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Modeling the Volatility of Rubber Price Return using VARMA GARCH Model

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Many studies have been conducted on the volatility of exchange rate affected by trade volume, trade price, and investment cost. However, studies on the effect of trade volume on the volatility of exchange rate have been inconclusive. The rubber industry is one of the most important economies in Thailand. We applied the VARMA-GARCH and VARMA-AGARCH models to determine the relationship between the volatility of Thai rubber price return and the volatility of different exchange rates. The coefficients of volatility of exchange rates comprise the Thai Baht, the Chinese Yuan, the Euro, and the Malaysian Ringgit; these currencies are significant in both models. The results indicate that the trade volume is an important factor in international product pricing. We recommend the Thai central bank set up some monetary policies to affect the rubber price.

Keywords: Volatility, Rubber price return, Export volume, Exchange rate return, VARMA-GARCH model, VARMA-AGARCH model.

Introduction

The exchange rate is a very important economic variable in international trade that has been the focus of every national government and numerous economists. Prior to 1973, majority of countries utilized the fixed exchange rate system proposed by Bretton Woods. After 1973, however, most of countries no longer limited the volatility of the exchange rate; their respective national central banks no longer usually controlled the volatility of the exchange rate to become managed floats. The exchange rate of those countries was then decided by the supply and demand in the exchange market. If the balance of payments was favorable, the foreign exchange supply was increased and the exchange rate appreciated. However, if the balance of payments was unfavorable, the foreign exchange rate demand was increased and the exchange rate depreciated. The influences of investment in imports have been increasing in recent years. The volatility of the exchange rate has performed as expected in the exchange market. Therefore, numerous factors affect the volatility of the exchange rate, and the risk of investment in exchange rate market has increased. Much research has been conducted on the volatility of the exchange rate affected by trade volume, trade price, and investment cost after the application of the flexible exchange rate system.

Under the supply and demand model which involves one export supply and one import demand, Ethier (1973) and Hopper, et al. (1978) posited that the price of international products become unstable if the volatility of the exchange rate increases drastically under the floating exchange rate system. Due to the exchange risk caused by the volatility of normal exchange rate in free market, the import and export firms conducting risk aversion will decrease the trade volume, regardless of whether the exchange rate risk is due to an exporter or importer. Some results in the literature revealed that the relationship between volatility of exchange rate and trade volume is not significant. Normally, firms decrease trade volume due to the instability of the real product price. This instability is caused not only by the volatility of the exchange rate, but also by the volatility of the product price in the home country and abroad. Further, the instability contributes to the lack of conclusive research on the effects of trade volume through the volatility of the exchange rate.

Thailand, Malaysia, and Indonesia are the major producers and exporters of rubber in the world. The total rubber output of these three countries is about 94% of the total world market in 2007, which amounts to approximately 8.32 million tons. The rubber industry is one of the most important economies in Thailand. The rubber plantations cover an area of 219,933 hectares, with an annual output of 3.056 million tons in 2007, of which approximately 2.772 million tons were exported (Office of the Rubber Replanting Aid Fund, 2008), as detailed in Table 1. The export of rubber constitutes nearly 90% of the total rubber output in Thailand. The Thai baht continued to appreciate and the demand for rubber increased, so the export price rose to 2.23 USD per kilogram in March 2007. A possible reason for this sudden increase in global rubber price is the increasing demand for rubber in the United States and

China. The U.S. Department of State website lists the 2010 per capita income of Thailand at a mere 4,716 USD. Although Thailand has advantages in the rubber industry, but unfortunately, it seems that the Thailand's personal income doesn't benefit at all. The key of increasing personal income to this contradiction is the farmer lack of knowledge of hedging the market.

The exchange rate becomes a crucial factor of international trading because trading in Thailand is highly dependent on the USA and Japan. Furthermore, other uncontrollable elements, such as tsunamis, floods, political environments, and so on, directly affect the exchange rate. At present, six major regions (Japan, China, USA, Malaysia, South Korea, and Europe) import rubber from Thailand. Therefore, we will focus on six variables (the relationship of exchange rates between six as mentioned above) in addition to the variable concerning the export price of rubber in Thailand.

