Greener Journal of Business and Management Studies

ISSN: 2276-7827

ICV 2012: 6.03

Submission Date: 03/06/014

Accepted: 07/07/014

Published: 08/07/014

Subject Area of Article: Agricultural and Forestry Economy Management

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Research Article

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ABSTRACT

Corn is a strategic commodity due to its high carbohydrate and protein content. In recent years, consumption for corn has increased because of the increasing population and high demand of corn from milling industries, livestock feed industry, and food consumption. The corn production fluctuates depending on weather and the presence of pests and diseases, whereas, corn consumption increases every year. Hence, the disequilibrium between production and consumption makes price fluctuate. There are many undesirable effects on the increase, such as: decrease or increase in the purchasing power of buyers and financial losses. Therefore it is important to analyze price dynamics of corn. The objectives of this research are to analyze the supply response in corn market, analyze corn price volatility in Indonesia, and choose the appropriate GARCH (Generalised Autoregressive Heteroscedastic) model to express price volatility. This research was conducted in Indonesia, because Indonesia is one of the top corn producers in the world. The methodology of this research uses GARCH model. The empirical results show that price volatility is an important risk factor.

Keywords: Supply response, price volatility, GARCH model.

INTRODUCTION

Corn is one of the strategic commodities because it contains a high measure of carbohydrate and protein. In recent years, corn consumption increased because of the increase in population, corn milling industry, livestock industry, and human needs. Production and consumption of corn in Indonesia is unbalanced. The total production of corn from 1983-2012 is 295,206,310 tons, but the total consumption of corn is 303,567,000 tons (Indonesia Central Bureau of Statistic, 2012). Gilbert and Morgan (2010), stated that productions can vary due to variations in farm areas planted in, yield variations, and weather variability. Consumptions vary because of changes in income, changes in price substitutes, and changes in tastes. The most important source of price variability is weather. This disequilibrium between production and consumption can lead to price volatility. Irawan (2007) stated that unbalance between production and consumption can make price fluctuate. In cases of excess production, price of commodity will be decreased.

The price of corn at the national level is highly dependent on the world price of corn. The demand of corn by the world is filled only by few corn-producing countries such as the United States, China, Brazil, Argentina and Mexico. According to the U.S. Grains Council in Supriyatna (2007), approximately 2.5 million tons of corn is used for animal feed and 3.9 million tons used for food and others. While ASIAN countries consume a total of 18.6 million tons of corn, as much as 13.9 million tons (75 per cent) is used for food. The need of the national corn for feed industry is growing faster than the production of corn. This is an indirect effect of the high demand. Another factor that makes importation of corn more is the corn quality, the quality of corn imported are better than locally produced corn (Supriyatna, 2007).

Price volatility has a major impact on producers and consumers. According to the Bustaman (2003), there are many undesirable effects on the increase, such as: decrease or increase in the purchasing power of buyers and financial losses. Volatility refers to variations in economic variables over time. Variations in prices become problematic when they are large and cannot be anticipated, therefore, creating a level of uncertainty which increases risks for producers, traders, consumers and governments and may lead to sub-optimal decisions (FAO, 2011).

The undesirable effect leads to the need for analysis for price volatility of corn. In addition, farmers as producers, needs selling price certainty before they decide to plant corn. This is done to reduce the risk of loss

due to lower prices. The same was experienced by consumers. Consumers in this study are the purchasing industries, because the industries generally buys corn in large numbers, so, consumers needs assurance that the price of corn can be controlled. Beside the corn price volatility, the input price also influences the willingness of farmers to plant corn. Therefore, it is important to identify the influence of different factors in corn supply response. The supply response can offer useful indications about the behavior of the corn market situations. Several variables that were used to establish the supply response model are: expected producer price, price volatility, and other production cost factors. A price equation is used to construct expectations about producer price in order to use the generated expected farmer's received price as a factor in the supply response equation. It also indicated on price volatility which factor is an important risk factor of the supply response equation.

According to Brulke (1982), Nerlove developed a supply response model, which estimates the farmer's response to price under the adaptive expectations hypothesis assuming that decision makers from the expectations are based on the past. Generalised Autoregressive Conditional Heteroscedastic (GARCH) model is one of the econometric models to analyze the time varying attributes of price transmission and price volatility in the market. The GARCH approach is used to discover the time variation of expected price and price volatility in the market.

This research was conducted in Indonesia, because Indonesia is one of the top corn producers in the world. The purposes of this research are as follows:

- a) Analyze the supply response in corn market.
- b) Analyze price volatility of corn in Indonesia.
- c) Choose the appropriate GARCH model to express price volatility.

