The Empirical Relationship Between Exchange Rates and Interest Rates in Post-Crisis Asia

Hwee Kwan CHOW*
Singapore Management University

Yoonbai KIM
University of Kentucky and
National University of Singapore

March 2004

Abstract

In post-crisis Asia, all crisis-hit countries (except Malaysia) announced a shift from exchange rate based monetary policy framework to the explicit adoption of inflation targeting that uses interest rates as the key monetary policy operating instrument. In this study, we examine the empirical relationship between exchange rates and interest rates, and investigate how the dynamics between them have changed following the crisis. This is carried out by constructing a bivariate VAR-GARCH model for each of the four Asian crisis countries, namely Indonesia, Korea, Philippines and Thailand. The findings suggest these countries do not use interest rate policy more actively to stabilize exchange rates after the crisis, and provide evidence that their domestic currencies exhibit greater sensitivity to competitors' exchange rates post-crisis. Further, the results indicate that increased exchange rate flexibility has not led to greater stability in interest rates in these economies.

Key Words: Exchange rate, interest rate, bivariate VAR-GARCH model, causation in volatilities

JEL classification: F33, F41

---

* Corresponding author: School of Economics and Social Sciences, Singapore Management University, 469 Bukit Timah Road, Singapore 259756. (Email) hkchow@ smu.edu.sg, PH:(65)6822-0868, FAX: (65) 6822-0833.

I. INTRODUCTION

The defacto peg to the US dollar of East Asia's currencies and the attendant moral hazard problem have often been cited as important causes of the 1997 financial crisis that hit the region. In the aftermath of the crisis, all the crisis-hit countries (with the notable exception of Malaysia) announced a shift from exchange rate based monetary policy framework to the explicit adoption of inflation targeting.[1] Notwithstanding continued official interventions in the foreign exchange markets, these countries, namely, Indonesia, (South) Korea, Philippines and Thailand announced their move towards using interest rates as the key monetary policy operating instrument. The experiences by these economies pose several interesting questions. For instance, do these countries employ the interest rate policy more actively to smooth exchange rate fluctuations in the post-crisis period? Are their exchange rates now more responsive to international pressure than before? Does greater exchange rate flexibility help reduce interest rate volatility?

To examine these issues, we explore the empirical relationship between the exchange rate and interest rate in levels and variability for the four Asian crisis countries. The levels relationship between the interest rate and the exchange rate can at times be ambiguous. For instance, whether higher interest rates are an essential part of the defense strategy for the currency in times of financial crisis is controversial. This uncertainty is well borne out in the context of the Asian financial crisis. While many economists, including those from the IMF, recommended sharp increases in the interest rate to stem large depreciation of the currency, some including Furman and Stiglitz (1998) argue that the high interest rate policy destabilizes exchange rates by raising corporate bankruptcies and accelerating capital outflows.[2]

With regard to the volatility relationship, it is conventionally argued that greater exchange rate variability is stabilizing in the sense that it releases the pressure off the economy and promotes

[1] Malaysia chose to impose capital controls in September 1998 and installed a fixed exchange rate. These measures have apparently succeeded in stabilizing not only the exchange rate but also the interest rate.
[2] Goldfajn and Gupta (1999) find that high interest rates helped stabilize exchange rates using monthly data for 80 countries for 1980-98. Cho and West (2001) report a similar finding for 5 East Asian crisis countries.

stability in such macroeconomic aggregates as interest rates, money supply and output. Indeed, one of traditional advantages of floating rates is that interest rates are more stable as the monetary authority is free from the burden of maintaining the exchange rate fixed. (Reinhart and Reinhart, 2001) Conversely, fixing the exchange rate is considered to induce intersectoral or intertemporal shift in volatilities to other variables (Frenkel and Mussa 1980; Frankel and Rose 1995; Rose 1995). In this approach, the Asian financial crisis is cited as an example of such volatility shifts under fixed or tightly managed exchange rate regimes.[3] On the other hand, the hypothesis that exchange rate volatility may enhance volatility in other variables such as interest rates has had many followers. (Nurkse 1944 and McKinnon 2001)