Table1. The export and output in Thailand

unit: ton

	Export								Total output
	Japan	China	U.S.A.	Malaysia	South Korea	Europe	Other	total	
2001	505,233	417,638	329,504	243,708	136,387	231,178	302,505	2,166,153	2,319,549
2002	435,453	368,114	302,174	296,989	139,295	233,390	266,664	2,042,079	2,615,104
2003	498,854	436,637	382,317	363,651	138,756	266,392	321,809	2,354,416	2,876,005
2004	542,837	650,898	278,693	365,486	165,832	294,239	275,465	2,573,450	2,984,293
2005	525,654	619,800	249,196	383,695	171,668	291,670	395,413	2,637,096	2,937,158
2006	540,485	573,385	237,858	403,506	185,308	281,090	410,766	2,632,398	3,136,993
2007	492,740	747,168	210,784	442,664	173,477	261,882	442,958	2,771,673	3,056,005
2008	405,599	827,369	213,080	413,049	151,824	262,182	430,659	2,703,762	3,089,751
2009	394,742	824,833	219,986	398,043	154,340	249,509	433,830	2,675,283	3,164,379
2010	346,302	1,128,553	177,859	443,000	171,530	268,693	330,510	2,866,447	3,252,135

Due to Thailand's place as the leading exporter of rubber in the world, and with agriculture being the one of the important industry in Thailand, this paper aims to discover the relationships between different volatilities of exchange rate and rubber price returns. Our aims are twofold: (1) to study the relationship between rubber export price and six kinds of exchange rates, and (2) to use historical information to forecast the volatility of export price with different exchange rates, thus helping the Thai government set up a monetary policy for increasing the price of rubber.

Review of the literature

Many scholars provide substantial research and basic theories on interrelation analysis of exchange rates. The evaluation of the risk of exchange rate is an important point of empirical research about its volatility. Doroodian (1999) mentioned that the estimation methods of volatility of exchange rate are standard deviation, deviation from trend, difference between forward and current spot rates, Gini mean difference coefficient, coefficient of variation, and the ARCH or GARCH model. Several studies have employed standard deviation to evaluate the volatility of exchange rate. For example, Daly (1998) applied moving standard deviation to estimate exchange rate; however, the method is unadvisable if the stability of the volatility of the exchange rate is uncertain. Baillie et al. (1989) employed the GARCH model to analyze the volatility of the exchange rate. Poso (1992), Caporale et al. (1994), and Doroodian (1999) used the GARCH method in their analyses.

Hooper et al. (1978) constructed the static model of import demand and export supply. This study supposed that the exporter is prone to risk aversion to analyze the effects on volume share and trade price from the volatility of the exchange rate. The results revealed that the uncertainty of the exchange rate has negative effects on volume share; however, the volatility of the exchange rate has positive effects on trade price. Akhtar et al. (1984) utilized normal exchange rata to analyze the effects of exchange rate risk on the export and import trade in American and German manufacturing. They discovered that a significant negative relationship existed between the export volume and import price of American manufacturing and the import and export trade volume of German manufacturing. When the exchange rate risk is increased, the international trade could be correspondingly decreased. Engle and Granger (1987) proved that income and relative price can affect the export volume significantly via the application of two-stage estimation, and that the volatility of exchange rate can influence the export volume in the short term via the error correction model. In and Sgro (1998) tested the co-integration relationship between variables, and then used the error correction model to discuss the effects of export volume in South Korea and Singapore. The error correction model reveals that the export volume variation in Singapore is primarily due to the exchange rate. Thorbecke (2006) discovered that the exchange rate variation would decrease Asian exports. The appreciation of exchange rate in developed countries can affect the export and import volume between countries, but the export volume is not guaranteed to increase if the U.S. dollar depreciates. Therefore, the United States government should not expect the appreciation of Asian currencies to increase the export volume to America. Jarita (2008) tested the export and import price with the volatility of the exchange rate of the Malaysian ringgit from January 1999 to December 2006 via the VECM model. The results proved that the effects on export and import price from the volatility of the exchange rate are significant.

On the other hand, a number of scholars think that exchange risk positively affects exports and imports. DeGrauwe (1988) noted that the exchange risk causes the substitution and income effect. The substitute effect denotes that when the volatility of the exchange rate increases, the exporter decreases the risk export trade, thus decreasing the export volume. The income effect denotes that when the volatility of the exchange rate increases, the exporter increases the expected return of the risk export trade, increasing the export volume. When the income effect is greater than the substitution effect, a positive relationship occurs between the volatility of exchange and the trade volume.

Giovannini (1988) discovered that when the exchange rate risk increased, most risk-neutral traders enter the market quickly and leave the market slowly. The number of traders in the market would increase, as will the trade volume. Bailey et al. (1988) assumed that traders can easily earn returns from the volatility of the exchange rate, coupled with knowledge on trade. Exchange risk and trade volume exhibit a positive relationship. Franke (1991) proved that when the volatility of the exchange rate increases, the cash flow from export increase is significantly greater than the entry and exit cost from the market for the trader who employed haphazard policies of entry and exit. Broll et al. (1999) proposed that the real options of export trade increase when the volatility of the exchange rate increases. Higher exchange rate volatility raises the potential benefit, resulting in positive effects for export volume.

From literature reviews, we know that exchange risk positively affects export and imports, but it only discusses about one country. In this research, we will try to find out the relationship between rubber price and exchange rate in different import countries.

