計畫名稱:

日本匯率市場波動對亞洲三匯率市場波動的影響:
台灣、韓國及泰國匯率市場之實證研究

Empirical Study on the influence of Japan Exchange Rate Volatility on Asia Three Exchange Rate Markets: Korea, Taiwan and Thailand

計畫主持人: 洪萬吉

計畫編號: CN10418

日本匯率市場波動對亞洲三匯率市場波動的影響：台灣、韓國及泰國匯率市場之實證研究

Empirical Study on the influence of Japan Exchange Rate Volatility on Asia Three Exchange Rate Markets: Korea, Taiwan and Thailand

Wann-Jyi Horng

Department of Hospital and Health Care Administration,

Chia Nan University of Pharmacy & Science, Tainan, Taiwan

E-mail: hwj7902@mail.cnu.edu.tw

Abstract

In this paper we construct a dynamic conditional correlation (DCC) and a trivariate IGARCH (1, 1) model to evaluate the associations of the Taiwan, the Korea and the Thailand exchange rate markets with a factor of Japanese exchange rate market. The empirical result shows that Korea's exchange rate market positively affect the Taiwan and Thailand exchange rate markets, and the volatility of the three exchange rate markets interact with one another. The variation risk of the Japan's exchange rate markets' volatility affects the variation risks of Taiwan, Korea and Thailand exchange rate markets. Therefore, based on the viewpoint of DCC, the explanatory ability of the trivariate IGARCH(1, 1) model is better than the traditional model of the trivariate GARCH. The evidence suggests that exchange rate market investors or international fund managers must evaluate the variation risk and relationships of the exchange rate markets' volatility.

Keywords: exchange rate market, DCC, trivariate IGARCH model.

1. Introduction

Under the trend of internationalization and the liberalization, the international investment and the worldwide circulation of capital are increasing, resulting in close relationships between countries and their respective exchange rate markets. Korea's economical physique belongs partly to an island economy, where positive includes to the foreign trade unfolds where ties between Thailand and Taiwan are close. We know that Korea is one of Asian four dragons, also Korea economy of growth in 2006 is 5%, and the forecast value of the grow rate is 4.3% in the future. We also know that Thailand is also the major economical financial system in the

Association of South-east Asia Nations. Thailand and Taiwan have a close relationship with the Korea based on the trade and the circulation of capital, and the Thailand is the most powerful global economic nation in the Association of South-east Asia Nations. Therefore, how these three exchange rate markets impact one another is certainly worth further discussion.

Among the financial time series non-linearity research literatures, Engle (1982) proposes the autoregressive conditionally heteroskedasticity (called ARCH) model and Bollerslev (1986) offers the generalization autoregressive conditionally heteroskedasticity (called GARCH) model. These two models can catch the financial properties when the conditional variance is not a fixed parameter. Nelson (1990) looks at stock price changes and discovers that they have both positive and negative relationships with the future stock price volatility. The GARCH model supposes a settled time conditional variance for the preceding issue of conditional variance and an error term square function. Therefore, the error term's positive and negative values do not respond to its influence on the conditional variance equation. The conditional variance only changes along with the error term's value change, and cannot go along with the error term's positive and negative changes. To improve this flaw, Nelson (1991) presents an exponential GARCH model and Glosten, Jaganathan, and Runkle (1993) give a GJR-GARCH model. These model are the so-called the models of asymmetric GARCH. There are many research studies on the asymmetric problem, such as Brooks (2001), Poon and Fung (2000), Christie (1982), French, Schwert, and Stambaugh (1987), Campell and Hentschel (1992), Koutmos and Booth (1995), and Koutmos (1996). These studies expand the research methods of the return volatility between stock markets. For statements on the multivariate GARCH model, scholars such as Yang (2005), Yang and Doong (2004), Granger, Hung and Yang (2002), Wang and Barrett (2002) and Bollerslev (1990) proposes the bivariate GARCH model

The main goal of this paper is to discuss the association of the Korea, the Taiwan, and the Thailand's exchange rate returns' volatility. The paper constructs the DCC and the trivariate GARCH theoretical model and examines whether or not there is an asymmetrical influence between the markets. We understand there possibly creates an influence on the three exchange rate markets, by using the multivariate Normal distribution for the stochastic error term. We also use the maximum likelihood algorithm method of BHHH (Berndt et. al., 1974) to estimate the parameters of the proposed model. The organization of this paper is as follows. Section 2 states the data characteristics. Section 3 provides trivariate GARCH model. Section 4 provides the proposed model and model checking. Section 5 provides the asymmetrical test of the proposed model and the last section gives the conclusion.

2. Data Characteristics

2.1 Data sources

This research discusses the exchange rate returns in the Korea, the Taiwan, and the Thailand and whether there is an association of the three exchange rate markets' volatility on each other. In the sample selection, this research uses the Korea exchange rate, Taiwan exchange rate, Thailand exchange rate as the sample. We select the sample period from January, 2002 to December, 2009 and use the exchange rate prices for all the dates. The data originate from the DataStream, a large database in Taiwan.

