh milk producers in Indonesia increased from 2013 to 2017. However, the increase in domestic fresh milk has not been able to fulfill the national demand. Low domestic fresh milk production is influenced by several factors, including low productivity and quality of fresh milk. Moreover, the price of fresh milk at the producer level set by the Milk Processing Industry is still low, decreasing the incentives for the producers to produce fresh milk.

Aside from economic growth and changing lifestyles of Indonesian people, the amount of milk consumption is strongly influenced by the population. Data from the Ministry of Agriculture shows that in 2017 the average milk consumption of the Indonesian population is 11.6 L/cap/year. These three milk producing regions also have characteristics as highly densed population regions, meaning that the regions also have signficant demand potentials. Figure 2 shows that population growth in the three provinces continued to increase from 2014 to 2017. According to Figure 2, West Java is the province with the largest population in Indonesia, followed by East Java, and Central Java.

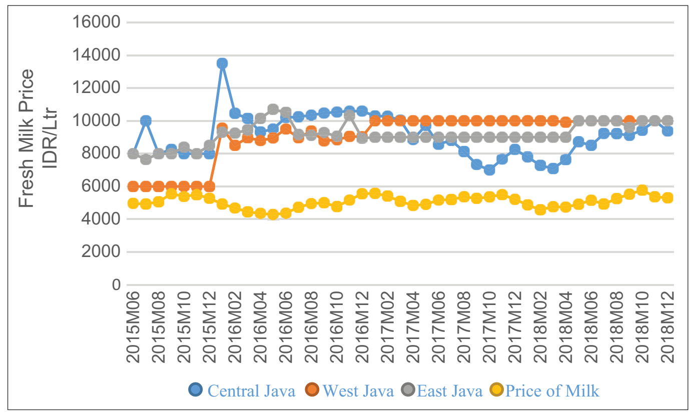
Ideal use of feed ingredients supports the needs of the cow by delivering nutrients post-ruminally. These additives more directly enable the cow to either support high milk production or to support her health. Profitability in dairy farming is dictated in large measure by managing feed costs and the efficiency by which

Figure 1: Indonesian domestic fresh milk production in 2013-2017



Source: Directorate General of Animal Husbandry and Animal Health 2017

Figure 2: The development of fresh milk prices in three regions of Indonesian fresh milk producers and world milk prices, 2015-2018



Source: Directorate General of Animal Husbandry and Animal Health 2017

feed is translated into milk production. Feed and other commodity prices can be very volatile, leading farmers to ask where prices are going and how they can cut feed costs. Changes in temperature and rainfall are likely to have an impact on global agriculture, affecting food availability (Porter et al., 2014).

Climate change poses a risk to the dairy supply chain as it will affect both average temperatures and precipitation and bring an increased incidence of extreme weather events. In addition, climate change may lead to more occurrences of animal diseases and increased thermal stress on cattle, affecting dairy production (Stem et al., 1988; Klinedinst et al., 1993). The ability and speed of adaptation of living things can be influenced by rapid and perceptible change in climate (Amuka et al., 2018).

Based on the discussion, this study aims to analyze the volatility in commodity prices of fresh milk which focuses on the three provinces of Indonesian fresh milk producers, as well as the factors that influence them. Several studies related to the price volatility of a commodity have been carried out (Nugraheni, 2014; Kornher and Kalkuhl, 2013; Rajeshwaran et al., 2014; Dong et al., 2011; Hardjanto, 2014); (Bozic and Novakovic, 2014), but few studies have focused on fresh milk. In specific, this study aims to analyze the impact of climate change on the volatility of fresh milk prices.

Figure 2 shows the difference in price movements in the provinces of East Java, West Java and Central Java. The price of fresh milk in East Java fluctuated from June 2015 to the end of 2016, after that the price was stable at Rp. 9 000/L and the price increased again in May 2018 to Rp. 10,000/L. In contrast to the price of fresh milk in West Java, prices were stable in June 2015 to the end of 2015, after this condition there were fluctuations throughout 2016 and prices stabilized in January 2017 to December 2018 at prices of Rp10,000/L. The most significant difference occurred in the development of the price of fresh milk in Central Java. Fluctuations occurred from June 2016 to December 2018.

