Investigating the Interaction between the Volatility of Exchange Rate and Stock Returns in Four Asian Countries

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Abstract

In this paper, we are interested to investigate how changes in exchange rate regime/ flexibility can affect the interaction between the volatility of exchange rate and stock returns in four selected Asian countries (Indonesia, Korea, Philippines and Thailand). The reason to focus the study on these countries is due to the drastic change in their exchange rate regime from fixed to flexible regime and inflation targeting aftermath the Asia financial crisis of 1997. In particular, we are interested to investigate the above matter by comparing the results of pre- inflation targeting (IT) and post-IT periods in addition to reveal macroeconomic factors that determine the relationship. For the purpose of analyses, a wide range of generalized autoregressive conditional heteroskedasticity, GARCH-type models are used to model the volatility of exchange rate and stock returns respectively for each country. The generated volatility series are used to be analyzed for the interaction effects under vector autoregressive (VAR) model. Our results detect significant bi-directional relationship between volatility of exchange rate and stock returns in three markets: Indonesia, Korea and Thailand. Also, the monetary variables (interest rate, money supply, international reserves) have significant impacts on determining the volatility of exchange rate and stock returns in Indonesia, Korea and Thailand. In general, the adoption of inflation targeting leads to different significant impacts across the four countries.

Keywords: inflation targeting, exchange rate regime, volatility of stock return

1. Introduction

The choice of exchange rate regime and monetary policy can have important effect to an economy especially for the small and developing economies like Asia. The Asian financial crisis of 1997 caused many Asian countries to abandon the fixed regime and switched to flexible exchange rate regime and inflation targeting. Among these countries are Indonesia, South Korea, Philippines and Thailand.

The drastic change of the exchange rate regimes implies greater flexibility in exchange rate and yet possibly higher volatility in exchange rate under the new flexible regime. Therefore, it is interesting to investigate how such changes in exchange rate flexibility (yet volatility) can affect the interaction between volatility of exchange rate and stock returns in these countries. In this paper, we conduct empirical analyses to investigate this issue by comparing the results between the pre- inflation targeting (IT) and post-IT periods. In addition, we also investigate if the monetary variables (interest rate, money supply and international reserves) can influence the interaction between volatility of exchange rate and stock returns in these four countries. For the purpose of analyses, the GARCH-type models and VAR model are applied. Our results reveal significant two-way relationship between volatility of exchange rate and stock returns in Indonesia, Korea and Thailand. Furthermore, the results shows that the three monetary variables have significance impacts on determining the movements of volatility series of exchange rate and stock returns in most cases. However, the impacts differ across countries. In Philippines, only money supply has significance impact on determining the movement of exchange rate volatility. The drastic change to inflation targeting and flexible exchange rate regimes impose significance impacts on the volatility of exchange rate and stock return. However, the impacts are different across countries.

The paper is organized as follows: section II is the review of empirical findings; section III explains the data; section IV explains the methodology; section V summarizes the results and section VI concludes the findings.

2. Review of Empirical Findings

The study on the relationship between volatility of exchange rate and stock returns is broad but inconclusive. Previous studies apply high frequency data either in daily, weekly or monthly based on a single country or a group of countries. For example, Agrawal *et al.* (2010) conducted their study based on a single country of India. They used daily data spanning 1999-2009 to investigate the relationship between volatility of stock returns and exchange rate in Indian market. The study had detected causality bidirectional relationship between the two variables. The result of GARCH (1, 1) revealed positive relationship between volatility of stock return and exchange rate.

Other study by Zakaria and Shamsuddin (2012) focused on emerging country of Malaysia. The study examined the relationship between stock market and macroeconomic volatility, for the period from January 2000 until June 2012. However, the study fails to detect significant impact of exchange rate volatility on determining the volatility of stock returns.

Some studies focused on a group of countries. For example, Kanas (2002) examined the influence of exchange rate changes on stock returns volatility for three industrialized countries (U.S., U.K. and Japan) over the period 1986-1998. The author used the daily data of closing stock values in domestic currency for the U.S. (Dow Jones Industrial Average), U.K.(FT All Share Price Index) and Japan (Nikkei). The results using EGARCH model revealed that stock return volatility has significant effect on determining the exchange rate movement for U.S., U.K. and Japan.