2.2 Returns calculation and trend of charts

In order to compute the exchange rate volatility rates, this paper adopts the natural logarithm of the exchange rate for every exchange rate market sample ($KER_t, TWER_t, THER_t, JER_t$) with one step difference and then multiplied by 100- namely, for the Korea's exchange rate market, the exchange rate volatility rates are $RKER_t = 100*[\ln(KER_t) - \ln(KER_{t-1})]$. For the Taiwan's exchange rate market, the exchange rate volatility rates are $RTWER_t = 100*[\ln(TWER_t) - \ln(TWER_{t-1})]$. For the Thailand's exchange rate market, the exchange rate volatility rates are $RTHER_t = 100*[\ln(THER_t) - \ln(THER_{t-1})]$. Finally, for the Japan's exchange rate market, the exchange rate volatility rates are $RJER_t = 100*[\ln(JER_t) - \ln(JER_{t-1})]$. Figure 1 is the trend charts of the Korea, the Taiwan, the Thailand and the Japan's exchange rate volatility rates in the sample period.

From Figure 1, we may see that the Korea, the Taiwan, the Thailand and Japan's exchange rates presents obviously the same direction of trend. From Figure 1, we also know that the volatility of these three exchange rate market returns have a volatility clustering phenomenon. We may also know that the Korea exchange rate market, the Taiwan exchange rate market and the Thailand exchange rate market have certain relevances on their return volatility processes. This also means that there are the mutual relations among these three exchange rate markets. This is also mainly the main motivation for discussing the relationships among the Korea, the Taiwan and the Thailand's exchange rate volatilities.

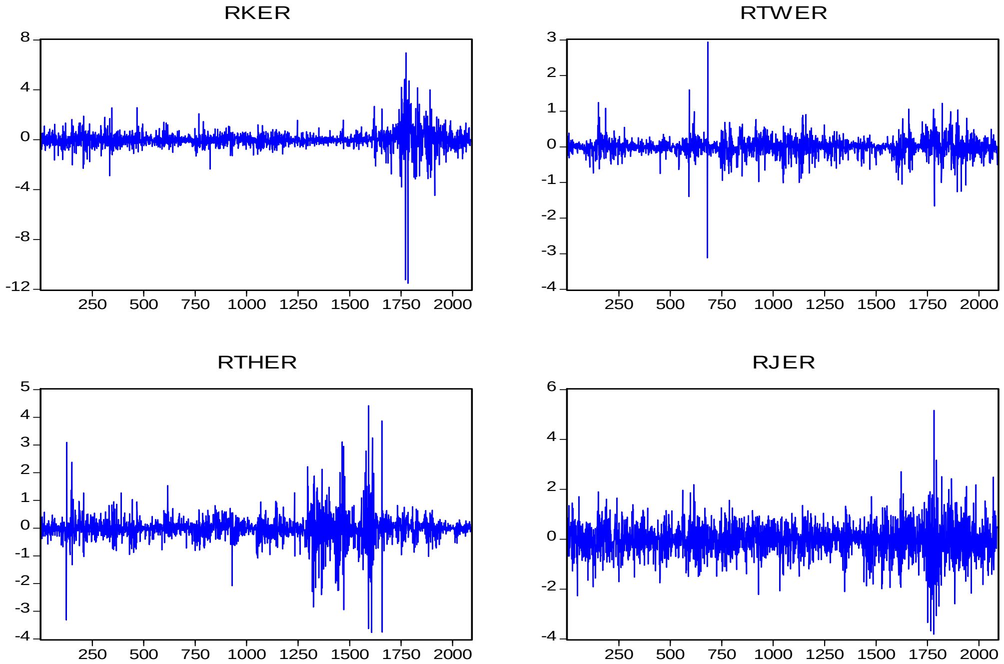

Figure 1. Trend charts of the Korea, Taiwan, Thailand and Japan's exchange rate return rates.

2.3 Statistics

The return rates of the exchange rates in the Korea、the Taiwan and the Thailand show a stationary state sequence. Table 1 shows some basic statistical analysis: mean value, standard deviation, kurtosis coefficient, skewed coefficient, and normal distribution examination. From Table 1, the average rate of the Korea's exchange rate market is -0.0061, the average rate of the Taiwan's exchange rate market is -0.0042, and the average rate of the Thailand's exchange rate market is -0.0135. The variation risk of the Korea's exchange rate market is 0.8031, the variation risk of the Taiwan's exchange rate market is 0.2688, and the variation risk of the Thailand's exchange rate market is 0.5016, and therefore the variation risk of the Korea's exchange rate market is the highest. From the Jarque-Bera statistics, under the null hypotheses of the normal distribution, we discover that the three exchange rate markets do not show a normal distribution. Moreover, the kurtosis is bigger than 3, and this demonstrates that the data have the phenomena of a heavy tail distribution. When the sample size is large enough, the heavy tail distribution will approximate the normal distribution.

Table 1. Data statistics

Statistic	RKER	RTWER	RTHER	RJER
Mean	-0.006082	-0.004163	-0.013471	-0.016458
S-D	0.803051	0.268849	0.501641	0.674377
Skewed	-2.071619	-0.244718	0.258566	-0.107444
Kurtosis	49.30940	21.94532	19.84703	6.910901
J-B N (p-value)	187980.2 (0.0000)	31232.37 (0.0000)	24703.98 (0.0000)	1334.056 (0.0000)
sample	2087	2087	2087	2087

Notes: (1)S-D denotes the standard deviation of data. (2)J-B N denotes the normal distribution test of Jarque-Bera. (3) p-value < α denotes significance (α =1%, α =5%, α =10%).