METHODOLOGY

Conceptual Framework

The framework of this research is to analyze Supply Response and Corn Price Volatility in Indonesia. Corn is the main commodity in Indonesia where the condition of total production of corn and total consumption is unbalance; 295,206,310 tons production and 3,567,000 tons consumptions. Volatility refers to variations in economic variables over time. Variations in prices become problematic when they are large and cannot be anticipated, thereby, creating a level of uncertainty which increases risks for producers, traders, consumers and governments (FAO, 2011).

One of the main problems of price volatility is on the production side. Corn production is very dependent on natural conditions, such as: climate, pests, and diseases. Thus, there is a need for analysis of the production side (supply side). The supply of corn is influenced by factors such as: the price of inputs, and the price of corn. The fluctuations of supply quantity are measured by Supply Response Model. Nerlove developed a supply response model, which estimates the farmer's response to price under the adaptive expectations hypothesis assuming that decision makers from their expectations are based on what happened in the past. The framework of this research is to analyze the corn supply response in Indonesia which is influenced by price shock and change in some variables such as fertilizer prices and corn price. The supply response equations are estimated with the GARCH price equation. The examination of the supply response equation can provide suggestions about the behavior of the industry.

Empirical Model

The focus of this research is to model the volatility of the corn price in Indonesia by using some GARCH-type approaches. An empirical specification of the corn supply response equation model can be described as:

$$\text{LNQ}_t = b_0 + b_1 \text{LNQ}_{t-1} + b_2 \text{LNFUP}_t + b_3 \text{LNPA}_t + b_4 \text{LNPPC}_t^e + b_5 \text{LNPPR}_t + b_6 \text{LNRPC} + b_7 \text{LNh}_t + \varepsilon_t$$

Where:

- LNQ_t : The corn production in time t
- LNQ_{t-1} : The corn production in time $t - 1$
- LNFUP_t : The real fertilizer urea price in time t
- LNPA_t : The corn planted area in time t
- LNPPC_t^e : The expected real producer price of corn in time t
- LNPPR_t : The real producer price of rice in time t
- LNRPC_t : The real retailer price of corn in time t
- LNh_t : The expected variance price in time t
- ε_t : A discrete time stochastic error and Ω_{t-1} is the information set of all past states up the time $t - 1$

The specification of the expected price equation given as:

$$\text{LNPPC}_t^e = d_0 + d_1 \text{LNPPC}_{t-1} + d_2 \text{LNPPC}_{t-2} + \varepsilon_t$$

Where:

- LNPPC_t^e : The expected producer price of corn in time t
- LNPPC_{t-1} : The real producer price of corn in time $t - 1$
- LNPPC_{t-2} : The real producer price of corn in time $t - 2$
- ε_t : A discrete time stochastic error and Ω_{t-1} is the information set of all past states up the time $t - 1$

The expected variance of real producer price of corn (h_t) gotten from the variance equation described as:

$$LNh_t = b_1 + b_2 \varepsilon_{t-1}^2 + b_3 h_{t-1}$$

All the alternative GARCH models are tested for several orders such as GARCH (1.2), GARCH (2.1), and GARCH (2.2). The Akaike information criterion and Schwarz criterion are used to indicate which model fits better.

RESULT AND DISCUSSION

Data Description and Analysis

In this research the corn crop data and price data used follow a yearly time series of a period from 1983 to 2012. Planted area, production yield, and producer price index are obtained from BPS (Indonesia Central Bureau of Statistic) online database. The other data such as producer price of corn, retailer price of corn, fertilizer urea price, pesticide price, and price of rice are obtained from Ministry of Agriculture Indonesia online database. All the variables are converted into natural logarithm terms and all prices are deflated by the producer price index, such as producer price of corn, retailer price of corn, fertilizer urea price, pesticide price, and price of rice. Descriptive statistics of the research data are shown in Table 1.

Table 1: Descriptive Statistics

	Fertilizer Urea Price (rupiah)	Planted Area (000 ha)	Producer Price of Corn (rupiah)	Producer Price of Rice (rupiah)	Production (000 tons)	Retail Price Of Corn (rupiah)
Mean	313.07	3206.44	464.56	612.85	7473.81	820.38
Median	299.69	3150.50	308.00	449.72	6801.50	355.50
Maximum	570.09	3744.00	1120.00	1255.46	10886.00	2451.00
Minimum	89.76	2440.00	98.00	167.27	4330.00	169.00
Std. Dev.	189.65	319.56	397.02	391.65	1981.55	838.024
Skewness	0.06	-0.44	0.75	0.72	0.13	0.967
Kurtosis	1.25	3.38	1.82	1.83	1.74	2.29
Jarque- Bera	2.05	0.62	2.45	2.28	1.11	2.89

Table 1 shows that Fertilizer urea price, producer price of rice, production, retail price of corn and producer price of corn have a positive skewness, while pesticide price and planted area have a negative skewness. A positive skewness indicates that observed values of the variable have a long tail to the right, large value, or a positive side. A negative skewness indicates that observed values of the variable have a long tail to the left, small value, or a negative side.