For the past studies, we can see that VARMA-GARCH and VARMA-AGARCH model usually used on financial market and VARMA-AGARCH performs better than VARMA-GARCH models in forecasting volatilities across different markets or assets. Therefore, we want to follow those literatures to discuss it in this research.

Before talking about the VARMA-GARCH model, we will introduce about ARMA model, The ARMA model (Autoregressive moving average model) is the important method for time series data which was made up from AR model and MA model. The models are as following:

AR(p)model

$$X_t = \mu + \sum_{i=1}^{p} \varphi_i X_{t-i} + \varepsilon_t \qquad (1)$$

MA(q) model

$$X_t = \mu + \sum_{i=1}^{q} \theta_i \varepsilon_{t-i} + \varepsilon_t \qquad (2)$$

ARMA(p,q)model

$$X_t = \mu + \sum_{i=1}^{p} \varphi_i X_{t-i} + \sum_{i=1}^{q} \theta_i \varepsilon_{t-i} \qquad (3)$$

Although the conditional correlation is modeled, which can be estimated in practice, it does not allow any interdependencies of volatilities across different markets or assets, and does not accommodate asymmetric behavior. In order to incorporate interdependencies of volatilities across different markets or assets, Ling, et al. (2003) proposed a vector autoregressive moving average (VARMA) specification of the conditional mean and the following GARCH specification for the conditional variance:

$$\Phi(L)(Y_t - \mu) = \Psi(L)\varepsilon_t \tag{4}$$

$$\varepsilon_t = D_t \eta_t \tag{5}$$

$$H_t = \omega + \sum_{l=1}^{r} A_l \vec{\varepsilon}_{t-k} + \sum_{l=1}^{s} \beta_l H_{t-l} \tag{6}$$

where $H_t = (h_{1t}, \dots, h_{mt})'$, $D_t = diag(h_{i,t}^{1/2})$, $\Phi(L) = I_m - \Phi_1 L - \cdots - \Phi_P L^P$, $\Psi(L) = I_m - \Psi_1 L - \cdots - \Psi_q L^q$ are polynomials in L, $\eta_t = (\eta_{1t}, \dots, \eta_{mt})'$, $\vec{\varepsilon}_t = (\varepsilon_{1t}^2, \dots, \varepsilon_{mt}^2)'$,and ω A_k for l=1,…,r and β_l for l=1,…,s are $m \times m$ matrices, and represent the ARCH and GARCH effects, respectively. Spillover effects are given in the conditional volatility for each market or asset in the portfolio, specifically where $A_l$and β_l are not diagonal matrix.

As in the univariate GARCH model, VARMA-GARCH model assumes that positive and negative shocks of equal magnitude have identical impacts on the conditional variance. In order to separate the asymmetric impacts of the positive and negative shocks, McAleer et al., (2009) proposed the VARMA-AGARCH specification for the conditional variance:

$$H_t = \omega + \sum_{l=1}^{r} A_k \vec{\varepsilon}_{t-l} + \sum_{l=1}^{r} C_l I(\eta_{t-l}) \vec{\varepsilon}_{t-l} + \sum_{l=1}^{s} \beta_l H_{t-l} \tag{7}$$

Where C_l are $m \times m$ matrices for l=1,…,r and $I_t = diag(I_{1t}, \dots, I_{mt})$, so that

$$I = \begin{cases} 0, \varepsilon_{k,t} > 0 \\ 1, \varepsilon_{k,t} \le 0 \end{cases} \tag{8}$$

where if m=1, it reduces to the asymmetric univariate GARCH or GJR. If $C_l = 0$ for all l it reduces to VARMA-GARCH. If $C_l = 0$ for all l, with $A_l$and β_l being diagonal metrices for all l and 1, then VARMA-AGARCH reduces to constant conditional correlation (CCC) model.

In literature regarding the VARMA-GARCH and VARMA-AGARCH model, Nianussornkul et al. (2009) discovered that the VARMA-GARCH and VARMA-AGARCH models exhibit significant volatility spillovers. The volatility spillover effects from the Singapore market to the other markets are statistically significant, indicating that hedging or speculation should be considered when the volatility in the Singapore bond market changes. As in the case of the univariate model, bonds in Indonesia and the Philippines also exhibit asymmetry in VARMA-AGARCH. Thus, the asymmetric model is superior to its symmetric counterpart in Indonesia and the Philippines. Ninanussornkul et al. (2009) used four models in the crude oil and precious metals markets. The results of asymmetric effects are significant in Brent and gold markets as GJR and EGARCH models, indicating that positive and negative shocks with equal magnitude have different impacts on conditional volatility. Therefore, asymmetric models are superior to symmetric models for Brent and gold markets, whereas the reverse applies for the silver market. Rolling windows are used to examine the time-varying conditional correlations of standardized shocks via the VARMA-GARCH and VARMA-AGRACH models. The rolling windows suggest that the assumption of constant conditional correlations is too restrictive, and indicate that the correlations of all pairs of assets are time-varying, especially after 2002. Chang et al. (2009 and 2010) used CCC, DCC, VARMA-GARCH, and VARMA-AGARCH in different oil markets. The estimates of volatility spillovers and asymmetric effects for negative and positive shocks on conditional variance suggest that VARMA-AGARCH is superior to the VARMA-GARCH model; positive shocks on the conditional variances suggest that VARMA-AGARCH is superior to other models. We regard VARMA-AGARCH to be superior to the VARMA-GARCH model in forecasting the volatilities across different markets or assets.