2.4 Unit root test

In order to match the suitable model, at first one may determine the stability of the time series data, as well as avoid the non-stationary state of the time series sequences and reduce the mistake of the empirical result. To do so, this paper uses the unit root tests of ADF (Dickey-Fuller, 1979 and 1981) and KSS (Kapetanios et al., 2003). Table 2 lists the ADF and KSS examination results. It shows that the Korea、Taiwan and Thailand's exchange rates do reject the null hypotheses, indicating that the sequences have the unit root- namely, non-stationary state sequences. Under the 1% significance level, all indices reject the null hypotheses, showing that the sequences do not have the unit root, have stationary state sequences, and we may carry on the time series analyses.

Table 2. ADF and KSS-Unit root test of the data

ADF	RKER	RTWER	RTHER	RJER
Statistic C-V (S-L)	-11.1884*** -3.9625 (α =1%)	-45.1662*** -3.4120 (α =5%)	-9.2760*** -3.1279 (α =10%)	-11.8852***
KSS	**RKER**	**RTWER**	**RTHER**	**RJER**
Statistic C-V (S-L)	-19.5555*** -2.82 (α =1%)	-24.2733*** -2.22 (α =5%)	-32.0814*** -1.92 (α =10%)	-20.1627***

Notes：(1) C-V denotes the critical value and S-L denotes significance level.
(2) *** denotes significance at the level 1%.

2.5 Co-integration test

From the co-integration test of Johansen (1991), we know that λ_{max} and the Trace statistics are not significant under the level 5% in Table 3. This demonstrates that the stock price of the three exchange rate markets, do have a co-integration relationship altogether. From Table 4, we see that the unconditional correlation matrix for the Korea、Taiwan and Thailand exchange rate markets have a relationships. Based on the Korea、Taiwan and Thailand's exchange rate markets do have the long-term co-integration relationships, these three markets can really affect one another. Therefore, we go a step further to understand the interactions of the three exchange rate markets.

Table 3. Cointegration test of Johansen (the lag of VAR is 3)

Null (H_0)	λ_{max}	**C-V ($\alpha = 5\%$)**	**Trace**	**C-V ($\alpha = 5\%$)**
None	23.4202	32.1183	51.5307	63.8761
At most 1	15.8558	25.8232	28.1105	42.9153
At most 2	6.8179	19.3870	12.2547	25.8721
At most 3	5.4367	12.5180	5.4367	12.5180

Notes：(1) C-V denotes the critical value.

(2) The lag of VAR is selected by AIC rule (Akaike, 1973).

Table 4. Unconditional relation matrix of Korea、Taiwan and Thailand's exchange rate markets

Coefficient	**KER**	**TWER**	**THER**	**JER**
KER	1	0.5950	0.3823	-0.2228
TWER	0.5950	1	0.6108	0.4556
THER	0.3823	0.6108	1	0.4853
JER	-0.2228	0.4556	0.4853	1

2.6 ARCH effect test

This paper further uses the ARCH effect test to determine the stock return volatility and whether there is the conditionally heteroskedasticity phenomenon. This research implements the Ljung-Box (1978) test method, the Lagrange Multiplier (LM) test method of Engle (1982), and the F distribution test method of Tsay (2004) to further confirm the variance of the residual error sequence and whether there is an ARCH effect, and then if there is an ARCH effect we use the GARCH model to match it suitably. The ARCH effect test takes the residual error square of the past q periods to carry on the regression analysis. The ARCH effect test is based on the AR model in Table 8. Its mathematical form is:

$$\hat{a}_t^2 = d_0 + d_1 \hat{a}_{t-1}^2 + \cdots + d_q \hat{a}_{t-q}^2 + v_t . \quad (1)$$

We test the null hypotheses $H_0 : d_1 = d_2 = \cdots = d_q = 0$ by (1) as above. When it rejects H_0, it means that it does have the ARCH effect- that is, we can use the GARCH model to fit it.

We next implement the LM, F, and Ljung-Box (L-B) test methods to examine the exchange rate returns and to determine whether there is a conditionally heteroskedasticity phenomenon. The results of the ARCH effect test for the three exchange rate markets are listed in Table 5. The results show that the three exchange rate return rates' analysis model has a significant statistical value under α =5% level and has the conditionally heteroskedasticity phenomenon. This suggests that it matches suitably and it could use the GARCH model to analyze the data.

Table 5. ARCH effect test for Korea、Taiwan and Thailand exchange rate markets (lag=30)

RKER	**Engle LM test**	**Tsay F test**	**L-B test** LB^2 **(1)**	LB^2 **(3)**
Statistic	708.3862	35.4820	7.6828	8.7282
(p-value)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
RTWER	**Engle LM test**	**Tsay F test**	**L-B test** LB^2 **(1)**	LB^2 **(3)**
Statistic	516.6635	22.6686	25.8430	7.0560
(p-value)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
RTHER	**Engle LM test**	**Tsay F test**	**L-B test** LB^2 **(1)**	LB^2 **(4)**
Statistic	449.6949	18.8970	13.3678	8.7759
(p-value)	(0.0000)	(0.0000)	(0.0000)	(0.0000)

Notes：p-value < α denote significance (α =1%, α =5%, α =10%).