The measure of kurtosis describes how data are concentrated around a single value, usually mean. Thus, kurtosis assesses how peaked or flat the data distribution is. The kurtosis of the normal distribution is 3. If the kurtosis exceeds 3, the distribution is peaked (leptokurtic) relative to the normal; if the kurtosis is less than 3, the distribution is flat (platykurtic) relative to the normal. Table 1 shows that the kurtosis value of the planted area is greater than three. It therefore means that planted areas are leptokurtic distributions which are more peaked than the normal bell curve. The kurtosis values of fertilizer urea price, pesticide price, producer price of corn, producer price of rice, production, and retail price of corn are less than three, which are indications of platykurtic distribution. This means that three variables are flatter than the normal bell curve.

The Jarque Bera test is a best fit test to determine whether sample data with the skewness and kurtosis is conforming to normal distributions. The Jarque-Bera value of Fertilizer urea price is 2.05, planted area is 0.62, producer price of corn is 2.45, producer price of rice is 2.28, production is 1.11, and retail price of corn is 2.89. The result shows that all the variables are normally distributed.

Unit Root Test

This research uses two kinds of unit root tests to examine the unit root test non-stationary state in corn data series. Stationary series can be defined as one with a constant mean, constant variance, and constant auto-co-variance for each given lag. The non-stationary data can lead to spurious regression. Spurious regression means when one of those variables is regressed on the other, the t-ratio on the slope coefficient would not be expected to be significantly different from zero, and the value of R^2 would be expected to be very low. This seems that the variables are not related to one another. However, if two variables are regressed and have a high R^2 , even the two variables are totally unrelated (Brooks, 2002).

Unit root tests on the data were evaluated. Table 2 presents the results of the Augmented Dickey Fuller (ADF) test and the Phillips-Perron (PP) test with intercept and trend. The various unit root test indicates that

the planted area (PA), fertilizer urea price (FUP), producer price of rice (PPR), producer price of corn (PPC), and retail price of corn (RPC) remains non-stationary in level, while in the first differences are stationary.

Corn Supply and Price Volatility

The purpose of the ARCH, GARCH, and EGARCH tests of supply response and expected price equation is to identify the effects of positive and negative changes in price on corn supply in Indonesia. The expected price and variance equations are estimated first before executing the supply response equations. As a result, the expected real producer price of corn (PPC_t^e) and expected variance of real producer price of corn (ht) can be included in supply response equation as one of independent variables. The results of GARCH-typed estimation to the expected price equation are shown in Table 3.

ARCH (1) model

Table 3 presents analytically the results of the supply response and price equation corresponding to GARCH type, first is ARCH (1) model. Residual diagnostic test is performed to check the explanatory power of the price and supply model. Jarque Bera statistics were performed to test normality in price equation. It is obvious that residuals are normally distributed in ARCH (1) model. This model shows some significant variables in both expected price equation and supply response equation. The expected price equation from this model is:

$$LNPPC_t^e = 5.779 + 0.691 LNPPC_{t-1} + 0.397 LNPPC_{t-2} + \varepsilon_t$$

This equation means that the increasing of 1 rupiah $LNPPC_{t-1}$ will increase $LNPPC_t^e$ 0.691 rupiah and the increasing of 1 rupiah $LNPPC_{t-2}$ will increase $LNPPC_t^e$ 0.397 rupiah. The value of R^2 for ARCH (1) is 0.92, it means that 92% pre-period of real producer prices of corn have significant influence on the expected real producer price of corn. The significance of variables performance is that variance variables has an influence to the dependent variables. The result indicates that variance variables b_0 and b_1 are significant in 5%. The size of b_0 and b_1 parameters in the ARCH (1) model determines dynamics of price volatility. The value of b_0 is 333.126 and the value of b_1 is smaller, that is 2.463. From the result, it shows that b_0 has a larger value, this indicates that volatility is persistent.