Methodology

Data variables and selection criteria

There are five levels of natural rubbers, from RSS1 to RSS5. The highest level is RSS1. However, RSS3 is primarily used in current and future world markets. Table 2 presents the variable names which were used in this study. The top six regions in terms of export volume are China, Malaysia, Japan, Europe, the United States, and South Korea. Rubber exports comprise approximately 90% of the total output of rubber in Thailand. Seven variables were examined: one concerning the rubber price in Thailand and six concerning the exchange rate in the six regions mentioned above. Each variable involved 1577 observations.

Table2. Introduce of Variable Names

Variables	Names
PRICE	Rubber price
BAHT	Exchange rate of Thailand Baht
CNY	Exchange rate of Chinese Yuan
EUR	Exchange rate of Euro Dollar
JPY	Exchange rate of Japanese Yen
KRW	Exchange rate of Korea Won
MYR	Exchange rate of Malaysia Riggit

Stationary and summary statistics of the variables

The returns of asset i at time t are calculated as following:

$$R_{i,t} = \log\left(\frac{P_{i,t}}{P_{i,t-1}}\right) \tag{9}$$

Where $P_{i,t}$ and $P_{i,t-1}$ are the closing prices of asset i for days t and t-1, separately.

All series data are stationary and tested by using the Augmented Dickey-Fuller (ADF) test, which is given as following:

$$\Delta y_t = \alpha + \beta t + \theta y_{t-1} + \sum_{i=1}^{P} \Delta y_{t-1} + \varepsilon_t \tag{10}$$

The null hypothesis is $\theta = 0$ which, if rejected, than means that the series y_t is stationary. The results shows that all series data are stationary in Table 3, which the estimated value of θ and the t-statistics of all the returns are significantly less than zero at the 1% level.

Table 3: ADF Test of Unit Roots in Returns

Returns	Coefficient	t-statistic
PRICE	-0.5165	-11.1036
BAHT	-1.0347	-24.7531
CNY	-1.0040	-23.9896
EUR	-1.0676	-25.5970
JPY	-1.0232	-24.4772
KRW	-1.1833	-28.7615
MYR	-1.0503	-25.1073

Table 4 illustrates the descriptive statistics of the variables. In this study, the standard deviation of rubber price returns is higher than all values for the volatility of the exchange rate. The PRICE, BAHT, and KRW are negative; as such, they skew significantly to the left. In this study, all the variables for the excess kurtosis statistics are positive, indicating that the distribution of returns has larger, thicker tails than the normal distribution. Therefore, the assumption of skewed-t is more appropriate in this study.

Table 4: Summary statistics

	PRICE	BAHT	CNY	EUR	JPY	KRW	MYR
Mean	0.0003	-0.0002	0.0000	-0.0001	0.0000	0.0002	0.0000
SD	0.0107	0.0032	0.0067	0.0090	0.0098	0.0107	0.0072
Skewness	-0.4902	-0.3293	0.3519	0.0463	0.0019	-0.1363	0.2140
Kurtosis	8.7482	7.1771	121.4066	34.492	30.5565	34.6872	88.4493
Max	0.0463	0.0163	0.1194	0.1085	0.1191	0.1167	0.1171
Min	-0.0529	-0.0188	-0.1104	-0.1113	-0.1062	-0.1154	-0.1083
JB	816.0708	429.1715	920686.5000	65126.9600	49864.6900	65939.1600	479482.4000

VARMA-GARCH and VARMA-AGARCH Model

For this study, we use VARMA-GARCH (Vector ARMA-GARCH) model to analysis data which was proposed by Ling, et al. (2003) and VARMA-AGARCH model which was proposed by McAleer, et al. (2009). The effect of fluctuation cannot be distinguished individually very clearly in the traditional multivariate GARCH model. The VARMA-GARCH model is as following:

$$Y_t = E(Y_t | F_{t-1}) + \varepsilon_t \quad (11)$$

$$\varepsilon_t = D_t \eta_t \quad (12)$$

$$H_t = \omega + \sum_{j=1}^{r} \alpha_{ij} \varepsilon_{i,t-j} + \sum_{j=1}^{s} \beta_{ij} H_{i,t-j} \quad (13)$$