3. Trivariate GARCH Model

If we solely use the single variable GARCH model to analyze the relatedness of the Korea, Taiwan, and Thailand's exchange rate return volatilities, permitting the exchange rate return volatility to change only along with time, then we are inclined to neglect the variance structure of these markets' exchange rate return volatilities. The analysis also produces the inefficiency and a bias of the model's estimation. In fact, the three exchange rate returns' volatility conditional variances are all favored along with the change in time, and the trivariate GARCH model can simultaneously consider the three exchange rate markets' volatility on time dependence. Therefore, the relatedness research.of the Korea, the Taiwan, and Thailand's exchange rate return volatilities is suitable. We hence may be used the trivariate GARCH model to discuss the three exchange rate markets' relationships and impacts for the Korea, the Taiwan, and Thailand's exchange rate market returns. The construction of the traditional GARCH(1, 1) model is as follows:

$$RKER_t = \phi_{11} RKER_{t-1} + \phi_{21} RTWER_{t-1} + \phi_{31} RTHER_{t-1} + a_{1,t} \tag{2}$$

$$RTWER_t = \varphi_{11} RKER_{t-1} + \varphi_{21} RTWER_{t-1} + \varphi_{31} RTHER_{t-1} + a_{2,t} \tag{3}$$

$$RTHER_t = \psi_{11} RKER_{t-1} + \psi_{21} RTWER_{t-1} + \psi_{31} RTHER_{t-1} + a_{3,t} \tag{4}$$

$$h_{11,t} = \alpha_{10} + \alpha_{11} a_{1,t-1}^2 + \beta_{11} h_{11,t-1} \tag{5}$$

$$h_{22,t} = \alpha_{20} + \alpha_{21} a_{2,t-1}^2 + \beta_{21} h_{22,t-1} \tag{6}$$

$$h_{33,t} = \alpha_{30} + \alpha_{31} a_{3,t-1}^2 + \beta_{31} h_{33,t-1} \tag{7}$$

$$q_{12,t} = c_0 + c_1 \rho_{12,t-1} + c_2 a_{1,t-1} a_{2,t-1} / \sqrt{h_{11,t-1} h_{22,t-1}} \text{，} \tag{8}$$

$$q_{13,t} = d_0 + d_1 \rho_{13,t-1} + d_2 a_{1,t-1} a_{3,t-1} / \sqrt{h_{11,t-1} h_{33,t-1}} \text{，} \tag{9}$$

$$q_{23,t} = e_0 + e_1 \rho_{23,t-1} + e_2 a_{2,t-1} a_{3,t-1} / \sqrt{h_{22,t-1} h_{33,t-1}} \text{，} \tag{10}$$

$$\rho_{12,t} = \exp(q_{12,t}) / (\exp(q_{12,t}) + 1) \text{，} \tag{11}$$

$$\rho_{13,t} = \exp(q_{13,t}) / (\exp(q_{13,t}) + 1) \text{，} \tag{12}$$

$$\rho_{23,t} = \exp(q_{23,t}) / (\exp(q_{23,t}) + 1) \text{，} \tag{13}$$

$$h_{12,t} = \rho_{12,t} \sqrt{h_{11,t}} \sqrt{h_{22,t}} \tag{14}$$

$$h_{13,t} = \rho_{13,t} \sqrt{h_{11,t}} \sqrt{h_{33,t}} \tag{15}$$

$$h_{23,t} = \rho_{23,t} \sqrt{h_{22,t}} \sqrt{h_{33,t}} \tag{16}$$

$\vec{a}_t' = (a_{1,t}, a_{2,t}, a_{3,t})$ obeys the trivariate normal distribution- namely, $N(\vec{0}, H_t)$,

among

$\vec{0}' = (0,0,0)$ and

$$H_t = \begin{bmatrix} h_{11,t} & h_{21,t} & h_{31,t} \\ h_{12,t} & h_{22,t} & h_{32,t} \\ h_{13,t} & h_{23,t} & h_{33,t} \end{bmatrix}, \quad h_{12,t} = h_{21,t}, \quad h_{13,t} = h_{31,t}, \quad h_{23,t} = h_{32,t}.$$

The probability density function of $\vec{a}_t$ is

$$f(a_{1,t}, a_{2,t}, a_{3,t} \mid H_t) = \frac{1}{(2\pi)^{3/2} |H_t|^{1/2}} \exp\left\{ \frac{-1}{2} \vec{a}_t' H_t^{-1} \vec{a}_t \right\} \tag{17}$$

Where $\rho_{12,t}$ is the dynamic conditional correlation (DCC) coefficient of $a_{1,t}$ and $a_{2,t}$, $\rho_{13,t}$ is the DCC coefficient of $a_{1,t}$ and $a_{3,t}$, and $\rho_{23,t}$ is the DCC coefficient of $a_{2,t}$ and $a_{3,t}$. In addition, H_t^{-1} is the inverse matrix of H_t. In this paper, we use the normal distribution for the stochastic error term, and also use the maximum likelihood algorithm method of BHHH (Berndt et. al., 1974) to estimate the parameters of the trivariate GARCH model.

4. Proposed Model and Model Checking

4.1 Trivariate GARCH model and parameter estimation

This section uses the trivariate GARCH model based on section 3- namely, it takes the (18)-(31) type to discuss the Korea, the Taiwan and the Thailand’s exchange rate return volatilities’ relatedness analysis. And consider the influence of Japanese exchange rate market factor on the study three exchange rate markets. The parameters’ estimation first considers a general model and is based on the estimated results. We then deletes some not so significant explanation variables. Finally, we obtains a simplification model for the Korea, the Taiwan and the Thailand’s exchange rate return volatilities’ relatedness analysis. From the empirical diagnosis results, we know that the Korea, the Taiwan and the Thailand’s exchange rate return volatilities may be constructed on the trivariate GARCH(1, 1) model with a DCC, the estimate results are stated in Table 6. The proposed model is given as follows:

$$RKER_t = \phi_{11} RKER_{t-1} + \phi_{21} RTWER_{t-1} + \phi_{31} RTHER_{t-1} + \phi_{41} RJER_{t-1} + a_{1,t} \quad (18)$$