Furthermore, Beer and Hebein (2008) investigated dynamic relationship between stock market and exchange rate in industrialized and emerging markets under the framework of the EGARCH model. The investigation used weekly data from 1997 to 2004 for the developing markets (U.S., Canada, U.K. and Japan) and emerging countries (Hong Kong, Singapore, South Korea, India and Philippines). The results showed no persistency in the volatility of stock market and exchange rate for developing countries. However, the study detected strong positive and significant spillover effect from exchange rate to stock markets in Canada, U.S. and India. The results reported by Beer and Hebein (2008) is contracted with the results reported by Kanas (2002). The differences may due to different sample period and frequency of the data.

More recent studies that reported significance relationship between both volatility series include Chkili (2012) and Kumar (2013). Chkili (2012) focused the study in emerging countries (Hong Kong, Singapore, Malaysia, Korea, India, Argentina, Brazil and Mexico). Applying the BEKK-MGARCH models, results revealed bi-directional relationship of shocks and volatility spillovers between the two markets in most countries. Kumar on the other hand, focused the analyses in India, Brazil and South Africa. His study also detected bi-directional volatility spillovers between stock and foreign exchange markets.

In general, previous studies report different results on the relationship between volatility of exchange rate and stock returns. Some studies detect significant positive relationship between exchange rate volatility and stock market movement. For example, Bodart and Reding (1999) found evidence on the positive and significant relationship between volatility of exchange rate volatility and stock returns. The authors examined the impact of exchange rate regime, volatility and international correlations on bond and stock markets based by comparing the ERM countries (Germany, France and Belgium) and non-ERM countries (Italy, U.K. and Sweden). Also, the study revealed that higher exchange rate variability for Germany market contributes to a lower cross-market correlation.

In addition to that, Karoui (2006) examined the correlation between the volatility of stock indexes returns and foreign exchange rate for 18 emerging countries with based on exchange rate in U.S. Dollar, British Pound, and Japanese Yen. The study detected positive relationship between volatility of exchange rate and equity return in majority of the sector indexes studied. As U.S. Dollar is the major currency used in commercial and monetary transaction, exchange rate in U.S. Dollar has higher risk compare to British Pound, and Japanese Yen.

Some studies report negative relationship between volatility of exchange rate and stock market returns. For instance, Subair and Salihu (2004) investigated the effects of exchange rate volatility on the Nigeria stock markets. The variables under investigation are annual stock market capitalization, gross domestic product, inflation rate, interest rate, and exchange rate volatility over the period 1981-2007. The Johansen cointegration test had detected a long run relationship between the variables. However, there is no long-run relationship between inflation and interest rate with the stock market capitalization. The result can be explained by a major participation of government in the stock market. The participation of Nigeria government may lead to a virile stock market, through coordination between efficient monetary and fiscal policy. However, the error correction model reported strong negative impact from exchange rate volatility to stock market in Nigeria in the short run. In other words, higher exchange rate volatility causes to lower growth rate of stock market capitalization.

Besides, Adjasi *et al.* (2008) investigated the effect of exchange rate volatility on the Ghana Stock Exchange and the effect of other macroeconomic variables on stock market volatility. The macroeconomic variables under investigation include money supply (MS), treasury bill rate (TBR), trade deficit (DT) and consumer price index (CPI). Using EGARCH model, the results reported a negative relationship between the two variables in Ghana. In other words, long run exchange rate depreciation will lead to the increase of the stock market returns. Furthermore, consumer price index tends to increase with the stock market volatility. Besides, the decline of the treasure bill rate volatility tends to raise the stock market volatility. Also, higher volatility in trade deficit will dampen the stock market activities.

Other studies reported mixed results or non interaction between volatility of exchange rate and stock returns. For instance, Muntazir and Usman (2013) focused the study in India, China and Pakistan. Their results reveal very little evidence on the cointegrating relationship between volatility of exchange rate and stock returns. Granger causality test also failed to detect causality relationship in India and China but not in Pakistan.

3. Data

The data used in this study include the monthly stock market indices and nominal exchange rates of domestic country per US$. The four stock indices are the Stock Exchange of Thailand (S.E.T) index, Jakarta Composite Index (JAKCOMP), Korea Composite Stock Price Index (KOSPI) and Philippines Stock Exchange Index (PSEi). Additionally, the monetary factors to be tested include interest rate, money supply and international reserves.