2. LITERATURE REVIEW

Volatility is a measure used to discuss the variability of prices or quantities, which economists generally focus on standard deviations (Gilbert and Morgan, 2010). Analysis of price volatility is not only relevant in the financial market or stock market but also in other commodity markets (Sumaryanto, 2009). According to FAO ([FAO] World Food and Agiculture Organization, 2011), volatility in food prices is a variation of prices that fluctuate and cannot be anticipated, thus increasing the risk to governments, producers, and consumers, especially when making decisions.

Volatility is divided into two, namely (1) historical volatility, namely volatility that describes the period which refers to past price movements, (2) implicit volatility, namely estimation of volatility carried out for the coming period, in contrast to historical volatility (Tothova, 2011). Based on the cause, volatility is divided into two types, namely (1) Transitory volatility is temporary volatility caused by uncertainty in the flow of orders, such as market panic and expectations, (2) Fundamental volatility is volatility caused by fundamental factors such as crop failure.

The research conducted by Dong et al. (2011). The results showed that the pattern of milk volatility gradually decreased with the announcement of the USDA price. Milk price volatility in addition to being influenced by market demand and supply conditions in the milk market, as well as changes in US exchange rates, it turns out that corn prices have a positive and statistically significant impact on milk price volatility.

Hardjanto (Hardjanto, 2014) conducted a study uses monthly time series data from January 1985 to December 2011. The research models used are autoregressive conditional heteroscedasticity (ARCH)/generalized autoregressive conditional heteroscedasticity (GARCH) and vector error correction model (VECM). The results showed that the prices of the three food commodities were volatile. Price volatility in corn commodities is influenced by real exchange rates, real interest rates, domestic corn production, and world corn prices. Price volatility in rice commodities is influenced by real exchange rates, real interest rates, world oil prices, and domestic rice production. While the factors that influence the volatility of soybean prices are the real exchange rate, real interest rates, world oil prices, domestic soybean production, world soybean prices, and rainfall.

Research on the main food price volatility was carried out by Nugraheni (Nugraheni, 2014). This study uses monthly time series data from 2002 to 2011. To see the impact of volatility using the ARCH-GARCH method, while to analyze the impact of shocks from factors that influence using the VAR/VECM method. The results showed that Indonesia's main food commodities were still volatile in price which would later complicate food self-sufficiency. Then, the analysis of influencing factors is seen in terms of the demand and supply of these food commodities.

The research was conducted by Busnita (Busnita, 2014). This study uses time-series data, to see volatility using the ARCH-GARCH method, while to see cointegration between factors that influence volatility using the VECM method. The results showed that world rice prices showed an increasing trend in early 2008 until mid-2009, after which they returned to normal with a new price balance until 2013. While in the VECM analysis estimates are made on the long and short term.

In the last few decades, there has been an increase in floods and droughts in several parts of the world (IRRI 2006). Most economic activities depend on natural resources, climate change has become an important factor that has an impact on productivity (Busnita, 2016). Over the past three decades, there have been changes in precipitation, floods and drought cycles caused by El Nino Southern Oscillation (Naylor et al., 2007; Boer, 2010). Previous research conducted by the International Food Policy Research Institute (2012) entitled "Climate change: Impact on agriculture and costs of adaptation." The results of this study indicate that there is an anticipated cost of climate change where there is an increase in wheat prices by 90% in 2050, 12% of rice, and 35% in corn.

3. METHODOLOGY

The analysis used in this study is descriptive analysis and quantitative analysis. Quantitative analysis is used to estimate the volatility of fresh milk prices and factors that affect volatility.

3.1. Test Stationarity

Test of stationary data is performed using the Augmented Dickey-Fuller (ADF) test. Stationarity test is carried out aiming to find out the time series data is not influenced by time.

3.2. Volatility Analysis of Fresh Milk Prices

ARCH stands for heteroscedasticity autoregressive conditional. This model was developed primarily to answer the problem of volatility in economic and business data, especially in the financial sector. This volatility is reflected in error variances that do not meet the homoscedasticity assumption (the variance of a constant error over time). The ARCH model was first introduced by Engle in 1982 which analyzed the existence of various residual problems in time series data.