$$RTWER_t = \varphi_{11} RKER_{t-1} + \varphi_{21} RTWER_{t-1} + \varphi_{31} RTHER_{t-1} + \varphi_{41} RJER_{t-1} + a_{2,t} \quad (19)$$

$$RTHER_t = \psi_{11} RKER_{t-1} + \psi_{21} RTWER_{t-1} + \psi_{31} RTHER_{t-1} + \psi_{41} RJER_{t-1} + a_{3,t} \quad (20)$$

$$h_{11,t} = \alpha_{10} + \alpha_{11} a_{1,t-1}^2 + \beta_{11} h_{11,t-1} + \eta_1 RJER_{t-2}^2 \quad (21)$$

$$h_{22,t} = \alpha_{20} + \alpha_{21} a_{2,t-1}^2 + \beta_{21} h_{22,t-1} + \eta_2 RJER_{t-2}^2 \quad (22)$$

$$h_{33,t} = \alpha_{30} + \alpha_{31} a_{3,t-1}^2 + \beta_{31} h_{33,t-1} + \eta_3 RJER_{t-2}^2 \quad (23)$$

$$q_{12,t} = c_0 + c_1 \rho_{12,t-1} + c_2 a_{1,t-1} a_{2,t-1} / \sqrt{h_{11,t-1} h_{22,t-1}} \quad (24)$$

$$q_{13,t} = d_0 + d_1 \rho_{13,t-1} + d_2 a_{1,t-1} a_{3,t-1} / \sqrt{h_{11,t-1} h_{33,t-1}} \quad (25)$$

$$q_{23,t} = e_0 + e_1 \rho_{23,t-1} + e_2 a_{2,t-1} a_{3,t-1} / \sqrt{h_{22,t-1} h_{33,t-1}} \quad (26)$$

$$\rho_{12,t} = \exp(q_{12,t}) / (\exp(q_{12,t}) + 1) \quad (27)$$

$$\rho_{13,t} = \exp(q_{13,t}) / (\exp(q_{13,t}) + 1) \quad (28)$$

$$\rho_{23,t} = \exp(q_{23,t})/(\exp(q_{23,t})+1) \tag{29}$$

$$h_{12,t} = \rho_{12,t}\sqrt{h_{11,t}}\sqrt{h_{22,t}}\ ,\ h_{13,t} = \rho_{13,t}\sqrt{h_{11,t}}\sqrt{h_{33,t}}\ ,\ h_{23,t} = \rho_{23,t}\sqrt{h_{22,t}}\sqrt{h_{33,t}} \tag{30}$$

$\vec{a}_t' = (a_{1,t}, a_{2,t}, a_{3,t})$ obeys the trivariate normal distribution- namely, $N(\vec{0}, H_t)$,

among $\vec{0}' = (0,0,0)$ and

$$H_t = \begin{bmatrix} h_{11,t} & h_{21,t} & h_{31,t} \\ h_{12,t} & h_{22,t} & h_{32,t} \\ h_{13,t} & h_{23,t} & h_{33,t} \end{bmatrix},\ h_{12,t} = h_{21,t},\ h_{13,t} = h_{31,t},\ h_{23,t} = h_{32,t}.$$

The probability density function of $\vec{a}_t$ is

$$f(a_{1,t}, a_{2,t}, a_{3,t} \mid H_t) = \frac{1}{(2\pi)^{3/2}|H_t|^{1/2}}\exp\left\{\frac{-1}{2}\vec{a}_t' H_t^{-1}\vec{a}_t\right\}, \tag{31}$$

where $\rho_{12,t}$ is the dynamic conditional correlation (DCC) coefficient of $a_{1,t}$ and $a_{2,t}$, $\rho_{13,t}$ is the DCC coefficient of $a_{1,t}$ and $a_{3,t}$, $\rho_{23,t}$ is the DCC coefficient of $a_{2,t}$ and $a_{3,t}$. In addition, H_t^{-1} is the inverse matrix of H_t.

By the estimated results of the trivariate IGARCH(1, 1) model with a DCC in Table 6, we test the estimated value of the parameters' coefficient to be significant or not with a P-value. In the sample period, the Korea's exchange rate volatility receives the previous one day's influence from the Korea's exchange rate market return (ϕ_{11}=-0.0823). The Korea's exchange rate return receives the previous one day's impact from the Taiwan's exchange rate market (ϕ_{21}=0.0937). The Korea's exchange rate volatility also receives the previous one day's impact from the Thailand's exchange rate market (ϕ_{31}=0.0669). The Taiwan's exchange rate volatility receives the previous one day's influence from the Korea's exchange rate market (φ_{11}=0.0359). The Taiwan's exchange rate volatility does not receive the previous one day's influence of the Taiwan's exchange rate market. The Taiwan's exchange rate volatility also receives the previous one day's influence from the Thailand's exchange rate market (φ_{31}=0.0396). The Thailand's exchange rate volatility receives the previous one day's influence of the Korea's exchange rate market (ψ_{11}=0.0224), the Thailand's exchange rate volatility receives the previous one day's influence of the Taiwan's exchange rate returns (ψ_{21}=0.0745), and it receives the previous one day's influence of the Thailand's exchange rate market (ψ_{31}=-0.0974). The three exchange rate markets also receives the previous one day's influence from the Japan's exchange rate market. From the empirical results as above, we also know that these three exchange rate markets do have the relationships.