When considering the interaction between the interest rate and the exchange rate, it is necessary to control the influence of extraneous factors. In the context of East Asia, we consider three major sources of shocks to regional financial markets: the U.S. interest rate, the yen-dollar exchange rate, and the average dollar exchange rate of neighboring countries. First, the U.S. interest rate measured by the federal funds rate sets a basic point of reference in the financial markets that are closely linked to the U.S. Second, fluctuations in the yen-dollar exchange rate strongly affect East Asian economies. Indeed, the sharp depreciation of the yen that started in 1995 has been considered as one of important causes of the Asian financial crisis.[4] Third, the average of the dollar exchange rates of other East Asian countries captures the effects of competition among East Asia countries.[5] There is a consensus that contagion was an important source of the financial crisis and trade competition a key channel of contagion in East Asia. See, for instance, Baig and Goldfajn (1999) and Glick and Rose (1999).

[3] The usual prescription to avoid financial crisis due to the insurance-effect of near pegged exchange rates includes greater exchange rate flexibility on the grounds that it would moderate otherwise volatile capital flows and help reduce excessive boom-bust cycle associated with capital flows. See, inter alia, Radelet and Sachs (1998) and Corsetti and Roubini (1999).

[4] See Kwan (1995) for related discussion.

[5] In the group of East Asian competitors, we include Malaysia, Singapore and Taiwan in addition to the four crisis countries under study.

In this paper, we apply the bivariate vector autoregression – generalized autoregressive conditional heteroskedastic (VAR-GARCH) model to weekly data for each of the four Asian crisis economies for simultaneous estimation of the level and volatility relations between the exchange rate and interest rate, and determine whether these relationships have been altered following the crisis.[6] To anticipate the main findings of the paper to the afore-mentioned questions: we found that exchange rate levels are more sensitive to competitors' exchange rate after the crisis. However, we found no evidence to support the more active use of interest rate policy to stabilize exchange rate in the post-crisis period. The results also indicate that increased exchange rate flexibility do not affect interest rate volatility positively or negatively in these economies.

The rest of the article proceeds as follows: the next section contains a preliminary analysis of historical exchange rate and interest rate movements. Section 3 describes the econometric methodology used in empirically determining the relationship between exchange rates and interest rates. The empirical results are presented in Section 4. This paper ends in Section 5 with some concluding remarks.

II. DATA AND STYLISED FACTS

We define the exchange rate as the local currency price of the US dollar, so that an increase signals a depreciation of the local currency. The call rate is used to represent interest rates. We employ weekly data obtained from *Datastream* for the period from 1993:1:1 to 2002:7:30.[7]

Figure 1 here

The panels in Figure 1 show for each of the four countries the log of the exchange rate (top) and its change (bottom) on the left-hand side and the interest rate (top) and its change (bottom) on the right-hand side. Figure 1e depicts the log-level and its change of the yen-dollar exchange rate

[6] Voluminous literature exists on GARCH models. For instance, Bodart and Reding (1999) study the effects of exchange rate volatility on cross-border bond and stock market correlation; while Edwards and Susmel (2000) apply a switching ARCH model to study transmission of interest rate volatilities in Latin American countries.

and the U.S. federal funds rate. Two vertical bars indicate the crisis period. It is defined as a one-year period starting June 1997 (one month before the Thai devaluation crisis erupted on July 2, 1997). A cursory reading of exchange rate changes in the figures suggests, however, that the crisis period may need to be defined differently for Korea. Since the financial crisis did not start until late 1997 and seemed to have lasted until late 1998, we define the crisis period for Korea as 1997:10:1 – 1998:12:1.

Table 1 here

On the eve of the 1997 financial crisis, all four countries intervene heavily to maintain export competitiveness or the trade balance within desired levels. Reinhart and Rogoff (2002) classify the exchange rate system in those countries as follows: crawling peg to the US dollar for Indonesia and Korea, de facto band around the US dollar for Philippines and de facto peg to the US dollar for Thailand.[8] McKinnon (2000) terms the stability of the dollar exchange "East Asian Dollar Standard."