The sample period spans 22 years from January 1990 until December 2012 except the series for Thailand interest rate which is only collected from February 1991 to December 2012. For the purpose of analysis and comparison, the sample data is partitioned into pre-Inflation Targeting (IT) and post-IT periods. For the effectiveness of monetary policy, inflation targeting should be implemented under flexible exchange rate regime. Therefore, pre-IT period indicates higher rigidity in exchange rate while post-IT period implies flexibility in exchange rate. These countries have adopted the inflation targeting (hence flexible exchange rate regime) at different time. Thailand has implemented inflation targeting in May 2000, Indonesia in January 2000, Korea in April 1998 and Philippines in January 2002 (see Table 1). All monthly data are obtained from *Datastream* and International Financial Statistic-CD ROM.

Table 1. Pre and post periods.

Country	Pre-IT	Post-IT
Thailand	1990M1-2000M4	2000M5-2012M12
Indonesia	1990M1-1999M12	2000M1-2012M12
Korea	1990M1-1998M3	1998M4-2012M12
Philippines	1990M1-2001M12	2002M1-2012M12

4. Methodology

The analyses can be divided into three main parts. In the first part of analyses, we conduct the preliminary tests such as unit-root test and cointegration test. In the second part, we proceed to generate the volatility series for exchange rate and stock returns using GARCH-type models (GARCH and EGARCH models). We compare the models and choose the volatility series that the model performs better. We then use the volatility series generated to proceed with VAR model estimation on the interaction relationship between these two series in the third part analyses. We summarize the discussions on the models/ methodology applied based on the following references: Alexander (2008), Lütkepohl and Krätzig (2004) and Alshogeafhri (2011).

4.1 Preliminary test: KPSS unit-root test

In this study, Kwiatkowski, Phillips, Schmidt and Shin (Kwiatkowski *et al.* (1992))

(KPSS) unit root test is applied to check for the stationarity of the series. The hypotheses are: y_t is I(0) or stationary against the alternative that y_t is I(1) or not stationary. In this study, we wish to test for the stationarity of two series, therefore y_t is the log of stock index and log of exchange rate series.

The KPSS test is based on the following linear regression (assume no linear trend term): $y_t = x_t + z_t$.
where x_t is a random walk, $x_t = x_{t-1} + v_t$, $v_t \sim iid\ (0, \sigma_v^2)$, z_t is a stationary process. It is also equivalent to state the test as:
$H_0 : \sigma_v^2 = o \Rightarrow y_t \sim I(0)$ vs $H_0 : \sigma_v^2 > o \Rightarrow y_t \sim I(1)$
Kwiatkowski et al. (1992) proposed the test statistic as $KPSS = \frac{1}{T^2} \sum_{t=1}^{T} S_t^2 / \hat{\sigma}_\infty^2$
Where T is the sample size, S_t is the accumulative of the residual function: $S_t = \sum_{j=1}^{t} \hat{\omega}_j$ with $\hat{\omega}_t = y_t - \bar{y}$ and $\hat{\sigma}_\propto^2$ is the estimator for $\sigma_\propto^2 = \lim_{T\to\infty} T^{-1} Var(\sum_{t=1}^{T} z_t)$, where $\hat{\sigma}_\infty^2$ represents the estimator of the long run variance of process z_t. The acceptance of KPSS test indicates the stationarity of y_t.

4.2 Preliminary test: Johansen-Julius (JJ) Cointegration Test

Johansen-Julius (JJ) cointegration test is applied to detect for the cointegrating relationship between variables. This test is performed before we conduct the VAR analysis.The test is applied on the two volatility series of exchange rate and stock returns to show that no cointegrating relationship exist between these series, hence it is valid to conduct the VAR estimation. The test is based on the error correction model with cointegration of order p :

$$\Delta y_t = c + (A_1 - I) y_{t-1} + A_2 y_{t-2} + ... + A_p y_{t-p} + \varepsilon_t \quad (1)$$

$$\Delta y_t = c + \sum_{j=1}^{p-1} \Gamma_j \Delta y_{t-j} + \prod y_{t-p} + \varepsilon_t \quad (1^*)$$

Equation (1) can be simplified to equation (1*) where $\Gamma_j = (A_1 + A_2 + ... + A_p - I)$ denotes the dynamics of the model in the short run, $\prod = (A_1 + A_2 + ... + A_p - I)$ shows the long run relationship between the variables studied and .I is the identity vector in the model.