The Schwarz information criterion is used to rank the appropriate model to use. The SIC values show that ARCH (1) model reached 12.799. In order to test for autocorrelation, it is necessary to investigate whether any relationship exists between the current value and any of its previous value. Durbin Watson value shows that relationship. From the Table 3, it shows that the Durbin Watson value from ARCH (1) model is 1.331 (dl value is 1.070 and du value is 1.339), it means that there is no autocorrelation in the residuals. The supply response equation from this model is:

$$LNQ_t = -2.024 + 0.394 LNQ_{t-1} - 0.049 LNFUP_t + 1.257 LNPA_t - 0.053 LNPPR_t + 0.045 LNRPC + 7.60 LNPPC_t^e - 9.61 LNht_t + \varepsilon_t$$

The value of R^2 for ARCH (1) is 0.98, it means that independent variables have strongly explained 98% variance of the dependent variable. Productivity $_{t-1}$, planted area, and expected producer price of corn are significant at 5%. It shows that those independent variables are strongly influenced by the corn supply response. While fertilizer price, producer price of rice, retailer price of corn and expected variance of corn producer price are insignificant. It shows that those variables are less influenced by the corn supply.

The Schwarz information criterion is used to rank the appropriate model to use. The SIC values show that ARCH (1) model reached 12.799. In order to test for autocorrelation, it is necessary to investigate whether any relationships exist between the current value and any of its previous values. From the Table 3, it shows that the Durbin Watson value from ARCH (1) model are 1.310, it means that there is no autocorrelation in the residuals.

GARCH (1.1) model

The GARCH (1.1) model shows some significant variables in both expected price equation and supply response equation. The expected price equation from this model is:

$$LNPPC_t^e = -0.137 + 0.589 LNPPC_{t-1} + 0.535 LNPPC_{t-2} + \varepsilon_t$$

This equation means that the increasing of 1 rupiah $LNPPC_{t-1}$ will increase $LNPPC_t^e$ 0.589 rupiah and the increasing of 1 rupiah $LNPPC_{t-2}$ will increase $LNPPC_t^e$ 0.535 rupiah. The value of R^2 for GARCH (1.1) is 0.91, it means that 91% pre-period of real producer prices of corn are significantly influenced by the expected real producer price of corn. The significance of variables performance is that variance variable has an influence

compared on the dependent variable. The result indicates that variance variable b_0 is significant in 5%, while b_1 is insignificant at 5%. The size of b_0 and b_1 parameters in the GARCH (1.1) model determines the dynamics of price volatility. The value of b_0 is 84.681 and the value of b_1 is smaller, that is 1.191. From the result, it shows that b_0 has a larger value, this indicates that volatility is persistent.

The Schwarz information criterion is used to rank the appropriate model to use. The SIC values show that GARCH (1.1) model reached 12.864. In order to test for autocorrelation, it is necessary to investigate whether any relationships exists between the current value and any of its previous values. Durbin Watson value shows that relationship. From the Table 3, it shows that the Durbin Watson value from GARCH (1.1) model is 1.182 (dl value is 1.070 and du value is 1.339), it means that there is no autocorrelation in the residuals. The supply response equation from this model is:

$$LNQ_t = -1.987 + 0.391LNQ_{t-1} - 0.056LNFP_t + 1.254LNPA_t - 0.059LNPPR_t + 0.047LNRPC + 7.58LNPPC_t^e - 1.56LNh_t + \varepsilon_t$$

The value of R^2 for GARCH (1.1) is 0.98, it means that independent variables have strongly explained 98% variance of the dependent variable. Productivity $t-1$, planted area, and expected producer price of corn are significant at 5%. It shows that those independent variables are strongly influenced by the corn supply response. While fertilizer price, producer price of rice, retailer price of corn and the expected variance of corn producer price are insignificant, it shows that those variables are less influenced by the corn supply.

The Schwarz information criterion is used to rank the appropriate model to use. A SIC values shows that GARCH (1.1) model reached 12.864. In order to test for autocorrelation, it is necessary to investigate whether any relationship exists between the current value and any of its previous value. From the Table 3, it shows that the Durbin Watson value from GARCH (1.1) model is 1.318, it means that no autocorrelation in the residuals.