And VARMA-AGARCH model is as following:

$$H_t = \omega + \sum_{j=1}^{r} \alpha_{ij} \varepsilon_{i,t-j} + \sum_{j=1}^{r} C_{ij} I_{ij} \varepsilon_{i,t-j} + \sum_{j=1}^{s} \beta_{ij} H_{i,t-j} \quad (14)$$

Where $H_t = (h_{1t}, h_{2t}, \dots, h_{mt}), \eta_t = (\eta_{1t}, \eta_{2t}, \dots, \eta_{mt}),\ D_t = \mathrm{diag}(h_{1t}^{1/2}, h_{2t}^{1/2}, \dots, h_{mt}^{1/2})$

For this study, the full model is in following:

$$A_t = \gamma_{A0} + \gamma_{A1} P_{t-1} + \gamma_{A2} B_{t-1} + \gamma_{A3} C_{t-1} + \gamma_{A4} E_{t-1} + \gamma_{A5} J_{t-1} + \gamma_{A6} K_{t-1} + \gamma_{A7} M_{t-1} + \varepsilon_{A,t} \quad (15)$$

$$\begin{bmatrix} \varepsilon_{A,t} \\ \varepsilon_{E.t} \end{bmatrix} | \Omega_{t-1} \sim N(0, H_t) \quad (16)$$

Where P is PRICE, B is BAHT, C is CNY, E is EUR, J is JPY, K is KRW, M is MYR and ε is error term.

We use normal distribution and MLE(Maximization Likelihood Estimation) to estimate the parameter of this model.

$$\hat{\theta} = argmin \frac{1}{2} \sum_{t=1}^{n} \left(log|Q_t| + \varepsilon_t^{'} Q_t^{-1} \varepsilon_t \right) \quad (17)$$

Where θ is the vector of parameters to be estimated on the conditional log-likelihood function, and $|Q_t|$ is the determinant of Q_t, the conditional covariance matrix.

Empirical Results

We employed these methods because the time-varying volatility can be estimated, and the asymmetric effects of positive and negative shocks of equal magnitude and volatility spillovers can be tested. The results of VARMA-GARCH and VARMA-AGARCH are shown in Table 5. The number of volatility spillovers and asymmetric effects are summarized in Table 6. From the Table5, the t-value of Γ from VARMA-AGARCH model is only 0.9247 which indicates statistical significance at the 1% level is 1.96. Therefore, the table 6 shows that the result of asymmetric effects is "No". Therefore, table 6 further shows that the volatility spillovers are not evident in the VARMA-AGARCH model. Therefore, the VARMA-GARCH is superior to VARMA-AGARCH in examining the volatility of rubber price return. Table 5 also indicates that four kinds of exchange rate returns exhibit spillovers to the volatility of rubber price returns. This occurs not only in the VARMA-GARCH model, but also in the VARMA-AGARCH model, which covers the Thai Baht, the Euro, and the Malaysian Ringgit. For Chinese Yuan, the significance of result of VARMA-GARCH model is better than VARMA-AGARCH model. About the relationship between volatility of rubber price and exchange rate, the coefficients are positive between volatility of rubber price and two kinds of exchange rate, which are CNY and MYR and the coefficients are negative between volatility of rubber price and other two kinds of exchange rate, which are BAHT and EUR.

Table 5: Estimates of VARMA-GARCH(1,1) and VARMA-AGARCH(1,1)

Returns of rubber price	ω	α_{PRICE}	α_{BAHT}	α_{CNY}	α_{EUR}	α_{JPY}
VARMA-GARCH	0.0000***	0.19727***	2.72806**	-1.98220**	-0.1345***	0.0150
	48.0720	4.45952	2.48305	-2.24116	-2.6031	0.2880
VARMA-AGARCH	0.0000***	0.16816**	2.84640**	-2.09856**	-0.5700***	0.0053
	53.2316	2.42505	2.34941	-2.07233	-3.2040	0.1022

Table5. (Continued 1)

Returns of rubber price	α_{KRW}	α_{MYR}	Γ	β_{PRICE}	β_{BAHT}
VARMA-GARCH	0.0108	-0.4402**		0.6268***	-1.6354***
	0.4377	-1.9663		26.1728	-3.3775
VARMA-AGARCH	0.0051	-0.1026*	0.0930	0.6115***	-1.5487***
	0.2135	-1.8380	0.9247	24.8285	-2.7376

Table5. (Continued 2)

Returns of rubber price	β_{CNY}	β_{EUR}	β_{JPY}	β_{KRW}	β_{MYR}
VARMA-GARCH	1.1463***	-0.3188***	0.0427	0.0515	0.5397***
	2.9576	-3.2276	0.5478	-1.6415	2.9496
VARMA-AGARCH	1.1115**	-0.3893***	0.1066	0.0524*	0.4809***
	2.3247	-3.4762	1.2550	1.6535	2.7582

Notes: (1) The two entries for each parameter are their respective estimate and Bollerslev and Woodridge (1992) robust t-ratios.
(2) * indicates statistical significance at the 10% level;
** indicates statistical significance at the 5% level;
*** indicates statistical significance at the 1% level.