The next step is to determine the rank of matrix $\prod$ in which the number of rank is corresponding to the number of independent cointegration vectors. There are several cases:

Case I: no rank ($\prod$) = 0)

There is no cointergrating relationship between variables. In other words, there is no linear combination of the variables existed in the vector y_t .

Case II: rank(Π)=1,

The initial assumption that all variables included in the y_t vector are $I \sim (1)$ is no longer applicable when rank (Π) is full rank.

Case III: rank (Π) = r

K is the number of variables included in this study, so totally we can only have at most K-1 rank. In this case when r is estimated at the range of $0 < r < K$, then variables included in the model are cointegrated, implying r linear combination among the two variables. We can conduct the following sequence of hypotheses:

$$H_o(0) : \text{rank}(\Pi) = 0 \quad \text{vs} \quad H_1(1) : \text{rank}(\Pi) > 0$$

$$H_o(1) : \text{rank}(\Pi) = 1 \quad \text{vs} \quad H_1(1) : \text{rank}(\Pi) > 1$$

$$\vdots \qquad\qquad\qquad\qquad \vdots$$

$$H_o(K-1) : \text{rank}(\Pi) = K-1 \quad \text{vs} \quad H_1(K) : \text{rank}(\Pi) = K$$

According to Lütkepohl and Krätzig (2004), if the null hypothesis cannot be rejected for the first time, then the corresponding cointegrating rank is selected, indicating VECM is the most appropriate model for further analysis. When all sequences of hypotheses cannot be rejected, VAR process in first differences should be applied for the subsequent analysis. VAR analysis is considered when all of the null hypotheses can be rejected.

4.3 Modeling Volatility Series - GARCH-Type Models

Before conducting the analyses, we perform the preliminary test: KPSS test to check for the stationarity of stock indices and exchange rate series (in log form). These series are not stationary at their levels but stationary after first differencing transformation. Therefore, we use the stationary series in first differencing (also known as returns) to proceed with our GARCH-type models estimation in generating the volatility series. The returns of stock indices and exchange rate are stated in the following form:

$$R_t^P = \ln(P_t) - \ln(P_{t-1})$$

$$R_t^E = \ln(E_t) - \ln(E_{t-1})$$

Both series assume to follow the AR(1) process as:

$$R_t = c_0 + c_1 R_{t-1} + \varepsilon_t \tag{2}$$

The noise series process is assumed to be normal distributed as $\varepsilon_t \mid \Omega_{t-1} \sim N(0, \sigma^2)$ and the conditional variance under GARCH(1,1) model can be computed as :

$$\sigma_t^2 = \alpha_0 + \alpha_1 \varepsilon_{t-1}^2 + \beta \sigma_{t-1}^2 \tag{3}$$

where Ω_{t-1} denotes to all the information available up to time (t-1), α_0 is the mean of yesterday's forecast and ε_{t-1}^2 is the lag of the squared residual obtained from the mean equation, also known as ARCH term. The ARCH terms represent the information about volatility from the previous time. The value will decline slowly but never reach zero. σ_t^2 is interpreted as the volatility or GARCH term. The GARCH term measures the impact of last period's forecast variance. The values of α_0, α_1 and β must be positive constants so that the conditional variance, σ_t^2 is always positive.

The GARCH(1,1) model is subject to the following assumption: $\alpha_1 + \beta_1 < 1$.When this condition is satisfied, ε_t has a constant unconditional variance and may be written as

$$\sigma_t^2 = \frac{\alpha_0}{1-\alpha_1-\beta_1}.$$

The EGARCH model is a non linear transformation of the classical GARCH model. The EGARCH model was designed to capture the asymmetric impact of good and bad news that absent in the GARCH model. Under the conditional normality assumption, the EGARCH (1, 1) model is computed as:

$$\log(\sigma_t^2) = \alpha_0 + \alpha_1\left[\frac{|\varepsilon_{t-1}|}{\sqrt{\sigma_{t-1}^2}} - \sqrt{\frac{2}{\pi}}\right] + \gamma\frac{\varepsilon_{t-1}}{\sqrt{\sigma_{t-1}^2}} + \beta_1\log(\sigma_{t-1}^2) \quad (4)$$

α_0 denotes the mean of yesterday's forecast while α_1 is the size of shock or the symmetric effect of the model. β_1 measures the level of persistency of volatility, the larger the β_1, the longer the time for volatility to diminish following a crisis in the market. γ measures the asymmetry impact on volatility or the leverage effects. When $\gamma > 0$, positive innovations are more destabilizing than negative innovations, hence the effect is negative. On the other hand, if $\gamma < 0$, we observe positive leverage effect.