EGARCH (1.0) model

The EGARCH (1.0) model shows some significant variables in both expected price equation and supply response equation. The expected price equation from this model is:

$$LNPPC_t^e = 9.500 + 0.687LNPPC_{t-1} + 0.383LNPPC_{t-2} + \varepsilon_t$$

This equation means that the increasing of 1 rupiah $LNPPC_{t-1}$ will increase $LNPPC_t^e$ 0.687 rupiah and the increasing of 1 rupiah $LNPPC_{t-2}$ will increase $LNPPC_t^e$ 0.383 rupiah. The value of R^2 for EGARCH (1.0) is 0.92, it means that 92% pre - period of real producer prices of corn are significantly influenced by the expected real producer price of corn. The significance of variables performance is that variance variable has an influence on the dependent variable. The result indicates that variance variable b_0 and b_1 are significant in 5%. The size of b_0 and b_1 parameters in the EGARCH (1.0) model determines dynamics of price volatility. The value of b_0 is 7.265 and the value of b_1 is smaller, that is 2.155. From the result, it shows that b_0 has a larger value, which indicates that volatility is persistent.

The Schwarz information criterion is used to rank the appropriate model to use. The SIC values show that EGARCH (1.0) model reached 12.576. In order to test for autocorrelation, it is necessary to investigate whether any relationship exists between the current value and any of its previous value. Durbin Watson value shows that relationship. From the Table 3, shows that the Durbin Watson value from EGARCH (1.0) model are 1.319 (dl value is 1.070 and du value is 1.339), it means that there is no autocorrelation in the residuals. The supply response equation from this model is:

$$LNQ_t = -1.929 + 0.384LNQ_{t-1} - 0.031LNFP_t + 1.240LNPA_t - 0.051LNPPR_t + 0.028LNRPC + 8.17LNPPC_t^e - 1.68LNh_t + \varepsilon_t$$

The value of R^2 for EGARCH (1.0) is 0.98, it means that independent variables have strongly explained 98% variance of the dependent variable. Productivity $t-1$, planted area, and expected producer price of corn are significant at 5%. It shows that those independent variables are strongly influence by the corn supply response. While fertilizer price, producer price of rice, retailer price of corn, and expected variance of corn producer price are insignificant. It shows that those variables are less influence by the corn supply.

The Schwarz information criterion is used to rank the appropriate model to use. The SIC values shows that EGARCH (1.0) model reach 12.576. In order to test for autocorrelation, it is necessary to investigate whether any relationships exists between the current value and any of its previous value. From the Table 3, shows that the Durbin Watson value from EGARCH (1.0) model are 1.215, it means that there is no autocorrelation in the residuals.

Table 2: Results of Unit Root Test

Variable	Augmented Dicky Fuller (with intercept)		Augmented Dicky Fuller (with intercept and trend)		Philip Peron (with Intercept)		Philip Peron (with intercept and trend)	
Original Data								
Planted Area	-0.6388	[0.8462]	-5.0469	[0.0017]**	-1.8589	[0.3460]	-5.1122	[0.0015]**
Production	0.5689	[0.9862]	-1.8505	[0.6537]	2.8172	[1.0000]	-1.6545	[0.7453]
Real Fertilizer Urea Price	-1.6626	[0.4389]	-2.1744	[0.4846]	-1.7867	[0.3793]	-1.8352	[0.6613]
Real Producer Price of Rice	-1.6617	[0.4370]	-0.5334	[0.9741]	-2.8025	[0.0703]*	-2.7370	[0.2303]
Real Producer Price of Corn	-1.4354	[0.5506]	-2.7361	[0.2306]	-2.4229	[0.1445]	-2.6394	[0.2670]
Real Retail Price of Corn	-1.4651	[0.5366]	-2.4660	[0.3410]	-1.3326	[0.6006]	-2.4660	[0.3410]
First Difference								
Planted Area	-11.0049	[0.0000]***	-10.9236	[0.0000]***	-12.9359	[0.0000]***	-13.6790	[0.0000]***
Production	-6.9260	[0.0000]***	-7.3782	[0.0000]***	-6.9543	[0.0000]***	-15.0590	[0.0000]***
Real Fertilizer Urea Price	-4.5929	[0.0011]**	-4.5272	[0.0063]**	-4.5828	[0.0011]**	-4.4983	[0.0067]**
Real Producer Price of Rice	-5.3640	[0.0002]***	-3.4526	[0.0700]*	-7.6698	[0.0000]***	-9.6004	[0.0000]***
Real Producer Price of Corn	-8.9518	[0.0000]***	-9.0241	[0.0000]***	-9.1950	[0.0000]***	-9.3858	[0.0000]***
Real Retail Price of Corn	-6.0357	[0.0000]***	-5.9181	[0.0002]***	-6.3836	[0.0000]***	-6.2429	[0.0001]***
Logarithm								
Log Planted Area	-0.7640	[0.8138]	-5.6438	[0.0004]***	-2.2399	[0.1973]	-5.6515	[0.0004]***
Log Production	0.24671	[0.9708]	-4.6101	[0.0050]**	0.5011	[0.9838]	-4.6101	[0.0050]**
Log Real Fertilizer Urea Price	-1.8237	[0.3620]	-2.0102	[0.5716]	-1.8735	[0.3394]	-2.0553	[0.5478]
Log Real Producer Price of Rice	-2.9717	[0.0496]**	-3.2527	[0.0943]*	-2.8658	[0.0618]*	-2.7861	[0.2131]
Log Real Producer Price of Corn	-1.3759	[0.5794]	-2.5516	[0.3031]	-2.0589	[0.2617]	-2.3588	[0.3917]
Log Real Retail Price of Corn	-1.5504	[0.4944]	-2.6537	[0.2614]	-1.3507	[0.5920]	-2.5975	[0.2839]
First Difference Logarithm								
Log Planted Area	-11.7985	[0.0000]***	-11.6766	[0.0000]***	-14.3318	[0.0000]***	-14.9343	[0.0000]***
Log Production	-10.0997	[0.0000]***	-10.0320	[0.0000]***	-15.9204	[0.0000]***	-24.7789	[0.0000]***
Log Real Fertilizer Urea Price	-5.3422	[0.0002]***	-5.2495	[0.0011]**	-5.3423	[0.0002]***	-5.2494	[0.0011]**
Log Real Producer Price of Rice	-5.4732	[0.0002]***	-3.5338	[0.0603]*	-7.8501	[0.0000]***	-10.3450	[0.0000]***
Log Real Producer Price of Corn	-8.4297	[0.0000]***	-8.5294	[0.0000]***	-8.4297	[0.0000]***	-9.3143	[0.0000]***
Log Real Retail Price of Corn	-7.0914	[0.0000]***	-6.9535	[0.0000]***	-7.2322	[0.0000]***	-7.2144	[0.0000]***