It is clear that the nominal exchange rates in all these countries were extremely stable in the pre-crisis period. Standard deviations are very small in comparison to that of the yen-dollar rate shown in Figure 1e, which is classified as one of a few truly floating exchange rates. Calvo and Reinhart (2002) In marked contrast, interest rates are far more volatile in the four countries than the benchmark federal funds rate. Calvo and Reinhart (2002) attribute the interest rate volatility to the "confidence problem."

At the onset of the crisis, all countries suffered large devaluations and their financial markets oscillated wildly. While the variability of exchange rate in all four countries (as measured by standard errors) shot up in the immediate aftermath of the crisis, they declined equally precipitously in the post-crisis period although they but remain slightly higher than the pre-crisis

[7] Although more data are available before 1993 for some countries, we have decided to use approximately symmetric lengths for each country for the pre- and the post-crisis periods.

levels. Interestingly, the interest rate series exhibited very different patterns. Except for Indonesia, interest rate fluctuations were much less pronounced post-crisis and the variability declined below pre-crisis levels. Hence, the exchange rates of the crisis countries appear to be more flexible while the volatility in their interest rates (except for Indonesia's) completely evaporated after the crisis. At a superficial level, this may be taken as an evidence of tradeoff between the volatilities of the exchange rate and the interest rate.

III. ECONOMETRIC METHEDOLOGY

All data series under study exhibit volatility clustering typical of financial data. Hence, we apply the bivariate VAR-GARCH model, where volatility is represented by conditional variance – the error variance in forecasting the variable one period advance using all currently available information.[9] The bivariate VAR-GARCH model can be summarized as follows:

$$(1) \quad \begin{bmatrix} y_{1t} \\ y_{2t} \end{bmatrix} = \begin{bmatrix} G_{10} \\ G_{20} \end{bmatrix} a + \sum_{n=1}^{P} \begin{bmatrix} G_{11}^{n} & G_{12}^{n} \\ G_{21}^{n} & G_{22}^{n} \end{bmatrix} \begin{bmatrix} y_{1,t-n} \\ y_{2,t-n} \end{bmatrix} + \begin{bmatrix} D_{11} & D_{12} & D_{13} \\ D_{21} & D_{22} & D_{23} \end{bmatrix} \begin{bmatrix} z_{1,t-1} \\ z_{2,t-1} \\ z_{3,t-1} \end{bmatrix} + \begin{bmatrix} u_{1t} \\ u_{2t} \end{bmatrix}$$

$$\begin{bmatrix} u_{1t} \\ u_{2t} \end{bmatrix} | \, \Omega_{t-1} \sim N(0, H_t)$$

$$(2) \quad \begin{bmatrix} h_{11,t} \\ h_{22,t} \end{bmatrix} = \gamma + \begin{bmatrix} A_{11} & A_{12} \\ A_{21} & A_{22} \end{bmatrix} \begin{bmatrix} h_{11,t-1} \\ h_{22,t-1} \end{bmatrix} + \begin{bmatrix} B_{11} & B_{12} \\ B_{21} & B_{22} \end{bmatrix} \begin{bmatrix} u_{11,t-1}^{2} \\ u_{22,t-1}^{2} \end{bmatrix} + \begin{bmatrix} C_{11} & C_{12} & C_{13} \\ C_{21} & C_{22} & C_{23} \end{bmatrix} \begin{bmatrix} z_{1,t-1}^{2} \\ z_{2,t-1}^{2} \\ z_{3,t-1}^{2} \end{bmatrix}$$

$$(3) \quad h_{12,t} = \rho [h_{11,t} h_{22,t}]^{1/2}$$

---

[8] In each case, the authority pegs the local currency to a basket of currencies of major trading partners (with strong emphasis on the US dollar) while holding sufficient discretionary power in setting the weights and currency combinations of the basket.