In this study, we modify the EGARCH(1,1) model to include the exogenous variables and dummy variables:

Volatility of exchange rate model:

$$\log(\sigma_{Et}^2) = \alpha_0 + \alpha_1\left[\frac{|\varepsilon_{Et-1}|}{\sqrt{\sigma_{Et-1}^2}} - \sqrt{\frac{2}{\pi}}\right] + \gamma\frac{\varepsilon_{Et-1}}{\sqrt{\sigma_{Et-1}^2}} + \beta_1\log(\sigma_{Et-1}^2) + aX_t + bD_t \quad (5)$$

Volatility of stock returns model:

$$\log(\sigma_{Pt}^2) = \alpha_0 + \alpha_1\left[\frac{|\varepsilon_{Pt-1}|}{\sqrt{\sigma_{Pt-1}^2}} - \sqrt{\frac{2}{\pi}}\right] + \gamma\frac{\varepsilon_{Pt-1}}{\sqrt{\sigma_{Pt-1}^2}} + \beta_1\log(\sigma_{Pt-1}^2) + aX_t + bD_t \quad (6)$$

where X_t = (*money supply, interest rate, international reserves*)
D_t = (*trend, seasonal dummy, IT dummy*)

D_t is a vector of dummy variables and IT represents the dummy for inflation targeting. The IT dummy is added to the regression to differentiate the pre- and post inflation targeting periods. The value of 1 is assigned for IT period while the value of zero is assigned for non-IT period.

4.4 Vector Autoregressive Model, VAR(p)

To analyze the relationship between volatility of exchange rate and stock returns, we proceed with the VAR model. VAR model is valid as there is cointegrating relationship between both series. Assuming that we have *K* variables in the system equation $y_t = (y_{t1},..., y_{Kt})'$, the p-order VAR(*p*) model can be written as:

$$y_t = A_1 y_{t-1} + ... + A_p y_{t-p} + \varepsilon_t \quad (7)$$

where A_i's are $(K \times K)$ coefficient matrices, $\varepsilon_t = (\varepsilon_{1t}, ..., \varepsilon_{Kt})'$ is an unobservable error term. The covariance matrix $E(\varepsilon_t \varepsilon_t') = \sum_\varepsilon$, where $\varepsilon_t \sim (0, \sum_\varepsilon)$ has a zero-mean independence white noise process and it is time-invariant. In this study, our VAR (*p*) model is modified and computed as

$$y_t = A_1 y_{t-1} + ... + A_p y_{t-p} + aX_t + bD_t + \varepsilon_t \qquad (8)$$

where X_t = (*money supply, interest rate, international reserves*),
D_t = (*trend dummy, seasonal dummy, IT dummy*)

$y_t = \begin{bmatrix} \sigma^2_{Et} \\ \sigma^2_{Pt} \end{bmatrix}$ consists of the volatility series generated using EGARCH(1,1) model, i.e. σ^2_{1t} and σ^2_{2t} are the volatility of exchange rate and stock return series respectively. The volatility series are obtained from EGARH(1,1) estimation but not from GARCH(1,1) model. The volatility series from EGARCH(1,1) is selected because the results of GARCH(1,1) do not fulfill the requirement of $\alpha_1 + \beta_1 < 1$.

5. Results

Table 2 summarizes the results of KPSS test based on the log exchange rate and log stock indices. As observed, all tests reject stationary using the log levels data. However, all series become stationary using the first differencing transformation. Therefore, we proceed with GARCH and EGARCH modelling using the stationary data in first differenced form or in returns of exchange rate and stock markets. As our GARCH(1,1) models do not fulfil the requirement of $\alpha_1 + \beta_1 < 1$, we use the volatility series generated from EGARCH(1,1) models to proceed with VAR estimation (see Table 3 for details).

