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Rice Price Volatility Measurement in Indonesia Using GARCH and GARCH-X Method

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Introduction

There has been a significant development in food and other agricultural commodity prices over the past few years. Price movement seems to follow a typical pattern (Bobenrieth et al., 2012; Brümmer et al., 2013; Huchet-bourdon, 2011; Prakash, 2011) such that the price increases with accelerating pace in one year followed by a sharp drop in the following year. Although in the recent decades, volatility has generally been lower but the variability has been high, with the important exception of rice (Gilbert and Morgan, 2010). This implies higher risks for both consumers and producers. To a commodity that holds strategic value such as rice in Indonesia, unpredictable shocks in price is highly undesirable. Indonesia has more than 32 million people who were still living on less than US$2 per day.

This study aims to understand the volatility trend of rice price in Indonesia, by exploring some possible drivers and test the significant impact of those drivers to overall volatility measurement. The GARCH (Bollerslev, 1986) and GARCH-X (Apergis & Rezitis, 2010) models are used to measure the rice price volatility. Some of the drivers that we tested are the impact of national rice reserve level, harvest season, international rice price, other macroeconomic variables and their combinations. This allows conclusions to be drawn about whether certain drivers have influential predictive capacity to the conditional variance of rice prices.

Data and Methodology

We consider a series of daily rice price from January 2006 to December 2013, with total T = 2086 observations. This data was obtained from Ministry of Trade, Government of Indonesia. The data was collected through market survey that was conducted daily on major consumer markets in all provinces in Indonesia. Meanwhile, estimated stock data was obtained from USDA WASDE from the same period.

GARCH(1,1) was built by Bollerslev (1986) and is an extension of an ARCH(1) model. The model representation is as follows:

$$\sigma_t^2 = \alpha_0 + \alpha_1 a_{t-1}^2 + \beta_1 \sigma_{t-1}^2$$

GARCH-X model allows the effect of short run deviations on the conditional variance to be taken into consideration. This new feature becomes more important to improve GARCH model estimations; especially in the event of an unaccounted information from other factors can effects GARCH estimations. When these other information are not taken in to consideration, GARCH model may provide biased estimates of persistence in variance. GARCH-X model representation is as follows (Apergis & Rezitis, 2010):

$$\sigma_t^2 = \alpha_0 + \alpha_1 a_{t-1}^2 + \beta_1 \sigma_{t-1}^2 + \gamma_1 z_{t-1}^2$$

Where z_{t-1}^2 is the squared and lagged error-correction term to indicate short run deviations.

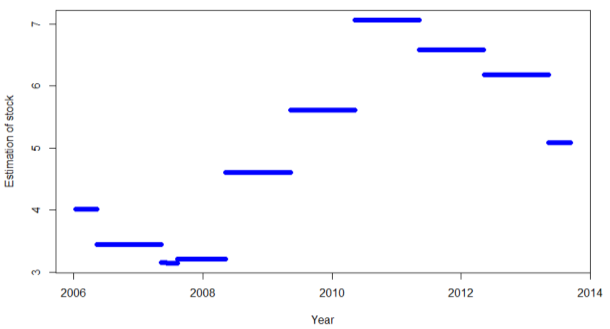
Study Design

This research is conducted to help us understanding which drivers have influential predictive capacity to the conditional variance of rice prices. The choices of certain macroeconomic variables are based on those which have significant predictive capacity on the volatility of rice prices, in this case (1) the estimations of stock level, (2) rice harvest seasonality, (3) the impact of Thailand rice as a benchmark for international rice price, and (4) other important macroeconomic variables related to new direction on food policy. Before 2009, Indonesian food policies were giving much attention on rice production. After commodity boom in 2007-2008, policies that promote food consumption diversity and local produce were enacted thru Presidential Decree No. 22/2009 (Suryana, 2007) which then become the main program for national food security program in 2010-2014 (Food Security Agency of Indonesia, 2011). Figure 1 shows the trend of stock level and Thailand rice price as mentioned above.

First, we would estimate volatility development via basic GARCH model. Then, we use GARCH-X with the introduction of external regressors as proxy to gauge macroeconomic variable of interest. These external regressors are tested both on mean model and variance model.

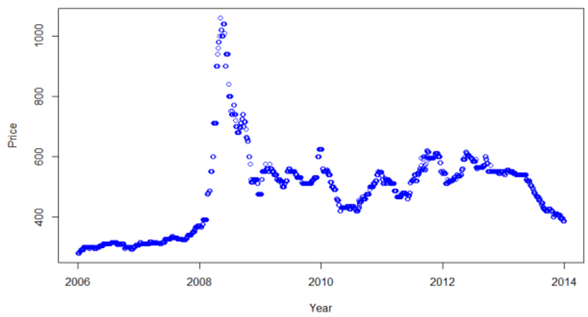
Figure 1. Different Types of External Regressors Tested

1a. Estimation of Beginning Stock Level of Government Stock 2006-2013



Source: USDA-NASS

1b. International Rice Price (Thailand Rice)