[9] Using conditional variance makes it possible to consider continuous changes in exchange rate variability instead of discrete changes associated with exchange rate regimes.

where $y_{1t} = \Delta e_t$, change in the log of the exchange rate, and $y_{2t} = \Delta r_t$, change in the interest rate. u_t is a 2×1 column-vector of forecast errors conditional on past information, Ω_{t-1}, with its 2×2 conditional covariance matrix $H_t = [h_{ij,t}]$. We employ three variables that are considered to represent major external shocks to the countries under study: the U.S. interest rate, z_{1t}, the yen-dollar exchange rate, z_{2t}, and the average dollar exchange rate of neighboring countries, z_{3t}. (z_{1t} and z_{3t} are in log.) The model is augmented by exogenous variables both in the mean and the variance equations.

The mean equation, Eq (1), shows that exchange rate changes and the interest rate follow a VAR process of order P. The optimal lag length P for the VAR process based on the Akaike Information Criterion (AIC) appears fairly short. It turns out that small lags of 1, 2 or 3 can adequately represent the mean equation in the models. This seems plausible with the use of weekly observations as opposed to more finely sampled data such as those of daily frequency. In the following, we report the estimation results for the model with 3 lags. Using other lags makes little qualitative difference to the results.

The variance equation, Eq (2), models the conditional variance of the residual vector as a linear function of its own past value as well as the past value of squared innovation. The model captures both transient and persistent volatility relationships over time and between the variables. Matrix A measures the extent to which the current levels of conditional variances are correlated with their past values. The conditional variances are also directly affected by squared errors in the previous period, as indicated by matrix B in the model. While matrix A shows long-term relationship between two volatilities, matrix B depicts short-term effects of shocks on the conditional variance. Of particular interest are off-diagonal terms in matrices A and B. Significantly negative (positive) estimates of A_{21} or B_{21} are taken as evidence of volatility tradeoff (enhancement) in which an increase in exchange rate variability leads to a decrease (increase) in interest rate volatility over the long-term or short-term respectively.

By adding exogenous variables in both the mean and variance equations, we can test important hypotheses related to the choice of the exchange rate regime in East Asia. In particular, we can test the evidence of soft-dollar pegging exchange rate policy by investigating the responses to changes in the yen-dollar rate. Small and insignificant responses would be consistent with implicit or explicit pegging to the US dollar, while large and significant responses would suggest that these countries attempt to offset at least partially fluctuations in the yen-dollar exchange rate.

There are various parameterizations of the multivariate GARCH model including the constant correlation model of Bollerslev (1990) adopted here. In this model, Eq (3), the covariance matrix (H_t) is time varying but the conditional correlation (ρ) across the equations is assumed to be constant over time. This specification ensures that the estimated conditional variance matrix to be positive semi-definite while allowing sufficient generality without an excessive number of parameters to be estimated.[10] In the above formulation we follow Ballie and Bollerslev (1987) and Schwert and Seguine (1990), in using the constant correlation assumption together with a GARCH (1,1) process. Preliminary experimentation with univariate models reveals that higher order ARCH and GARCH terms turn out to be insignificant in most cases and that the conditional variances are well approximated by the simple model.

I V. EMPIRICAL RESULTS

[10] Another way to impose the positive semi-definiteness of covariance matrices is the BEKK formulation developed by Baba, Engle, Kraft, and Kroner (1989). This representation is not employed, as it is not clear how the coefficients can be tested or interpreted in this context.

Tables 2 and 3 report the estimation results of the bivariate VAR-GARCH model for the level and variance equations respectively. In the levels equation, the main coefficients of interest are G_{21}^{i} (for i=1,2,3), which show whether countries attempt to adjust the interest rate in response to changes in the exchange rate. With the exception of pre-crisis Philippines, none of the G_{21}^{i} coefficients turned out to be significant. The insignificant coefficients point to the lack of responsiveness in the interest rates to changes in the domestic currency. This suggests that interest rates have not been more actively managed to stabilize the exchange rate in the post-crisis period than before.[11]