Note: Figures in square brackets [] are the significance level of residual test statistics. *t statistics significant level at 10%; **t statistic significant level at 5%; ***t statistic significant level at 1%

EGARCH (1.1) model

The EGARCH (1.1) model shows some significant variables in both expected price equation and supply response equation. The expected price equation from this model is:

$$\text{LNPPC}_t^e = 18.789 + 0.868 \text{LNPPC}_{t-1} + 0.197 \text{LNPPC}_{t-2} + \varepsilon_t$$

This equation means that the increasing of 1 rupiah LNPPC_{t-1} will increase LNPPC_t^e 0.868 rupiah and the increasing of 1 rupiah LNPPC_{t-2} will increase LNPPC_t^e 0.197 rupiah. The value of R^2 for EGARCH (1.1) is 0.93, it means that 93% pre - period of real producer prices of corn significantly influence the expected real producer price of corn. The significance of variables performance is that variance variable has an influence on the dependent variable. The result indicates that variance variable b_0 and b_1 are significant in 5%. The size of b_0 and b_1 parameters in the EGARCH (1.1) model determines dynamics of price volatility. The value of b_0 is 10.126 and the value of b_1 is smaller, that is 1.909. From the result, it shows that b_0 has a larger value, which indicates that volatility is persistent.

The Schwarz information criterion is used to rank the appropriate model to use. The SIC values show that EGARCH (1.1) model reached 12.671. In order to test for autocorrelation, it is necessary to investigate whether any relationship exists between the current value and any of its previous value. Durbin Watson value shows that relationship. From the Table 3, it shows that the Durbin Watson value from EGARCH (1.1) model are 1.662 (dl value is 1.070 and du value is 1.339), it means that no autocorrelation in the residuals. The supply response equation from this model is:

$$\text{LNQ}_t = -1.899 + 0.378 \text{LNQ}_{t-1} - 0.235 \text{LNFUP}_t + 1.234 \text{LNPA}_t - 0.043 \text{LNPPR}_t + 0.022 \text{LNRPC} + 8.55 \text{LNPPC}_t^e + 4.42 \text{LNh}_t + \varepsilon_t$$

The value of R^2 for EGARCH (1.0) is 0.98, it means that independent variables have strongly explained 98% variance of the dependent variable. Productivity $t-1$, planted area and expected producer price of corn are significant at 5%. It shows that those independent variables are strongly influenced by the corn supply response. While fertilizer price, producer price of rice, retailer price of corn and expected variance of corn producer price are insignificant. It shows that those variables are less influenced by the corn supply.