Table 6: Summary of Volatility Spillovers and Asymmetric Effects

Returns	Number of volatility spillovers		Asymmetric effects
	VARMA-GARCH	VARMA-AGARCH	
Rubber Prices	5	5	NO

We used rolling windows to examine the time-varying conditional correlations using the VARMA-GARCH and VARMA-AGARCH models. The rolling window size was set at 1,000 for the exchange rate of six regions that import rubber from Thailand, and the results are shown in Figures 2 and 3, respectively. In the case of the VARMA-GARCH model, the correlations of six variables are not constant over time; as such, the assumption of constant conditional correlations may be too restrictive. However, the changes in the estimated correlations are minimal. The correlation between the volatility of rubber price returns and volatility of all the exchange rate returns are small (not more than 0.1). The result from the VARMA-AGARCH model is similar to that from the VARMA-GARCH model.

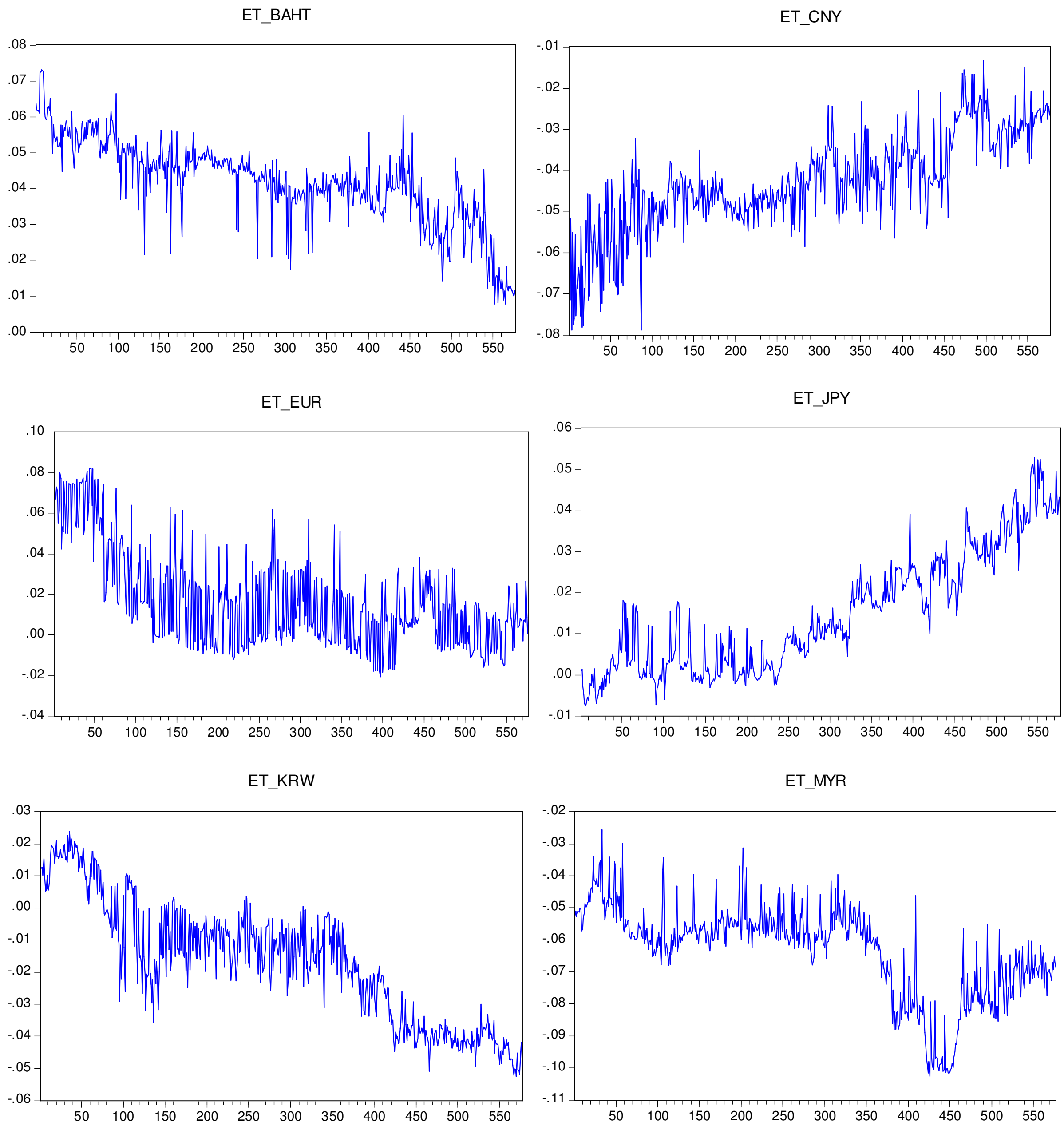

Figure 1: Dynamic Path of Conditional Correlations in VARMA-GARCH model

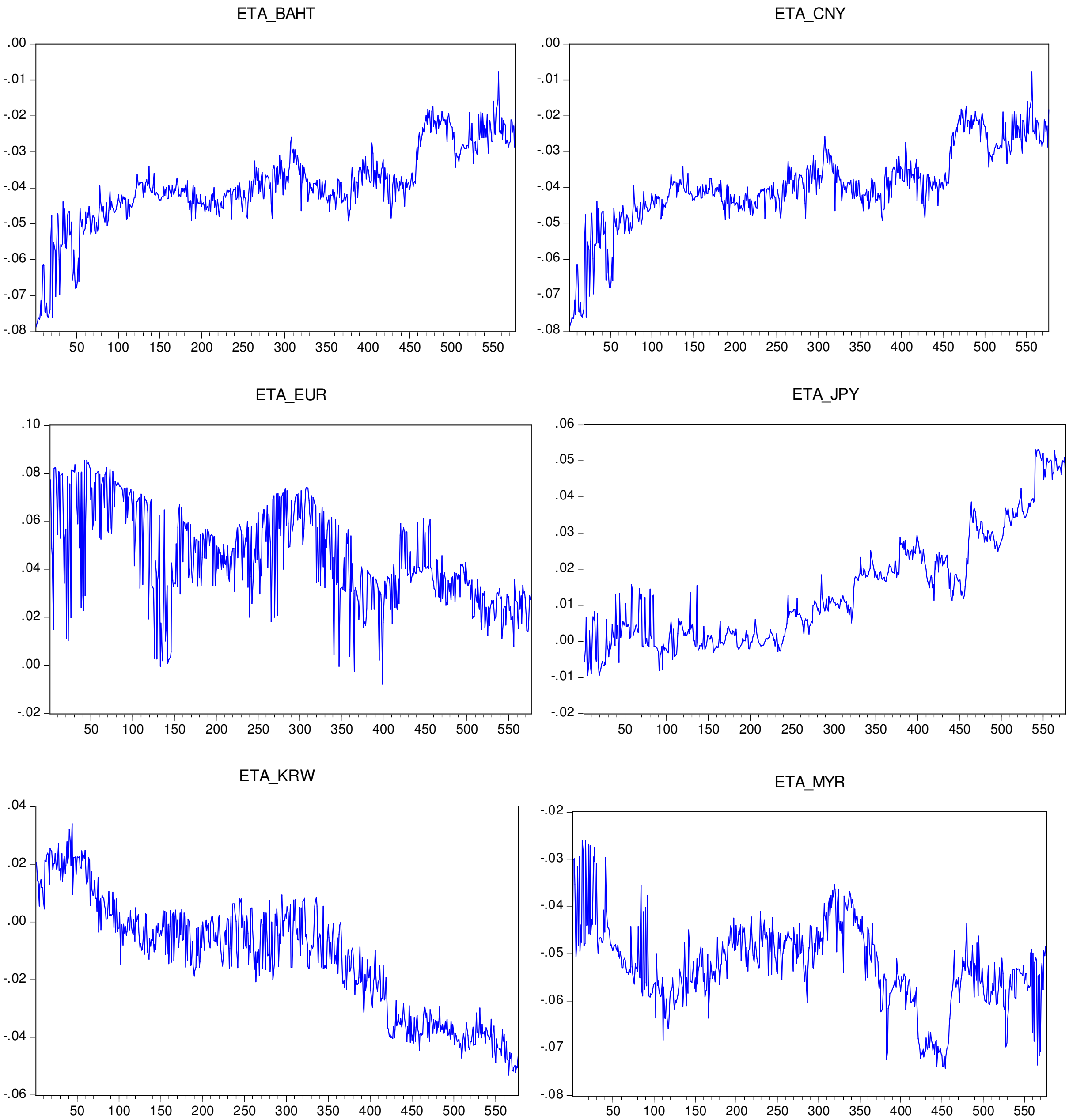

Figure 2: Dynamic Path of Conditional Correlations in VARMA-AGARCH model

Conclusion

This paper estimated the conditional volatility, covariance, and correlation volatility of rubber price returns via multivariate volatility models. The VARMA-GARCH model revealed that volatility spillovers were evident between the volatility of rubber price return and the volatility of four exchange rate returns in the model, namely, the Thai Baht, the Chinese Yuan, the Euro, and the Malaysian Ringgit. The VARMA-GARCH model exhibited the same results as the VARM-AGARCH model. As such, the volatility of rubber price return will be affected by these four volatilities of exchange rates in both models.