On the other hand, the correlation coefficient value of the Korea and the Taiwan exchange rate volatilities is significant ($\hat{\rho}_{12}$=0.4620). This result means the Korea exchange rate's volatility has a positive influence to the Taiwan exchange rate's volatility, and they are precisely a synchronized mutual influence. When the variation risk increase of the Korea exchange rate market, the investor's risk in the Taiwan exchange rate market is able to increase. Likewise, when the variation risk fall of the Korea exchange rate market, the investor's risk in the Taiwan exchange rate market is also able to be reduced. Similarly, the correlation coefficient value of the Korea and the Thailand exchange rate volatilities is significant ($\hat{\rho}_{13}$=0.3042). This result also shows that Korea exchange rate's volatility has a positive influence on the Thailand exchange rate's volatility. The correlation coefficient value of the Taiwan and the Thailand exchange rate volatilities is also significant ($\hat{\rho}_{23}$=0.2854). This result also shows that the Thailand exchange rate's volatility has a positive influence on the Taiwan exchange rate's volatility.

The observed conditional variance equation of the estimated coefficient, under the 10% significance level, demonstrates that all the conditional variance estimated coefficients are significance in Table 6. This result works when the exchange rate volatility of the Korea, the Taiwan, and the Thailand are different to the traditional GARCH model with a constant conditional correlation. The previous one days' residual error square item and the previous one day's conditional variance will affect the Korea, the Taiwan, and the Thailand's exchange rate volatilities and also can produce the different variation risks, among which, $\alpha_{11}+\beta_{11}+\eta_1=1$, $\alpha_{21}+\beta_{21}+\eta_2=1$, and $\alpha_{31}+\beta_{31}+\eta_3=1$. The volatility of variation risk is the lowest ($\beta_{21}=0.5214$) for the Korea and Thailand's exchange rate markets. Also, $\alpha_{11}+\beta_{11}+\eta_1$, $\alpha_{21}+\beta_{21}+\eta_2$, and $\alpha_{31}+\beta_{31}+\eta_3$ conforms to the parameter of the IGARCH model's conditional supposition. The variation risk of the three exchange rate markets also receives the previous two day's influence from the Japan's exchange rate market. The single variable GARCH and bivariate GARCH models are unable to respond to this information, but the DCC and the trivariate IGARCH(1, 1) model might truly catch the Korea, the Taiwan, and the Thailand's exchange rates' volatility process. Therefore, the explanatory ability of the trivariate IGARCH(1, 1) model with a DCC is better than the models of the single variable and the bivariate GARCH.

Table 6. Parameter estimation of the trivariate IGARCH(1, 1) model with a DCC

Parameter	ϕ_{11}	ϕ_{21}	ϕ_{31}	ϕ_{41}	φ_{11}	φ_{21}
Coefficient	-0.0823	0.0937	0.0669	0.1074	0.0359	0.0039

(p-value)	(0.0006)	(0.0171)	(0.0000)	(0.0000)	(0.0000)	(0.8957)
Parameter	φ_{31}	φ_{41}	ψ_{11}	ψ_{21}	ψ_{31}	ψ_{41}
Coefficient	0.0396	0.1014	0.0224	0.0745	-0.0974	0.0538
(p-value)	(0.0000)	(0.0000)	(0.0144)	(0.0141)	(0.0008)	(0.0000)
Parameter	α_{10}	α_{11}	β_{11}	η_1	α_{20}	α_{21}
Coefficient	0.0055	0.1429	0.8403	0.0168	0.0093	0.4743
(p-value)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
Parameter	β_{21}	η_2	α_{30}	α_{31}	β_{31}	η_3
Coefficient	0.5214	0.0043	0.0095	0.1958	0.7958	-0.0084
(p-value)	(0.0000)	(0.0008)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
Parameter	c_0	c_1	c_2	d_0	d_1	d_2
Coefficient	1.6029	-3.7153	-0.1086	0.5936	-4.6918	-0.0225
(p-value)	(0.0000)	(0.0000)	(0.0023)	(0.0000)	(0.0000)	(0.1400)
Parameter	e_0	e_1	e_2			
Coefficient	-2.2112	4.2157	0.1768			
(p-value)	(0.0000)	(0.0000)	(0.0000)			
Parameter	$\bar{\rho}_{12,t}$	min $\rho_{12,t}$	max $\rho_{12,t}$	$\bar{\rho}_{13,t}$	min $\rho_{13,t}$	max $\rho_{13,t}$
Coefficient	0.4620	0.0787	0.9878	0.3042	0.0239	0.9164
(p-value)	(0.0000)			(0.0000)		
Parameter	$\bar{\rho}_{23,t}$	min $\rho_{23,t}$	max $\rho_{23,t}$			
Coefficient	0.2854	0.0516	0.8961			
(p-value)	(0.0000)					

Notes: (1) p-value< α denotes significance (α =1%, α =5%, α =10%).

(2) The min ρ_t denotes the minimum value of DCC coefficient, and the max ρ_t denotes the maximum value of DCC coefficient.

4.2 Model checking of the standard residual for trivariate GARCH

The trivariate GARCH model is appropriate to examine the standard residual error and a standard residual error square series by the test method of Ljung-Box to see whether there still exists auto-correlation. This is done by the standard residual error Q test of LB (10) to LB (30) with a P-value and the standard residual error square series Q test of LB^2(10) to LB^2(30) with a P-value in Table 7. The diagnosis presents that the DCC and the trivariate GARCH(1, 1) model already has no auto-correlation of the standard residual error. This is also shown by Table 8. The DCC and the trivariate GARCH(1, 1) model already does not have an ARCH effect of the standard residual error square series. Therefore, this model matches quite suitably and is appropriate.