The Schwarz information criterion is used to rank the appropriate model to use. The SIC values show that EGARCH (1.1) model reached 12.671. In order to test for autocorrelation, it is necessary to investigate whether any relationships exist between the current value and any of its previous value. Table 3 shows that the Durbin Watson value from EGARCH (1.1) model are 1.119, it means that there is no autocorrelation in the residuals.

Table 3: Results of Price Volatility and Supply Response

Variable	ARCH (1)	GARCH (1,1)	EGARCH (1,0)	EGARCH (1,1)
1. Expected Price Equation				
d0	5.779 [0.297]	-0.137 [0.988]	9.500 [0.006]**	18.789[0.006]**
LNPPC _{t-1}	0.691[0.000]***	0.589 [0.003]***	0.687 [0.000]***	0.868 [0.000]***
LNPPC _{t-2}	0.397[0.000]***	0.535 [0.011]**	0.383 [0.000]***	0.197 [0.000]**
2. Variance Equation				
b0	333.126 [0.025]**	84.681 [0.569]	7.265 [0.000]***	10.126[0.000]***
b1	2.463 [0.001]***	1.191 [0.015]**	2.155 [0.000]***	1.909 [0.002]**
b2		0.345 [0.054]*		-0.332 [0.001]**
R ²	0.92	0.91	0.92	0.93
Schwarz criterion	12.799	12.864	12.576	12.671
Durbin Watson stat	1.331	1.182	1.319	1.662
Jarque Bera	0.330	0.130	1.610	0.895
3. Supply Response Equation				
C	-2.024 [0.000]***	-1.987 [0.001]**	-1.929 [0.000]***	-1.899 [0.002]**
LNQ _{t-1}	0.394 [0.000]***	0.391 [0.000]***	0.384 [0.001]**	0.378 [0.001]**
LNFPUP	-0.049 [0.280]	-0.056 [0.253]	-0.031 [0.489]	-0.235 [0.623]
LNPA	1.257 [0.000]***	1.254 [0.000]***	1.240 [0.000]***	1.234 [0.000]***
LNPPR	-0.053 [0.272]	-0.059 [0.243]	-0.051 [0.275]	-0.043 [0.366]
LNRPC	0.045 [0.339]	0.047 [0.298]	0.028 [0.581]	0.022 [0.675]
LNPPC _t ^e	7.60 [0.014]**	7.58 [0.018]**	8.17 [0.008]**	8.55 [0.011]**
LNht	-9.61 [0.290]	-1.56 [0.232]	-1.68 [0.525]	4.42 [0.916]
R ²	0.98	0.98	0.98	0.98
Durbin Watson stat	1.310	1.318	1.215	1.119

Note: Figures in square brackets [] are the significance level of residual test statistics. *t statistics significant level at 10%;

t statistic significant level at 5%; *t statistic significant level at 1%

From all models it shows that the sign of the coefficient for the real fertilizer price and real producer price of rice are negative. It means that when those variables increase supply of corn will be decrease. High fertilizer price will make farmers decrease the quantity of fertilizers, this makes the corn supply decrease. Producer price of rice is the variable that substitutes corn. When the price of rice is higher, it will make corn supply to decrease, because, farmers tend to plant rice. In the other condition, when the price of rice decreases it will make corn supply to increase. The sign of the coefficient for the productivity $t-1$, planted area, retailer price of corn, and expected producer price of corn, and expected variance of corn producer price are positive. It means that when those variables increase, it will make supply of corn to increase too. Productivity in the past year and planted area are the important variables for corn supply. If those variables increase, it will make the corn supply to increase too while, the retailer price of corn and expected producer price of corn will influence the corn supply. Corn supply will be higher if the corn price is high; this is because, farmers want to have good income.

The Appropriate Model

This research used ARCH (1), GARCH (1.1), EGARCH (1.0) and EGARCH (1.1) to analyze the supply response and expected price equation. All of the models show several different results. To choose the appropriate model and good model, several diagnostic tests were conducted.

Residual Diagnostics / ARCH LM test

ARCH LM test carries out Lagrange multiplier tests to test whether the standardized residuals exhibit additional ARCH. If the variance equation is correctly specified, there should be no ARCH left in the standardized residuals.

Table 4: ARCH LM Test

Estimation	ARCH (1)	GARCH (1.1)	EGARCH (1.0)	EGARCH (1.1)
F statistics	0.136	0.131	2.133	0.189
Probability F Variable	0.714	0.719	0.155	0.666
Residual ²	0.688	0.702	0.098	0.520

Table 3 shows the result of Heteroscedasticity Test, from all of the model ARCH (1), GARCH (1.1), EGARCH (1.0) and EGARCH (1.1) all the variable are greater than 5%. It means that all the variables are not significant. The not significant levels, shows there is no ARCH effect left in the standardized residual.

