Rice Price Volatility of Expors Leaders in World Markets Using TGARCH Model

Kewalin Somboon[1], Chonrada Nunti[2](✉), and Varattaya Jangkrajarng[3]

[1] Faculty of Economics, Maejo University, Chiang Mai, Thailand
[2] Faculty of Economics, Chiang Mai University, Chiang Mai, Thailand
nuntichonrada@gmail.com
[3] Department of Management and Entrepreneurship, Faculty of Business Administration, Chiang Mai University, Chiang Mai, Thailand

Abstract. This paper studies the price volatilities of rice regarding the world market leaders as Thailand, India, and Vietnam provided by the time-series data of the monthly rice export prices between 1998 – 2021. The study found that the most suitable model is the TGARCH model considered by the lowest AIC criteria. The results showed that Thailand has less price volatility than other countries when compared to India and Vietnam, but the volatility between them was only slightly different. Hence, in terms of being the world leader in rice exports competition, each government needs to provide a policy of accelerating rice quality development to compete for the global market share.

Keywords: Price Volatility · Rice Price · Rice exports leaders · World markets

1 Introduction

The most necessary grain related to the global food condition is rice. Rice has become a principal food for more than half of the global citizenry. Since the global population continues increasing while food production for consumption has only increased slightly which is contrary to the needs of the world's populations who consume rice as a main course. According to the report of The International Grains Council (IGC), Global rice production has increased continuously. In 2019/20 found that global rice production amounted to 498.6 million tons which are estimated in 2020/21 that rice production will increase to 504.1 million tons. In 2019, the world's top 10 rice-producing countries belong to Mainland China followed by India, Indonesia, Bangladesh, Vietnam, Thailand, Myanmar, Philippines, Pakistan, and Cambodia, respectively.

Nevertheless, rice production in some countries is only for domestic consumption. The leading countries in rice exports are India, Thailand, and Vietnam, respectively. The fierce competition among them in the global rice trade is as follows, the competitive markets for rice exports between Thailand and Vietnam are the Philippines, Malaysia, Hong Kong, Mainland China, Singapore, Senegal, Cameroon, and Mozambique. In addition, it is also found that Thailand and India are competitors in The United States, Benin, and Yemen. Lastly, the competitive markets for rice exports between India and Vietnam are

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Saudi Arabia, Iraq, and The United Arab Emirates. Hence, the fewer volatilities in rice prices, the more advantage in rice exports over other countries.

In the study of volatility using Econometric methods starting from the concept of [1] which developed Autoregressive condition heteroskedasticity (ARCH) for conditional estimation and forecasting of the volatility (conditional variances) where the change of data has a concentration of volatile (volatility clustering or volatility pooling). Later, [2] extended the study of Engle to Generalized autoregressive conditional heteroskedasticity (GARCH). The conditional variance was based on the ARMA procedure. Nevertheless, [2] stated that there are two limitations on the GARCH model, Firstly, if a SHOCK (abnormality) appears either negative or positive, the volatility conditional will enlarge in a shockingly negative or positive way. This volatility asymmetry is conditional known as the effect of leverage, which influences exponential powers that the linear GARCH model cannot capture. Secondly, The GARCH model requires variables to be non-negative for forcing the variance of the conditional to be positive without exception.

Subsequently, one of the most popular models that provides for transforming data into marginal distribution is the GJR-GARCH model which expressed by [3]. Nevertheless, [4] expressed that the responding of the prices of financial asset might asymmetrically to both good and bad news. Hence, the TGARCH model or the threshold GARCH were developed the by [3, 5] for capture the effect of asymmetric in both good and bad news, in order to investigating a significant difference in the series volatility by computes the conditional variance equation with a multiplicative dummy variable [5].

2 Research Methodology

The process of this study after testing the unit root is to do model selection, considered by the lowest AIC criteria among the GARCH, GJR-GARCH, and TGARCH models.