Table 7. Q test of the standard residual and its squared series

Korea	$LB(10)$	$LB(20)$	$LB(30)$	$LB^2(10)$	$LB^2(20)$	$LB^2(30)$
Statistic	3.3476	9.1425	29.2980	5.7531	11.6136	17.6818
(p-value)	(0.9270)	(0.9812)	(0.5020)	(0.8356)	(0.9287)	(0.9635)
Taiwan	$LB(10)$	$LB(20)$	$LB(30)$	$LB^2(10)$	$LB^2(20)$	$LB^2(30)$
Statistic	12.2169	20.4580	31.7551	0.5641	1.4313	1.8527
(p-value)	(0.2708)	(0.4296)	(0.3790)	(1.0000)	(1.0000)	(1.0000)
Thailand	$LB(10)$	$LB(20)$	$LB(30)$	$LB^2(10)$	$LB^2(20)$	$LB^2(30)$
Statistic	13.9149	25.9134	31.2487	1.2297	2.3567	5.3534
(p-value)	(0.1769)	(0.1687)	(0.4033)	(0.9996)	(1.0000)	(1.0000)

Notes: p-value< α denotes significance (α =1%, α =5%, α =10%).

Table 8. ARCH effect test of the standard residual for L-B test

Korea	$LB^2(10)$	$LB^2(20)$	$LB^2(30)$	F test	
Q statistic	0.5628	0.3893	1.1197	statistic	0.6163
(p-value)	(0.5736)	(0.6971)	(0.2630)	(p-value)	(0.9493)
Taiwan	$LB^2(10)$	$LB^2(20)$	$LB^2(30)$	F test	
Q statistic	-0.1682	-0.1957	-0.0177	statistic	0.0608
(p-value)	(0.8665)	(0.8449)	(0.9858)	(p-value)	(1.0000)
Thailand	$LB^2(10)$	$LB^2(20)$	$LB^2(30)$	F test	
Q statistic	-0.2506	-0.2385	-0.3582	statistic	0.1744
(p-value)	(0.8021)	(0.8115)	(0.7202)	(p-value)	(1.0000)

Notes: p-value< α denotes significance (α =1%, α =5%, α =10%).

5. Asymmetric Test of the Trivariate GARCH Model

Because of the parameter estimation and the standard residual error diagnosis in the above IGARCH(1, 2) model with a DCC, the examination only can check if the model matches up with the suitable quality, but it actually is unable to look up whether the model has an asymmetrical phenomenon. Therefore, Engle and Ng (1993) develop a diagnosis test in order to examine whether the model has asymmetrical risk or not. This research uses this diagnosis test to carry out the examination. The examination method of the model hypotheses has the following four examination methods: (1) sign bias test (2) negative size bias test (3) positive size bias test (4) joint test.

After the above-mentioned results, Table 9 asymmetrically examines the result for the Korea's exchange rate market as: (a) The sign bias test does not reveal (α =10%). (b) The negative size bias test does not reveal (α =10%). (c) The positive size bias test does not reveal (α =10%). (d) The joint test does not reveals (α =10%). Table 9 asymmetrically examines the result for the Taiwan's exchange rate market as: (a) The sign bias test does not reveal (α =10%). (b) The negative size bias test reveals (α =5%). (c) The positive size bias test does not reveal (α =10%). (d) The joint test does not reveal (α =10%). Table 9 asymmetrically examines the result for the Thailand's exchange rate market as: (a) The sign bias test does not reveal (α =10%). (b) The negative size bias test does not reveal (α =10%). (c) The positive size bias test does not reveal (α =10%). (d) The joint test does not reveal (α =10%). From the positive size bias test and the joint test, we know that the exchange rate markets of the Korea, the Taiwan and the Thailand do not have an asymmetrical phenomenon in the sample period.

Table 9. Asymmetric test of the trivariate GARCH model

Korea	Sign bias test	Negative size Bias test	Positive size Bias test	Joint test
F statistic	3.8511	0.0748	0.2554	1.4246
(p-value)	(0.0498)	(0.7845)	(0.6134)	(0.2337)
Taiwan	Sign bias test	Negative size Bias test	Positive size Bias test	Joint test
F statistic	3.1889	0.1819	1.1847	1.7080
(p-value)	(0.0743)	(0.6698)	(0.2765)	(0.1633)
Thailand	Sign bias test	Negative size Bias test	Positive size Bias test	Joint test
F statistic	2.3524	1.1788	0.3136	1.1899
(p-value)	(0.1252)	(0.2777)	(0.5756)	(0.3121)

Notes: p-value< α denotes significance (α =1%, α =5%, α =10%).