Before conducting the estimation, we need to check for the cointegrating relationship and determine the optimal lag length. Johansen-Julius cointegration test is employed to detect the cointegrating relationship between volatility of exchange rate and stock returns. The results fail to detect any cointegrating relationship, suggesting that VAR model is the suitable model to be applied (see Table 4). Referring to the rules of the cointegration test (Lütkepohl and Krätzig, 2004), we estimate VAR model in level for the case of Indonesia, Korea and Philippines but apply VAR model in first differencing for the case of Thailand.

In order to determine the optimal lag length for the VAR system, four different criteria including the Akaike information criterion (AIC), final prediction criteria (FPE), Hannan-Quinn information criterion (HQ) and Schwarz information criterion(SC) are employed. The optimal lag lengths to be selected are 9, 7, 2 and 10 for Indonesia, Korea, Philippines and Thailand respectively. The results of VAR estimation are summarized in Table 5. In this study, we impose the subset restriction on the coefficient matrices in order to improve the results. System SER will eliminate the parameter with the smallest *t*-ratio in each step. For further explanation about subset restriction selections, check the Help System of JMulTi software. The model is checked by applying several diagnostic tests (LM test for autocorrelation, CUSUM test for stability and the correlation of residuals). Our models have passed the diagnostic tests. Due to limitation of space, we do not present the results of diagnostic tests here.

Table 5 summarizes the results of VAR estimations. The results show significance interactions between volatility of exchange rate and stock returns across countries. Although both series do not exhibit the long-run relationship, they are evidences on the short-run bi-directional relationship between the two series.

Moving to the determination of macroeconomic/ monetary factors, the results show that these three variables have significance impacts on determining the movements of volatility of exchange rate and stock returns in most cases. It is observed that the monetary variables of interest rate and money supply lead to higher volatility of exchange rate and stock return in Korea. On the other hand, the international reserves tend to reduce the volatility of exchange rate but increase the stock return volatility in Korea. In Philippines, only money supply shows significance impact, i.e. higher stock reserves leads to higher volatility of exchange rate in Philippines. In the case of Thailand, the significance monetary variables that determine the two volatility series are interest rate, money supply and international reserves. Our results show that interest rate tends to increase the volatility of stock market returns. Additionally, money supply leads to higher volatility of Thai baht and stock return.

Besides, our results also reveal significance effect on the implementation of inflation targeting on the relationship between these two volatility series. For instance, the adoption of IT leads to greater volatility of exchange rate and stock return in Indonesia but it leads to lower volatility of stock return in Philippines. This result is in line with the results reported by Curado and Rocha (2011), who found a positive relationship between exchange rate volatility and free-floating exchange rate. The authors also explained that one of the costs of IT adoption is the greater increase in exchange rate volatility. Inflation targeting leads to different impacts on the two volatility series in Thailand. The implementation of inflation targeting tends to lower the volatility of Thai baht but it leads to greater volatility of stock return in Thailand.

5.1 Impulse Response Function (IRF) and Forecast Error Variance Decomposition (FEVD)

Plotting the impulse responses is a practical way to explore the response of each variable to shocks. The statistical significance of the impulse response function is examined at 95% confidence bound. The results of IRF are consistent with the results of forecast error variance decomposition (FEVD) in terms of the volume of responses. The results of IRF can be provided upon request. The results of FEVD are summarized in Table 5. The results of FEVD suggest that each of the variables can be explained by the disturbance of others, implying interaction effects between volatility of exchange rate and stock returns.

The results show that at the first month horizontal, it is forecasted that 1% increase in the shock of exchange rate volatility accounts for the 100% forecast on the movement of exchange rate volatility but its forecast error variance decomposition on the volatility of stock return volatility is 0%. The results hold for all countries. Therefore, the results show that the exchange rate volatility shocks do not cause to an immediate response in the volatility of stock returns in all four countries. When the time horizontal (monthly) increases, the impact of exchange rate volatility shock on exchange rate volatility is diminishing but its impacts on the volatility of stock market is increasing. Comparing the results across countries, a very low impact of exchange rate shock on the volatility of stock returns in Philippines and Thailand is observed.