<u>Table 2 here</u>

All the Asian crisis countries appear to adjust their exchange rate more sensitively in the post-crisis period to changes in the neighbors' exchange rate. Coefficients C_{13} become significant as we move from pre- to post-crisis periods for Indonesia, Korea and the Philippines. As for Thailand, the coefficients C_{13} that are significant in both sample periods exhibited an increase in magnitude following the crisis. This suggests that contagion has become a more important factor of exchange rate determination after the crisis. However, the evidence on soft-dollar pegging exchange rate policy is mixed. We found C_{12} coefficients to be significant only for post-crisis Korea and Thailand for both sample periods, indicating greater responsiveness in exchange rates to changes in the yen-dollar rate only for these cases. There is no indication that these countries use the interest rate to adjust to exogenous shocks as none of the C_{2j} (for j=1,2,3) coefficients turn out to be significant. If we take the coefficients on the US interest rate as an indicator of financial openness, the results seem to suggest that there is little difference in the extent of actual openness before and after the crisis in these countries.

<u>Table 3 here</u>

[11] A possible explanation of the aversion to the use of interest rates as an instrument to stabilize exchange

In the variance equation, the key coefficients of interest are A_{21} and B_{21}, which capture the long-term influence and short-term impact of exchange rate variability on interest rate volatility respectively. Significantly negative A_{21} or B_{21} estimates provide evidence of volatility trade-off for Indonesia and Korea in the post-crisis period and for pre-crisis Philippines. In the case of Thailand, B_{21} is significantly positive, suggesting that greater exchange rate flexibility increases interest rate volatility. The A_{21} and B_{21} estimates are insignificant for all other cases.

On balance, there is no strong evidence that greater exchange rate variability enhances interest rate volatility in the long run or on impact. At the same time, there is only marginal support for the hypothesis that greater exchange rate flexibility stabilizes the interest rate. A possible explanation for the absence of a consistent volatility relationship between observed exchange rates and interest rates is that they are distorted by restrictions on interest rates and official interventions in the foreign exchange market respectively.

V. CONCLUDING REMARKS

In this paper, we investigate the empirical relationship between the exchange rate and the interest rate for four Asian crisis countries – Indonesia, Korea, Philippines and Thailand – by applying the bivariate VAR-GARCH model to weekly data. Exogenous variables are introduced to both the mean and variance equations to capture the influence of external shocks. The results show increased sensitivity of the exchange rate to competitors' exchange rates after the crisis, suggesting that contagion is now a more important factor in exchange rate determination. On the other hand, there is no evidence that these crisis countries have used interest rate policy more actively to defend their domestic currencies in the post-crisis period. This concurs with the results of Calvo and Reinhart (2002) in that countries which have replaced foreign exchange intervention with interest rate policy for smoothing exchange rate fluctuations are those with high interest rate

---

rates could be the potential negative impact of interest rate hikes on the level of economic activity.

variability, exempting the Asian countries. In addition, we found interest rates in post-crisis Asia do not seem to have become more responsive to exogenous shocks. These findings contradict with the announced policy shift and the adoption of interest rates as key operating monetary policy instrument in the four countries.

As for the interaction between exchange rate and interest rate volatility, there is no strong evidence that an increase in exchange rate variability is associated with an increase in interest rate volatility in any of the four countries. However, there is only marginal support for the volatility trade-off hypothesis that greater exchange flexibility is stabilizing in terms of lowering the variability in the interest rate. These results are broadly consistent with Rose (1995) and Baxter and Stockman (1989) in that exchange rate volatility is neither the price of certain intertemporal/intersectoral tradeoff nor to be transmitted to other variables. They imply that to the extent that exchange rate volatility is considered harmful, it should be reduced and the reduction will not be costly at least in terms of increased interest rate volatility. In addition, our results imply in their face value that letting the exchange rate be more flexible does not have to be costly as suggested by the insignificant effect on such a key variable as interest rate volatility. We hasten to add that drawing such an implication may be unwarrantedly strong since observed exchange rates and interest rates are presumably distorted due to restrictions on interest rates and international capital flows and interventions in the foreign exchange market. That would be a topic for further study.

ACKNOWLEDGEMENTS

We thank Reiny Iriana and Shirley Fong for research assistance and Yung-hsiang Ying for his help with the data. This research was supported by University Research Grant (No. R-122-036-112) at the National University of Singapore.