The ARCH model has evolved with the generalization of the model into GARCH introduced by Bollerslev (Bollerslev, 1986). GARCH is a generalized autoregressive conditional heteroscedasticity. The GARCH model states that the residual range does not only depend on the previous period's residuals but also depends on the variance or residual range of the previous period. The general form of the GARCH model (r, m):

$$ht = K + \delta_1 h_{t-1} + \delta_2 h_{t-2} + ... + \delta_r h_{t-r} + \alpha_1 \varepsilon^2_{t-1} + \alpha 2 \varepsilon^2_{t-2} + ... + \alpha_m \varepsilon^2_{t-m} \quad (1)$$

Information:

ht = Fresh milk price volatility (June 2015-December 2018)

K = Constant variance

ε^2_{tm} = ARCH term or volatility in the previous period

$\alpha_1, \alpha_2 ..., \alpha_m$ = Estimated order coefficient m

$\delta_1, \delta_2 ..., \delta_m$ = The estimated order r coefficient

h_{t-r} = GARCH or variety in the previous period

3.3. Identification Phase

In the ARCH-GARCH model, identification is first done to find out whether the analyzed data contains heteroscedasticity or not. Testing the existence of ARCH effects by observing the autocorrelation coefficient function (ACF) and partial ACF (PACF) values. The existence of the ARCH effect is indicated by the autocorrelation coefficient of data that is significantly squared in the first 15 lags (Firdaus, 2011).

3.4. Estimation Phase

At this stage, a simulation of several models is carried out using the average model that has been obtained. Then proceed with estimating the model parameters. At this stage, the best model selection is carried out by considering the significance of the estimation parameters using the goodness of fit because it uses the Maximum Likelihood method. The goodness of fit is seen based on the Log-Likelihood value and the smallest Akaike Information Criterion (AIC) and Schwartz Criterion (SC) criteria.

3.5. Evaluation Phase

Evaluation is carried out by observing several indicators, namely whether the error has been normally distributed; randomization of errors seen from the autocorrelation and squared error functions and testing of ARCH-GARCH effects from errors. At this stage, the Jarque Bera (JB) normality test is performed to check the normal standard residuals of the model.

3.6. VECM

The VECM is used to analyze the factors that influence the volatility of fresh milk prices in West Java. The first step is to test the data stationarity, as in the previous method. The next step is deciding optimum lag autocorrelation is useful to eliminate problems in a system. The optimum lag length will be searched using available information criteria, including the AIC and Schwarz Information Criterion criteria. The optimum lag is determined by the lag that has the smallest AIC or SC criteria. If the information criterion only refers to a lapse candidate, then the candidate hose is optimal. After testing the optimum lag, the next step is to test the stability of the VAR system on the lag. The VAR estimation is stable if it has a modulus smaller than one and is located within its unit circle.

Cointegration tests are performed to determine whether the variables that are not stationary are cointegrated or not. Cointegration is a long-term relationship between variables that although individuals are not stationary, linear combinations between these variables can be stationary (Thomas, 1997). Cointegration relationships in a system of equations imply that in the system there is an error correction model that describes the existence of short-term dynamics consistently with long-term relationships, representing long-term equilibrium relationships (Verbeek, 2008). If the cointegration test results have a trace statistic value greater than the critical value, there is cointegration in the equation

The VECM model specifications that will be used in this study are in the form of a matrix as follows:

$$DY_{t-1} = \eta + P\, Y_{t-1} + \text{å}_{i=1}^{k-1} GY_{t-1} + e_t \quad (2)$$

Information:

μ_t = Vector regression coefficient

Y_t =Variable climate change and feed cost

ε_t = Error term

4. RESULTS AND DISCUSSION

The method used to analyze the volatility of the price of fresh milk is the ARIMA method by determining the best model, then analyzed by the ARCH-GARCH method by determining the best model. The initial stage is to do stationary test data, can use the unit root test developed by Dickey-Fuller. The unit root test commonly used is ADF with a null hypothesis that indicates the existence of unit-roots. Data stationarity test results are ADF t-statistic values of all variables smaller than the data critical value at the level of 5%. These results indicated that the data processed in East Java has been stationary in the first difference and does not contain unit roots, while for data processed in West Java and Central Java it has been stationary at the level and does not contain unit-roots. It should be noted that data that is said to be stationary is flat, does not contain trend components, with constant diversity, and there are no periodic fluctuations (Burhani, 2013).

The next step is to determine the ARMA/ARIMA tentative model by looking at the pattern of the Correlogram ACF and the PACF. Then determine the best ARMA/ ARIMA model by looking at the criteria in AIC and the smallest SC, which can be seen in Table 3.