Unlike shock of exchange rate volatility, the shock of stock return volatility leads to an immediate change in volatility of exchange rate and stock returns in all countries. For instance, 1% increase in the shock of Thailand stock return volatility can explain 22% of exchange rate volatility and 78% of stock return volatility at the first month horizon. The shock to the exchange rate volatility shows an increasing trend in Korea, Philippines and Thailand. The results illustrate that shocks of Thailand stock return volatility exert the highest impact on Thai baht volatility among the countries.

Table 2: Results of KPSS stationary test

Panel A: Unit root test for the Pre-IT period

Country	Variables	Levels	First difference I(1)
Indonesia	E	2.7363**	0.1262
	S	1.4021**	0.1009
Korea	E	1.1718**	0.2230
	S	0.4946**	0.2639
Philippines	E	3.8010**	0.1490
	S	1.1226**	0.2640
Thailand	E	2.6139**	0.1118
	S	2.0160**	0.1731

Panel B: Unit root test for the Post-IT period

Country	Variables	Levels	First difference I(1)
Indonesia	E	0.2255**	0.1108
	S	4.8191**	0.1475
Korea	E	1.2546**	0.0930
	S	4.6213**	0.0514
Philippines	E	3.7642**	0.1540
	S	3.8764**	0.0764
Thailand	E	4.7921**	0.2258
	S	4.1534**	0.1032

Panel C: Unit root test for the full sample period

Country	Variables	Levels	First difference I(1)
Indonesia	E	7.2339**	0.1421
	S	1.8532**	0.2356
Korea	E	3.6180**	0.1020
	S	2.6334**	0.1453
Philippines	E	6.0954**	0.3325
	S	1.3052**	0.1950
Thailand	E	3.7855**	0.1974
	S	1.9369**	0.2344

Notes: E denotes the log of exchange rate and S denotes the log of stock index

: ** denotes 5% significance level

Table 3: GARCH estimation

	Indonesia	Korea	Philippines	Thailand
Mean equation : $R_e = C + \eta R_{e;t-1}$				
C	0.263**	0.046	-0.001	-0.054
η	0.102	0.164**	0.061	0.170**
Variance equation: $\sigma_{1t}^2 = \alpha_0 + \alpha_1 \varepsilon_{1t-1}^2 + \beta_1 \sigma_{1t-1}^2 + a_1$ interest rate + a_2 money supply + a_3 international reserves + b_0 trend+ b_1 IT				
α_0	3.589**	-2.851**	-12.696	15.492**
α_1	0.824**	0.851**	0.290	0.115**
β_1	0.433**	0.204**	0.563	0.729**
a_1	0.371**	0.528**	0.574	1.038**
a_2	1.432**	0.835**	1.639	0.303**
a_3	-1.094**	-0.308**	-0.392	-1.994**
b_0	-	-	-	0.033**
b_1	1.650**	2.852**	-1.497	-1.739**

NOTE: ** denote significance at 5%

Table 4: Johansen-Juselius Cointegration Test

Trace Statistic	Hypothesis		Test value	P value	90%	95%
	Null	Alternative				
Indonesia	r=0	r>0	72.91	0.0000**	17.98	20.16
	r=1	r>1	15.39	0.0024**	7.60	9.14
Korea	r=0	r>0	48.95	0.0000**	17.98	24.69
	r=1	r>1	20.40	0.0002**	7.60	12.53
Philippines	r=0	r>0	43.30	0.0000**	17.98	20.16
	r=1	r>1	9.25	0.0475**	7.60	9.14
Thailand	r=0	r>0	14.39	0.2694	17.98	20.16
	r=1	r>1	4.07	0.4138	7.60	9.14

NOTE: ** denote significance at 5%

Table 5. Results of VAR estimation for Philippines and Thailand.

Coeff. for variables	Indonesia		Korea		Philippines		Thailand	
	VE	*VP*	*VE*	*VE*	*VE*	*VP*	*VE*	*VP*
VE(-1)	--	-0.055 **	0.494**	0.494**	0.494**	0.748**	-0.126 **	0.656 **
VE(-2)	0.29	--	0.220**	0.220**	0.220**	-0.173	-0.279 **	--
VE(-3)	-0.404**	-0.23**					0.135 **	--
VE(-4)	-0.469**	0.077**					--	--