Source: Thomson Reuters Datastream

Results and Discussion

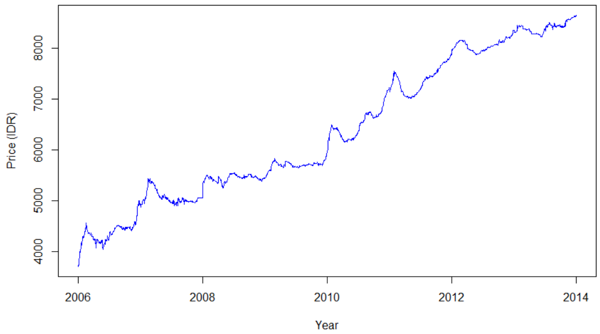
Rice Price Development 2006 – 2013

Figure 2 shows rice price developments over the past seven years. In the period between 2007 and 2008, domestic rice price in Indonesia were also experiencing strong increase like most of other agricultural commodity prices. In 2008, the average daily rice price increase in Indonesia was 0.03 percent however the price of rice could increase up to 4.72 percent in one day. This highly peculiar event happened in the middle of dry season period accompanied by rising uncertainty in production due to bad weather conditions.

Overall, there were some unusual price hikes especially in the beginning of year: 2006, 2007, 2008 and 2010. These increased volatility correlate to low rice harvest during dry season which occurred from October to January. In late 2008, agricultural productions were hampered due to bad weather especially frequent floods. From 2006 to 2008, estimation of stock level was also relatively low. Combination of both suppressed harvest and low stock has triggered higher volatility in the episodes of 2006-08 compare to 2009-13.

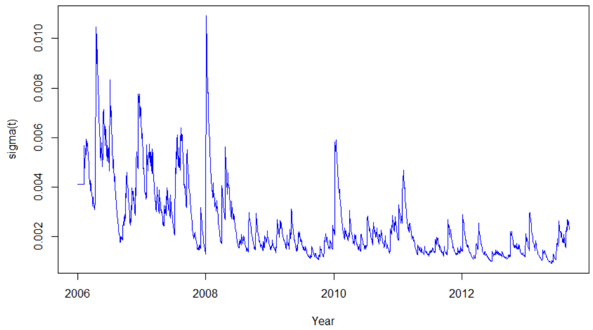
The case was different when rice price volatility increased in early 2010. Although it was also dry season period, the level of rice stock was relatively higher compared to previous year. Some possible explanations are: (1) domestic market was unrest due to psychological impact of market instability, (2) long dry season has caused postponement in rice productions and harvest, and (3) domestic importers reactions to the issue of increased international rice price (Alimoeso, 2010).

Figure 2. Domestic Rice Price in Indonesia 2006 - 2013



Source: Ministry of Trade, Government of Republic Indonesia

Figure 3. Conditional Variance of Rice Price Return



Source: own calculation

Empirical result

Insertion of external regressors in the model shows that, regardless the position, most regressors have significant impact. However, their magnitudes are relatively small.

Based on Akaike model selection criteria GARCH-X with combinations of external regressors (rice harvest season in the mean model and estimations of stock level in the variance model) is the most suitable. Other combinations of external regressors that also show good results are: estimation of stock in the mean model and dummy matrix for macroeconomic policy in the variance model; and international rice price in the mean model and estimation of stock level in the variance model. It seems like these regressors are important in some ways toward improving volatility estimations, however with GARCH-X model that we are using now, we can only test the impact one by one or as pairs but not all at once.

Figure 3 shows the conditional variance of rice price return. Based on diagnostic result, we will then use the example from GARCH-X with external regressor of rice harvest season in the mean model and estimations of stock level in the variance model to discuss more detail about rice price volatility in Indonesia. The parameter estimates of this model are presented in table 1:

Table 1: Parameter estimation of GARCH-X model with seasonality in mean and stock level in variance

Parameters	μ	ν1 (mean model)	Φ	α1	β1	ν2 (variance model)
Estimate	0.000235 (0.000063) ***	-0.000266 (0.000091) ***	0.000000 (0.000000)	0.050235 (0.003739) ***	0.900672 (0.005722) ***	0.000000 (0.000000)

Note: One, two and three asterisks indicate significance at the 10, 5 and 1 percent level respectively. The value in parentheses is Standard Errors.

The result shows that external regressors do not have significant effect on variance model. However, their impacts on mean model are significant. The impact of seasonality at mean model is significant at 1 percent level. The negative sign imposed that harvest season and price volatility has inverse relationship: during rice harvest period (high supply), we can expect rice price volatility to fall. However, the parameter estimates value is relatively small compare to α or β. Thus, even though seasonality is an important variable in effecting the phase of volatility, but its magnitude is negligible.

Conclusions and Outlook

Our study on rice price volatility shows that the volatility of rice price is driven more by its own-variance rather than external shocks. Introduction of relevant external regressors such as stock level estimations, rice harvest seasonality, international rice price or dummy vector for other macroeconomic variable to GARCH-X are found to be able to improve the overall volatility estimation. Parameters of these external regressors are statistically significant to better describe price observations in GARCH-X model. However, the impact of these external regressors is very small compared to the impacts of own-variance or external shocks.

Maintaining sufficient level of rice stock at government reserve is important to keep rice market's social-psychology stable, but it is not enough to give meaningful impact in reducing price volatility. Obviously, good price stabilization policy should be able to combine reasons for price volatility and cost of stabilization at balance proportion. The challenge is then to understand the forces behind price volatility. Then one also needs to take into account on how to better manage these drivers along with their combinations at once.

Further research on the drivers using multivariate model would lead to a more comprehensive understanding about rice price volatility behavior.

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