6. Conclusions

There are many factors that may influence exchange rate market, such as the overall economic agents and overall currency supplies, interest rates, prices, and inflation rates. Each factor can have an influence on the exchange rate volatilities. This research discusses three exchange rate market volatilities' influence of the Korea, the Taiwan and the Thailand. We use data from January, 2005 to December, 2012 on the Korea, the Taiwan and the Thailand's exchange rate as the sample. The empirical result shows that the Korea, the Taiwan and the Thailand's exchange rate volatilities may be constructed in the trivariate IGARCH(1, 1) model with a DCC. This model also passes a standard residual error and the ARCH effect test, demonstrating that the trivariate IGARCH(1, 1) model's fittings are appropriate. The empirical result also obtains that the average estimation value of DCC coefficient ($\hat{\bar{\rho}}_{12}$ =0.4620) of the Korea and Taiwan two exchange rate markets is positive, the average estimation value of DCC coefficient ($\hat{\bar{\rho}}_{13}$ =0.3042) of the Korea and Thailand two exchange rate markets is also positive, and the average estimation value of DCC coefficient ($\hat{\bar{\rho}}_{23}$ =0.2854) of the Taiwan and Thailand two exchange rate markets is also positive. This result demonstrates that the Korea exchange rate volatility affects the Taiwan and Thailand exchange rate risks, and the Taiwan exchange rate volatility also affects the Korea and Thailand exchange rate risks. The empirical result also discovers that the Korea, the Taiwan and the Thailand's exchange rate market volatilities do not have the asymmetrical phenomenon in the sample period. The variation risk of the three exchange rate markets also receives the previous two day's influence from the Japan's exchange rate market.

The theories and the models discussing on the exchange rate volatility properties of financial commodities are countless, and this research only uses the trivariate GARCH model to discuss the three exchange rate markets of the Korea, the Taiwan and the Thailand. The three exchange rate markets' return volatility also shows the relationships. For future research, we suggest that the others multivariate GARCH models can be used for further analysis.

References

1. Akaike, H. (1973). Information Theory and an Extension of the Maximum Likelihood Principle. In 2d. International Symposium on Information Theory, edited by B. N. Petrov and F. C. Budapest: Akademiai Kiado, 267-281
2. Bollerslev, T. (1986). Generalized autoregressive conditional hetroscedasticity. Journal of Econometrics, 31, 307-327.
3. Bollerslev, T. (1990). Modeling the coherence in short-run nominal exchange rates: a multivariate generalized ARCH model. Review of Economics and Statistics, 72, 498-505.
4. Berndt, E.K., Hall, B.H., Hall, R.E. and Hausman, J.A. (1974). Estimation and inference in nonlinear structural models. Annals of Economic and Social Measurement, 4, 653-665.
5. Christie, A.A. (1982). The stochastic behavior of common stock variances: value, leverage and interest rate effects. Journal of Financial Economics, 10, 407-432.
6. Campell, J.Y. and Hentschel, L.(1992). No news is good news: an asymmetric model of changing volatility in stock returns. Journal of Financial Economic,

31, 281-318

7. Dickey, D.A. and Fuller, W.A .(1979). Distribution of estimates for autoregressive time series with a unit root. Journal of the American Statistical Association, 74, 427-431.

8. Dickey, D.A. & Fuller, W.A. (1981). Likelihood Ratio Statistics for Autoregressive Time Series with a Unit Root. Econometrica, *49*, 1057-1072.

9. Engle, R.F. (1982). Autoregressive conditional heteroscedasticity with estimates of the variance of United Kingdom Inflation. *Econometrica*, 50, 987-1007

10. Engle, R.F. and Ng, V.K. (1993). Measuring and testing the impact of news on volatility. Journal of Finance, 45, 1749-1777.

11. French, K.R., Schwert, G.W. and Stambaugh, R.F. (1987). Expected stock returns and volatility. Journal of Financial Economics, 19, 3-29.

12. Granger, C.W., Hung, J.B. and Yang, C.W. (2000). A bivariate causality between stock prices and exchange rates: evidence from recent Asian Flu. The Quarterly Review of Economics and Finance, 40, 337-354.

13. Glosten, L.R., Jagannathan, R. and Runkle, D.E. (1993). On the relation between the expected value and the volatility on the nominal excess returns on stocks.Journal of Finance, 48, 1779-1801.

14. Johansen, S. (1991). Estimation and hypothesis testing of cointegration vector in gaussian vector autoregressive models. Econometrica, 59, 1551-1580.

15. Koutmos, G. and Booth, G.G. (1995). Asymmetric volatility transmission in international stock markets. Journal of International Money and Finance, 14, 747-762.

16. Koutmos, G. (1996). Modeling the dynamic interdependence of major European stock markets. Journal of Business Finance and Accounting, 23, 975-988.

17. Kapetanios, G., Shin, Y. and Snell, A. (2003). Testing for a unit root in the nonlinear STAR framework. Journal of Econometrics, 112(2), 359-379.

18． Ljung, G.M. and Box, G.E.P. (1978). On a measure of lack of fit in time series models. Biometrika, 65, 297-303.

19. Nelson, D.B. (1990). Stationarity and persistence in the GARCH(1,1) model. Econometric Theory, 6, 318-334.

20. Nelson, D.B. (1991). Conditional heteroscedasticity in asset returns: A new Approach. Econometrica, 59, 347-370.

21. Poon, W. P. H. and Fung, H.G. (2000). Red chip or H shares: Which China-backed securities process information the fastest?. Journal of Multinational Financial Management, 10, 315-343.

22. Tsay, R.S. (2004). Analysis of Financial Time Series. New York: John Wiley

& Sons, Inc.
23. Wang, K.L. and Barrett, C.B. (2002). A new look at the trade volume effects of real exchange rate risk. Cornell University work paper.
24. Yang, S.Y. and Doong, S.C. (2004). Price and volatility spillovers between stock prices and exchange rates: empirical evidence from the G-7 countries. International Journal of Business and Economics 3(2), 139-153.
25. Yang, S.Y. (2005). A DCC analysis of international stock market correlations: the role of Japan on the Asian Four Tigers. Applied Financial Economics Letters 1(2), 89-93.