VE(-5)	--	0.263**					0.208 **	--
VE(-6)	-0.364**	-0.307**					--	0.338 **
VE(-7)	0.128**	0.124**					-0.133**	--
VE(-8)	-0.201**	-0.295**					--	1.297**
VE(-9)	-0.545**	--					-0.148**	0.985**
VE(-10)							-0.08	0.424**
VP(-1)	1.662**	1.012**	0.02	0.02	0.02	0.795**	0.100 **	--
VP(-2)	--	-0.515**	0.022	0.022	0.022	-0.104 *	--	--
VP(-3)	-0.318**	0.835**					-0.079 **	--
VP(-4)	1.975**	0.169**					--	--
VP(-5)	0.655**	--					-0.044*	-0.111**
VP(-6)	--	-0.120**					--	--
VP(-7)	-0.428**	--					0.038*	--
VP(-8)	0.301**	0.298**					--	-0.130**
VP(-9)	--	-0.177**					--	--
VP(-10)							-0.031	-0.092*
Constant	934.036 **	--	--	--	-21.849	-25.87	--	--
a_1	-202.086	--	303.173**	48.032 **	-0.047	-1.639	--	4.673 **
a_2	276.162 **	57.742 **	740.494 **	62.950 **	4.464 *	10.698	12.293 **	13.504 **
a_3	-199.874 **	-29.496 **	-491.220 **	18.961**	-2.774	-5.365	-7.339 **	-8.930 **
b_1	--	--	548.228 **	69.310 **	0.146	-22.499**	-0.887 **	4.493 **
Seas(1)			-138.204**	--	--	--	--	--
Seas(2)			--	--	--	--	--	--
Seas(3)			--	--	--	--	--	--
Seas(4)			--	--	--	--	--	--
Seas(5)			--	--	--	--	--	--
Seas(6)			-59.692	--	--	--	--	--
Seas(7)			--	--	--	--	--	--
Seas(8)			-107.923	--	--	--	--	--
Seas(9)			-85.121	--	--	--	--	--
Seas(10)			-77.551	--	--	--	--	--
Seas(11)			--	--	--	--	--	--

** and * denote significance at 5% and 10% respectively

-- denotes that the regressors are being eliminated during procedure of subset restriction selection

VE represents the volatility of exchange rate

VP denotes the volatility of stock returns

Table 6. Results - FEVD.

Countries	Month	Exchange rate Volatility		Stock Return Volatility	
		VE	*VP*	*VE*	*VP*
Indonesia	1	1.00	0.00	0.15	0.85
	4	0.50	0.50	0.12	0.88
	8	0.20	0.80	0.13	0.87
	12	0.19	0.81	0.11	0.89
Korea	1	1.00	0.00	0.19	0.81
	4	0.95	0.05	0.15	0.85
	8	0.85	0.15	0.20	0.80
	12	0.79	0.21	0.23	0.77
Philippines	1	1.00	0.00	0.02	0.98
	4	0.97	0.03	0.17	0.83
	8	0.94	0.06	0.24	0.76
	12	0.92	0.08	0.26	0.74
Thailand	1	1.00	0.00	0.22	0.78
	4	0.94	0.06	0.29	0.71
	8	0.93	0.07	0.30	0.70
	12	0.92	0.08	0.49	0.51

VE represents the volatility of exchange rate
VP denotes the volatility of stock returns

6. Conclusion

This paper summarizes our empirical results on the interaction between volatility of exchange rate and stock returns in four Asian countries that experience drastic change in their exchange rate regimes due to financial crisis of 1997. Our main objective is to reveal how the drastic switch from fixed to flexible exchange rate and inflation targeting regime in these countries can affect the inter-relationship between volatility of exchange rate and stock returns. In addition, we also investigate if the three monetary variables (interest rate, international reserves and money supply) can influence the interaction between both volatility series. Our data are tested using unit-root and cointegration tests. The GARCH-type models are applied to generate the volatility series for exchange rate and stock returns. We then proceed to analyze the interaction relationship between both volatility series using the VAR model. Our results are checked using some diagnostic tests. Our results fail to detect the long-run cointegrating relationship between both volatility series. However, we are able to reveal a two-way short-run relationship between the volatility of exchange rate and stock return in all countries. Interest rate, money supply and international reserves have significance impacts on determining the movements of volatility of exchange rate and stock return in most cases. Besides, we also observe significance impact on the change of the volatility of exchange rate and stock return between the pre-IT and post-IT periods.

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