2.1 The GARCH Models

Let a GARCH (p, q) process be a process (ϵ_t) when its first two conditional moments exist and satisfy, first condition is;

$$E(\varepsilon_t|\varepsilon_u, u < t) = 0, \quad t \in \mathbb{Z} \tag{1}$$

and second condition is, there exist constant ω, α_i, $i = 1, 2, 3, ..., q$ and β_j $j = 1, 2, 3, ..., p$ such that;

$$\sigma_t^2 = Var(\varepsilon_t|\varepsilon_u, u < t) = \omega + \sum_{i=1}^{q} \alpha_i \varepsilon_{t-1}^2 + \sum_{j=1}^{p} \beta_j \sigma_{t-j}^2, t \in \mathbb{Z} \tag{2}$$

Equation (2) can be written as

$$\sigma_t^2 = \omega + \alpha(B)\epsilon_t^2 + \beta(B)\sigma_t^2, t\epsilon\mathbb{Z} \tag{3}$$

When the regular backshift operator is B for $B^i\epsilon_t^2 = \epsilon_{t-i}^2 andB^i\sigma_t^2 = \sigma_{t-i}^2 foranyintegeri$, and degree q and p has α and β be their polynomials, respectively,

$$\alpha(B) = \sum_{i=1}^{q} \alpha_i B^i, \ \beta(B) = \sum_{j=1}^{p} \beta_j B^j. \quad (4)$$

After $\beta(\ddagger) = 0$, then we get

$$\sigma_t^2 = \omega + \sum_{i=1}^{q} \alpha_i \epsilon_{t-i}^2 \quad (5)$$

An ARCH(q) process, $Let \epsilon_t^2$ be the variable $V_t = \epsilon_t^2 - \sigma_t^2$. Then substituting in (2) we get,

$$\epsilon_t^2 = \omega + \sum_{i=1}^{r} (\alpha_i + \beta_i)\epsilon_{t-1}^2 + v_t - \sum_{j=1}^{p} \beta_j v_{t-j}, \ t \in \mathbb{Z} \quad (6)$$

Let the assembly $\alpha_i = 0(\beta_j = 0)$ *when* $i > q\ (j > p)$ when r = max (p, q). An ARMA model is provided the structure of linear in this equation, to allow the linear predictions computation simpler. Below further assumptions, we found that when GARCH (p, q) is (ϵ_t), , then an ARMA (r, p) process is (ϵ_t^2). Especially, the admits of square of an ARCH (q) process, representing an AR(q) when it is stationary. The ARMA representation are beneficial for the estimation of GARCH processes.

2.2 The TGARCH Model

[1] stated that "mean zero, serially uncorrelated processes with non-constant variances conditional on the past, but constant unconditional variances" was the basic concepts of the ARCH or autoregressive conditional heteroscedastic model. While [2] expressed that the conditional volatility through the GARCH or generalized ARCH model was removed by the constraint. The GARCH (p, q) process was modified by conditional variance equation of the ARCH model as follows,

$$Y_t = \beta\prime X_t + \varepsilon_t, \ \varepsilon_t|\psi_t N\left(0, \sigma_t^2\right), \quad (7)$$

$$\sigma_t^2 = \alpha_0 + \sum_{i=1}^{p} \alpha_i \varepsilon_{t-i}^2 + \sum_{j=1}^{q} \beta_j \sigma_{t-j}^2 \quad (8)$$

[4] shown that there is a positive conditional variance that guaranteed by $\beta_j \geq 0(j = 1, \ldots, q)$, $\alpha_0 > 0$, $\alpha_0 \geq 0(i = 1, \ldots, p)$. Let q be the lags of ARCH's length and the square of residuals denoted by ε_t^2. Thus, the data set at t is assumed to derived from ε_t, the disturbances' distribution which can be denoted by ψ_t.

Nevertheless, [4] expressed that the responding of the prices of financial asset might asymmetrically to positive and negative news. Hence, the TGARCH model was developed by [3, 5] for capture the effect of asymmetric in both good and bad news, in order to investigating a significant difference in the series volatility by computes the conditional variance equation with a multiplicative dummy variable [5]. The specifications for TGARCH (1, 1) and more generally TGARCH (p, q) are given by

$$\sigma_t^2 = \alpha_0 + \alpha_1\varepsilon_{t-1}^2 + \gamma_1 N_{t-1}\varepsilon_{t-1}^2 + \beta_1\sigma_{t-1}^2 \tag{9}$$

$$\sigma_t^2 = \alpha_0 + \sum_{i=1}^{p}(\alpha_i + \gamma_1 N_{t-i})\varepsilon_{t-i}^2 + \sum_{j=1}^{q}\beta_j\sigma_{t-j}^2 \tag{10}$$

Regarding Eq. (9), α_1 has affected by a positive shock, whereas $\alpha_1 + \gamma_1$ has affected by a negative shock. Thus, positive news has a less impact on volatility than negative news when $\gamma_1 > 0$ ([5]).