Residual Diagnostics – Normality Test

Normality test displays descriptive statistics and a histogram of the standardized residual. The Jarque Bera statistics was used to test the null to determine whether the standardized residuals are normally distributed. If the standardized residuals are normally distributed, the Jarque Bera should not be significant. The result shows:

a) ARCH (1) model.

Jarque Bera statistics reached 1.137 with probability value of 0.566. This value is greater than 5%. It means that Jarque Bera statistics is not significant. Thus, the standardized residuals are normally distributed.

b) GARCH (1.1) model

Jarque Bera statistics reached 1.114 with probability value of 0.572. This value is greater than 5%. It means that Jarque Bera statistics is not significant. Thus, the standardized residuals are normally distributed.

c) EGARCH (1.0) model

Jarque Bera statistics reached 2.138 with probability value of 0.343. This value is greater than 5%. It means that Jarque Bera statistics is not significant. Thus, the standardized residuals are normally distributed.

d) EGARCH (1.1) model

Jarque Bera statistics reached 2.651 with probability value of 0.265. This value is greater than 5%. It means that Jarque Bera statistics is not significant. Thus, the standardized residuals are normally distributed.

All the diagnostics tests show that ARCH (1), GARCH (1.1), EGARCH (1.0) and EGARCH (1.1) model have no ARCH effect left and are normally distributed. From the entire model, we can choose EGARCH (1.1) model as the appropriate model to describe expected price equation system and supply response equation. This model is the appropriate model because it has high R^2 value both for expected price equation and supply response equation.

With the result of EGARCH (1.1) model, we can see the corn price volatility and supply response condition in Indonesia. From the results, a price equation is used to form expectations about producer price of corn as a factor in the supply response equation. Price volatility represents an important risk factor of the supply response equation. An increase of price volatility implies higher uncertainty about future prices, a result that can affect the producer's welfare. Indonesia corn market is dominated by a small number of farmers. Therefore, this price volatility that has uncertainty about future prices can make farmers inflict financial loss. Price information are needed for farmers to help farmers decide the farming activities. The price information also can help farmers to increase their income.

CONCLUSION

This research analyzed the corn price volatility and supply response in Indonesia. The expected price equation and the supply response equation was analyzed with ARCH (1), GARCH (1.1), EGARCH (1.0) and EGARCH (1.1) model. Some results from the analysis are:

1. Producer price of corn have significant influence on the expected producer price of corn and the estimation of expected price equation shows that price volatility is persistent.
2. Fertilizer price, retailer price of corn, producer price of rice and the expected variance of corn producer price have less influence on corn supply response. While, Productivity $t-1$, planted area, and expected producer price of corn have more influence on the corn supply response.
3. The appropriate model to describe the expected price equation system and supply response equation is EGARCH (1.1).

RECOMMENDATION

The empirical result shows that price volatility is a risk factor in the Indonesia corn market. Recommendation from this research is that government has to control the corn price in order to control the market supply. For the corn farmer, at the low price period, farmers can save corn stock and sell it at the high price period. So, we can minimize the financial loss for farmers. Variables that significantly influence the corn supply response are productivity $_{t-1}$, planted area, producer price of rice and expected producer price of corn. Therefore, farmers and government should be more focused on those variables. With higher productivity and planting area, farmers can get more income, besides that, if farmer knows the corn price information and rice price information (rice is a substitute commodity of corn), they can easily decide about their farming activity.

There are several kinds of GARCH extension which are commonly used. EGARCH and GARCH model already shows the good performance in this research, hopes that further research will expand the other research to test the other GARCH model. The further research can use simultaneous and 3 Stage Least Square to estimate supply response and corn price volatility, hoping that this model can improve the estimation.

COMPETING INTERESTS

Authors have no competing interest to declare.

AUTHORS' CONTRIBUTIONS

All authors contributed to this work. Riza Rahimi Bachtiar participated in drafting the article, analysis data, interpretation of data, and also designed the manuscript. Wen-I Chang, Ratya Anindita, and Muslich Mustadjab participated in revising critically for important intellectual content and gave final approval of the version to be submitted and any revised version.

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Cite this Article: Bachtiar RR, Wen-I C, Anindita R, Mustadjab M, 2014. Supply Response and Corn Price Volatility in Indonesia. Greener Journal of Business and Management Studies, 4 (3): 058-069.