REFERENCES

Baba, Y., R. Engle, D. Kraft and K. Kroner, "Multivariate Simultaneous Generalized ARCH," unpublished manuscript, University of California at San Diego, Department of Economics, (1989).

Baig, T. and I. Goldfajn, "Financial Market Contagion in the Asian Crisis," *IMF Staff Papers* 46 (June 1999), 167-195.

Baillie, R.T. and T. Bollerslev, "A Multivariate Generalized ARCH Approach to Modelling Risk Premia in Forward Exchange Rate Markets," *Journal of International Money and Finance 9* (1987), 309-324.

Baxter, M. and A. Stockman, "Business Cycles and the Exchange Rate Regime: Some International Evidence," *Journal of Monetary Economics* 23 (May 1989), 377-400.

Bodart, V. and P. Reding, "Exchange Rate Regime, Volatility and International Correlations on Bond and Stock Markets," *Journal of International Money and Finance* 18 (1999), 133-151.

Bollerslev, T. "Modelling the Coherence in Short-run Nominal Exchange Rates: A Multivariate Generalised ARCH Model," *Review of Economics and Statistics* 72 (1990), 498-505.

Calvo, G. and C. Reinhart, "Fear of Floating," *Quarterly Journal of Economics* CXVII, No. 2, (2002), 379-408.

Cho, D. and K. West, "Interest Rates and Exchange Rates in the Korean, Philippine, and Thai Exchange Rate Crisis," Paper presented at the NBER Conference on *Management of Currency Crisis*, Monterey, California, March 2001.

Corsetti, G., P. Pesenti, and N. Roubini. "What Caused the Asian Currency and Financial Crisis?" *Japan and the World Economy* 11 (1999), 305-373.

Edwards, S. and R. Susmel, "Interest Rate Volatility and Contagion in Emerging Markets: Evidence from the 1990s," *NBER Working Paper* No. W7813 (July 2000).

Frankel, J. A. and A. Rose, "Fixing Exchange Rates: A Virtual Quest for Fundamentals," *Journal of Monetary Economics* 36 (1995), 3-37.

Frenkel, J. A. and M. Mussa, "The Efficiency of Foreign Exchange Markets and Measures of Turbulence," *American Economic Review* 70 (1980), 374-381.

Furman, J. and J. Stiglitz, "Economic Crisis: Evidence and Insights from East Asia," *Brookings Papers on Economic Activity*, 1998:2, 1-135.

Glick, R. and A. Rose, "Contagion and Trade: Why Are Currency Crises Regional?" *Journal of International Money and Finance* 18 (1999), 603-617.

Goldfajn, I. and P. Gupta, "Does Monetary Policy Stabilize the Exchange Rate Following a Currency Crisis?" *IMF Working Paper* 99/42 (1999).

Kwan, C. H., *Economic Interdependence in the Asia-Pacific Region*, London: Routledge (1995).

McKinnon, R., "After the Crisis, The East Asian Dollar Standard Resurrected," in J. Stiglitz and S. Yusuf eds. *Rethinking the East Asian Miracle*, World Bank and Oxford University Press (2001), 197-246.

Nurkse, R., *International Currency Experience: Lessons of the Interwar Period*, Geneva: League of Nations (1944).

Radelet, S. and J. D. Sachs, "The East Asian Financial Crisis: Diagnosis, Remedies, Prospects," *Brookings Papers on Economic Activity* (1998:1), 1-90.