2.3 The GJR-GARCH Model

Regarding the literature, there are several ways to handle the asymmetric influence phenomenon, for instance, the effect of financial leverage is understood as asymmetric influence of positive and negative news on the future variance of time series. However, positive news corresponds to good returns (profits) and negative news corresponds to bad returns (losses). Thus, while modeling returns it is vital to take that into consideration.

One of the most popular models provides for transforming data into marginal distribution is the GJR-GARCH model which expressed by [3]. The GJR (p, q) model is defined in the following way: the time series $\{\varepsilon_t\}_{t\in Z}$ follows the GJR-GARCH (p, q) model when

$$\varepsilon_t = \sqrt{h_t\eta_t}, \tag{11}$$

where,

$$h_t = \alpha_0 + \sum_{i=1}^{q}\alpha_i\varepsilon_{t-i}^2 + \sum_{j=1}^{p}\beta_j h_{t-j} + \sum_{i=1}^{q}\gamma_i I_{\{\varepsilon_{i-1}<0\}}\varepsilon_{t-i}^2$$

and $\{\eta_t\}$ are arbitrary innovations with mean zero and variance 1. From (11) the the indicator function of the interval [a, b] denoted by the function $I_{[a,b]}$, this is $I_{[a,b]}(x) = 1$ while $x \in [a, b]$ and $I_{[a,b]}(x) = 0$ while $x \notin [a, b]$. Additionally, the parameters fulfill the conditions:$\alpha_0 > 0, \alpha_i \geq 0, i = 1, \ldots, q, \beta_1 \geq 0, j = 1, \ldots, p, \gamma_i = 1, \ldots, q$.

Hence, when parameters γ_i is bigger than zero then the bad returns have a stronger influence on volatility than the good returns. Thus, the sensitivity of volatility function h_t with respect to bad returns is identified by parameters γ_i.

3 Data

The descriptive statistics for the leader of rice export countries sourced by CEIC database are presented in Table 1 including India, Vietnam, and Thailand on a monthly basis which collected between 1998 to 2021, and its import are presented in Fig. 1. The procedure of this study after testing the unit root is to do model selection, considered by the lowest AIC criteria among the GARCH, TGARCH, and GJR-GARCH models.

Table 1. The descriptive statistics of price rice of exports leaders

Statistics	INDIA	THAILAND	VIETNAM
Mean	332.79	294.36	338.72
Median	356.00	276.00	350.00
Maximum	481.00	930.00	1075.00
Minimum	168.00	163.00	148.00
Std. Dev.	78.16	115.97	125.20
Skewness	−0.28	2.43	1.24
Kurtosis	2.07	10.68	7.73
Jarque-Bera	13.63	976.35	337.56
Probability	(0.001)	(0.000)	(0.000)

Source: Calculation

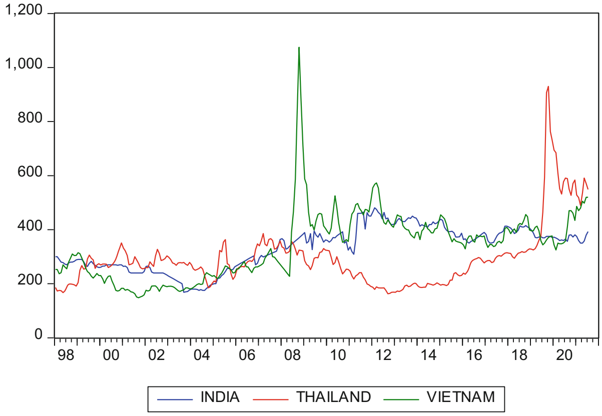

Fig. 1. The descriptive statistics of natural rubber imports in ASEAN

4 Empirical Result

4.1 Time Series Unit Root Test

In the process of checking the time series unit root test, the Augmented Dickey-Fuller (ADF) test is employed. The results provide that all the variables are stationary shown in Table 2.

4.2 Model Selection

The model using in this study were GARCH, TGARCH, and GJR-GARCH to measure the volatility are presented in Table 3. The results from the AIC values showed that the TGARCH model gave the lowest AIC value which was the most appropriate for this study.