The coefficients of volatility in exchange rates in the Thai Baht, the Chinese Yuan, the

Euro, and the Malaysian Ringgit are significant in both the models; as such, the respective exchange rates of these currencies are very important factors in the volatility of rubber price returns. Table 1 indicates that China and Malaysia are the top two markets that import Thai rubber. The currencies of these regions can therefore affect the rubber price. The rolling window reveals that the correlation between the volatility of rubber price returns and all the values for the volatility of exchange rate returns is small (not more than 0.1) not only on the VARMA-AGARCH model, but also on the VARMA-GARCH model.

This study has observed that the exchange rate return of the Thai Baht can affect the rubber price return. From the result, we therefore suggest that the Thailand government set up monetary policies to control the rubber price, such as trading US dollars to control the volatility of exchange rate of Thai Baht. Table 1 reveals that the top two importers of Thai rubber are China and Malaysia; as such, the volatility of rubber price will be affected by the volatility of exchanges rate in the most important export countries. This finding further indicates that the trade volume is an important factor for the international product price.

References

Akhtar, M. A and Hilton, R. S. (1984), "Exchange Rate Uncertainty and International rade: Some Copceptual Issues and New Estimates for Germany and the United States," Federal Reserve Bank of New York.

Bailey, M. J., Tavlas, G. S. and Ulan, M. (1986), "Exchange-rate variability and trade performance: evidence for the big seven industrial countries," Weltwirtschaftiliches Archiv, 122, 466-477.

Baillie, R. T. and Tim B. (1989), "The message in Daily Exchange Rates: A Conditional Variance Tale," Journal of Business and Economic Statistics, 7, 297-305.

Broll, U. and Eckwert, B. (1999), "Exchange Rate Volatility and International Trade," Southern Economic Journal, 66, 178-185.

Caporale, T. and Doroodian K. (1994) "Exchange Rate Volatility and the Flow of International Trade," Economics Letters, 46, 49-54.

Chang, C.-L., M. McAleer and R. Thansuchat, (2009), "Modelling Conditional Correlations for Risk Diversification in Crude Oil Markets", Journal of Energy Markets, 2(4), 1-23.

Chang, C.-L., M. McAleer and R. Tansuchat, (2010), "Analyzing and Forecasting Volatility Spillovers, Asymmetries and Hedging in Major Oil Markets", Energy Economics (Elsevier), 32, 1445-1455 (ISI).

C.Nianussornkul, Chang, C.-L., M. McAleer and S. Sriboonchitta., " Modelling the Volatility in Bond Prices in South-East Asia"(2009), International on Finance and Accounting, Thailand

C.Ninanussornkul, K. Ninanussornkul, P. Boonyasana and T. Sriwichailanphan., (2009) "Volatility and Volatility Spillovers in Crude Oil and Precious Metals Markets" ", International on Finance and Accounting, Thailand.

Daly, K. (1998), "Does Exchange Rate Volatility Impede the Volume of Japan's Bilateral Trade?" IMF Staff Paper, 35, 63-84.

De Grauwe, P. (1988), "Exchange Rate Variability and the Slowdown in Growth of International Trade," IMF Staff Paper, 35, 63-84.

Doordian, K.(1999), "Does Exchange Rate Volatility Deter International Trade in Developing Country?" Journal of Asian Economics,10, 465-74.

Ethier, W. (1973) "Internatilonal Trade and the Forward Exchange Market," American Economic Review, 63, 494-503.

Franke, G.. (1991) "Exchange Rate Volatility and International Trading Starategy," Journal of International Money and Finance, 10, 292-307.

Giovannini, A. (1988) "Exchange Rate and Traded Goods Prices," Journal of International Economics 24, 45-68.

Hooper, P. and Kohlagen, S. W. (1978), "The Effects of Floating Exchange Rate Uncertainty on the price and Volume of International Trade." Journal of International Economics, 8, 483-511.

In, F. and Sgro, P, (1998), "Export Growth and Its Determinants: Some Evidence for South Korea and Singapore," Applied Economics Letters, 5(4), 225-30.

Jarita, D. (2008), "Impact of Exchange Rate Shock on Prices of Imports and Exports," Munich Personal RePec Archive working paper.

Ling, S. and M. McAleer (2003)," Asymptotic Theory for a Vector ARMA-GARCH Model", Econome tric Theory, 19, 278-308.

McAleer, M., S. Hoti and F. Chan, (2009), "Structure and asymptotic theory for multivariate asymmetric conditional volatility." Econometric Reviews 28, 422-440.

Poso, S. (1992), "Conditional Exchange Rate Variability and the Volume of International Trade: Evidence from the Early 1990's," Review of Economics and Statistics, 74, 325-329.

Thorbecke, W. (2006)," The Effects of Exchange Rate Changes on Trade in East Asia", REITI Discussion Paper Series working paper.