The next step is to test the ARCH effect. The purpose of the ARCH effect test is to determine whether there is a heteroscedasticity problem in the model. If there is an ARCH effect or heteroscedasticityon the estimated model, then the model can be further analyzed using the ARCH-GARCH method. The ARCH affect test results show that the price of fresh milk in West Java is the only variable which has ARCH effect. Hence, the model can be continued with the analysis using the ARCH-GARCH method. The selection of the best ARCH-GARCH model is done by considering the smallest AIC and SC values,

Table 3: The best ARMA/ARIMA models

Price of fresh milk	The best ARMA/ARIMA model
East Java	ARIMA (1,1,0)
West Java	ARMA (0,0,1)
Central Java	ARMA (1,0,0)

the largest Log-Likelihood value, all significant coefficients in the variance equation, and having a positive value of all the various equation coefficients.

Then the error normality test was performed on the best GARCH model. The results of the normality test show a probability higher than the critical level of 1%, 5%, or 10% so that the data is normally distributed. Then, the evaluation of the GARCH model is done by testing the ARCH effect. From the results of the ARCH LM test, the price of fresh milk in West Java has a greater probability than the 5% critical level. This indicates that the variable price of fresh milk in West Java Java has been free from the effects of heteroscedasticity. The ARCH-GARCH model that has been obtained has been declared good after the testing (Asmara, 2011).

The analysis shows that the best ARCH-GARCH model for estimating the volatility of the price of fresh milk in Java is the ARCH (1.0) model. Based on the model, information is obtained about the pattern of volatility in the price of fresh milk in West Java in the period June 2015 to December 2018. The equation of West Java fresh milk prices volatility obtained is as the following:

$$h_t = 0.0078 + 0.1575\varepsilon^2_{t-1}$$

The model provides information that the pattern of fresh milk price movements in West Java is influenced by the volatility of the previous period. This model can be interpreted if at the price of a commodity today there is a relatively large residual value, the price level of the commodity tomorrow will tend to be large (Burhani, 2013). The high and low volatility of the price of fresh milk is indicated by the value of the ARCH coefficient. The ARCH coefficient value of the previous period in the model of 0.1575 shows that the value is less than one and is relatively small, indicating that the volatility is low.

4.1. VAR/VECM Pre-estimation Test

The first step taken in the VAR/VECM pre-estimation test is the stationary test data using the ADF test. If the test results show a probability value less than the real level used or the absolute value of t-ADF is smaller than the absolute value of McKinnon Critical Value, then the data has been stationary and does not contain the root of the unit.

The next step is to determine the optimum lag based on the criteria of the SC. The optimum lag test results show the optimum lag in lag 2. Then the stability of the VAR model is done to ensure the selected lag is stable. The results of this test show value the AR modulus characteristic of the polynomial has a value of no more than one. These results indicate that the VAR model has been stable so that the Impulse Response Function and Forecast Error Decomposition (FEVD) analysis is valid. Then the next step is to do the cointegration test.

4.2. Analysis of Volatility Response of West Java Fresh Milk Prices on Climate Change and Feed Prices

Impulse Response Function (IRF) analysis is used to see the response of West Java's fresh milk prices to climate change shocks and feed prices. Based on Figure 3, climate shock causes fluctuating prices of West Java fresh milk. The positive response of climate change shocks on volatility in West Java's fresh milk prices. The effect of climate change causes the prices fresh milk to fluctuate from the beginning of the month. Then it will reach the level of his stable to the bull n 25th at 0.0047%. Previous research (Oktaviani et al., 2017) shows that shocks to climate change are also positively responded to by rice price volatility. Additionally, the positive response was also indicated by shocks on feed prices by the volatility of West Java's fresh milk prices. At the beginning of the period up to the second month, feed price shocks are in a negative response. Then there was a fluctuation in the response, reaching a stability level of 21 months at 0.0007%.

The results of Forecast Error Decomposition (FEVD) indicate that the largest contributing factor to the price of fresh milk in West Java is the volatility of West Java's fresh milk price of 72.12% in the 12 months, followed by climate change of 26.49%, and feed prices of 1.38%. These results indicated that climate change leads to a relatively significant fluctuations