Table 2. Time series unit root test

	Thailand	India	Vietnam
ADF statistic	−17.968***	−12.253***	−10.065***
P-value	0.0000	0.0000	0.0000

Source: Calculation

Table 3. Model Selection

Model	AIC		
	Thailand	India	Vietnam
GARCH	8.3804	7.6467	9.0057
TGARCH	**8.3026**	**7.5856**	**8.9987**
GJR-GARCH	8.3351	7.6457	8.9989

Source: Calculation

4.3 The Rice Price Volatility with TGARCH of India

Regarding the analysis of the price volatility of Indian rice export by using TGARCH model found that $\alpha + \beta = 0.991$, meaning that the prices of Indian rice export are very volatile while $\omega = 1.618$ represented the affected by information asymmetric in Indian rice export prices. Additionally, when considering the coefficient of Υ ($\Upsilon = -0.232$), found that the price volatility of Indian rice export in the previous period was inversely related to the current rice prices shown in Table 4.

Table 4. The Rice Price Volatility with TGARCH of India

		Estimate parameter	S.E.	P-value
India	**Distribution**	Normal		
	mu	300.28	13.423	0.000
	AR(1)	0.981	0.007	0.000
	MA(1)	0.119	0.053	0.024
	ω	1.618	0.424	0.000
	α	0.408	0.090	0.000
	β	0.583	0.076	0.000
	Υ	−0.232	0.117	0.048

Source: Calculation

Table 5. The Rice Price Volatility with TGARCH of Thailand

		Estimate parameter	S.E.	P-value
Thailand	**Distribution**	Normal		
	mu	191.694	11.969	0.000
	AR(1)	0.710	0.011	0.000
	MA(1)	0.330	0.064	0.000
	ω	1.036	0.346	0.000
	α	0.307	0.055	0.000
	β	0.604	0.044	0.000
	ϒ	−0.587	0.145	0.000

Source: Calculation

4.4 The Rice Price Volatility with TGARCH of Thailand

Regarding the analysis of the price volatility of Thai rice export by using TGARCH model found that $\alpha + \beta = 0.911$, meaning that the prices of Thai rice export are more volatile but less than Indian rice export prices, while $\omega = 1.036$ represented the affected by information asymmetric in Thai rice export prices. Additionally, when considering the coefficient of Υ ($\Upsilon = -0.587$), found that the price volatility of Thai rice export in the previous period was inversely related to the current rice prices shown in Table 5.

4.5 The Rice Price Volatility with TGARCH of Vietnam

The analysis of the price volatility of Vietnam rice export by using TGARCH model found that $\alpha + \beta = 0.957$ (unconditional variance), meaning that the prices of Vietnam rice export are the second most volatile when compared to Indian and Thai rice export prices, while $\omega = 2.065$ (mean variance) represented the affected by information asymmetric in Vietnam rice export prices. Additionally, when considering the coefficient of Υ showed the threshold effect, found that there was a statistical significance of 0.001 which indicates that the price volatility of Vietnam rice exports fluctuates in a non-linear show as Table 6.

Table 6. The Rice Price Volatility with TGARCH of Vietnam

		Estimate parameter	S.E.	P-value
Vietnam	**Distribution**	Normal		
	mu	257.996	13.536	0.000
	AR(1)	0.985	0.008	0.000
	MA(1)	0.239	0.035	0.000
	ω	2.065	1.281	0.007
	α	0.254	0.084	0.000
	β	0.703	0.090	0.000
	ϒ	−0.304	0.093	0.001

Source: Calculation

5 Conclusion

According to the analysis of Rice price volatility of exports leaders in the world markets, found that the rice export prices of the three leading exporters are not much different. Thus, in terms of the world leader in rice exports competition, each government needs to provide a policy of accelerating the rice quality development to compete for the global market share. The price volatility of rice export was caused by the rice import policies of trading partners which numerous governments that import rice have encouraged the expansion of their own cultivation areas to increase rice production to support domestic consumption demand. Climate change affects world rice production and the rice price intervention policy affects the competitiveness of rice in the world market. Nevertheless, regarding the study of rice price volatility of exports leaders in the world markets. Thailand has less rice price volatility when compared to India and Vietnam. Meaning that Thailand has continuously controlled their rice exported quality which leads to being able to maintain customers in the world market.

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