Figure 3: Impulse Response of West Java's fresh milk prices and its determinant

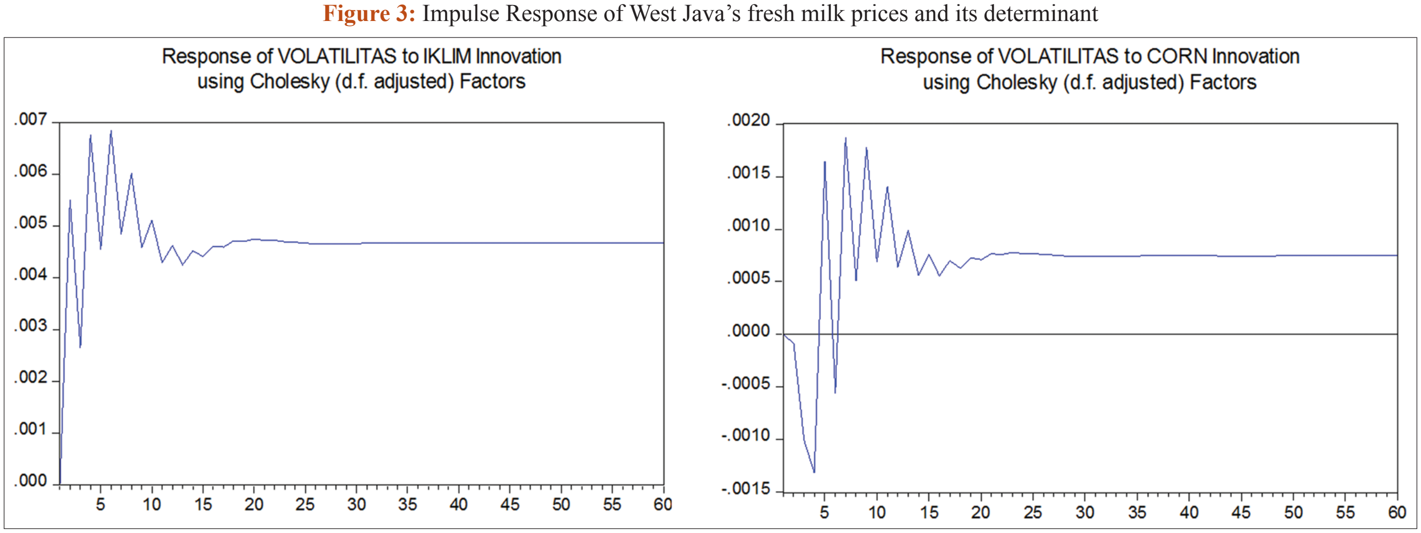


Table 4: The best ARCH model of West Java's fresh milk price volatility

Fresh milk price	The best ARCH model
West Java	ARCH (1,0)

Table 5: Data stationarity test

Variable	t-Statistic	Prob*
Volatility	−17.3842	0.0001
Climate	−4.0273	0.0032
Corn	−2.7836	0.0690
D(corn)	−7.1758	0.0000

Table 6: FEVD results

Contribution of influence factors on changes in variables		
Fresh milk price volatility	Climate change	Feed cost
72.12%	26.49%	1.38%

in the price of fresh milk in West Java. Climate change is considered as one of the factors contributed to the animal stress. Moreover, climate variablity in terms of temperature also affects the production costs structure at the dairy farm in producing fresh milk, making supply rise at a slower pace than demand. Fundamental factors of demand and supply significantly determine the price volatility in the spot market (Manasseh et al., 2016). Consequently, this led to a rise in fresh milk price.

5. CONCLUSIONS AND RECOMMENDATIONS

The results using the ARCH-GARCH method on the price of fresh milk in the three provinces of the largest dairy producers in Indonesia shows that fresh milk price volatility only occured in West Java province, and was affected by the fresh milk price volatility on the previous period. Fluctuations in the price of fresh milk in West Java occurred above and below the average value throughout 2016. On the other hand, the volatility of fresh milk price in East Java and Central Java are non evidet despite fluctuations throughout the study period. The results of VECM method showed that climate change had a positive impact on the volatility of West Java's fresh milk prices, both in the short and long run. Also, feed prices have a positive impact on the volatility of milk prices throughout West Java and will achieve a level of stability in the long run.

Based on the results of the FEVD, it can be concluded that in the short run, the highest response to all research variables is thevolatility in the price of fresh milk itself. Therefore, the government is expected to further increase in carrying the capacity to increase domestic fresh milk production. The policy that is expected to be carried out by the government is by promoting dairy farm investment. In order to maintain price stability, a fair reference priceon milk prices between the milk processing industry and local farmers is needed. The government needs to review the policy of partnerships between the milk processing industry and local farmers.

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