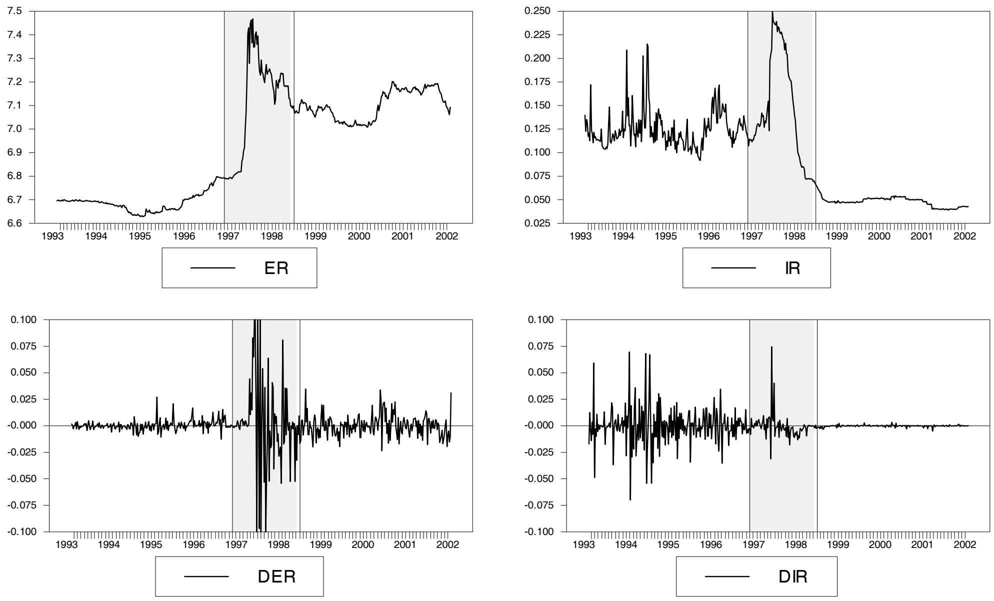
Reinhart, C. M. and V. R. Reinhart, "What hurts most: G3 Exchange Rate or Interest Rate Volatility?" in Sebastian Edwards and Jeffrey Frankel eds. *Preventing Currency Crises in Emerging Markets*, Chicago: University of Chicago Press (2001), 73-99.

Reinhart, C. M. and K. S. Rogoff, "The Modern History of Exchange Rate Arrangements: A Reinterpretation," *NBER Working Paper* No. 8963 (2002).

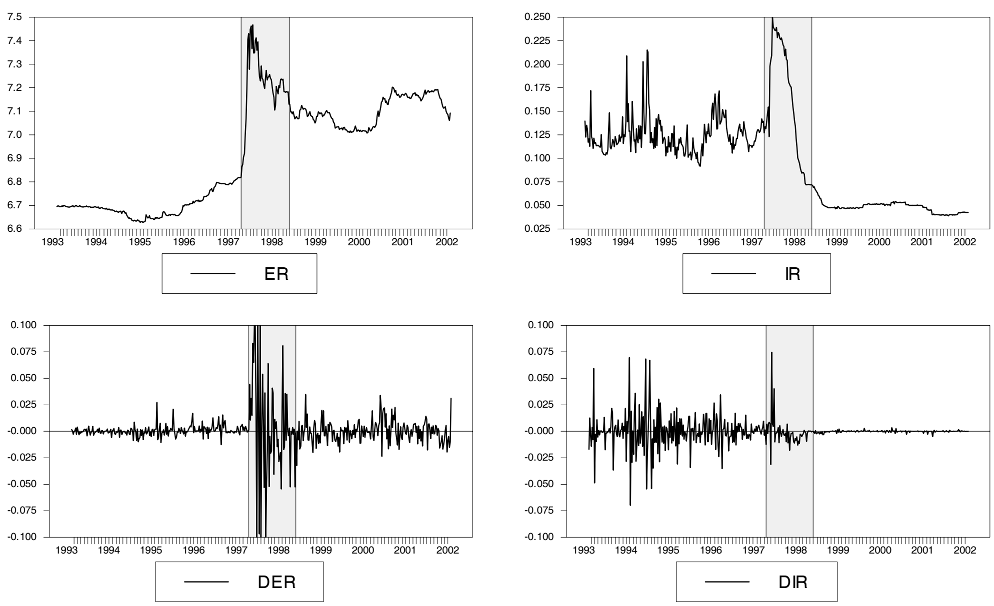
Rose, A. K. "After the Deluge: Do fixed Exchange Rates Allow Inter-temporal Volatility Tradeoff?" *NBER Working Paper* No. 5219 (1995).

Schwert, G.W. and P.J. Seguine, "Hetroskedasticity in Stock Returns," *Journal of Finance* XLV, No 4 (1990), 1129-1155.

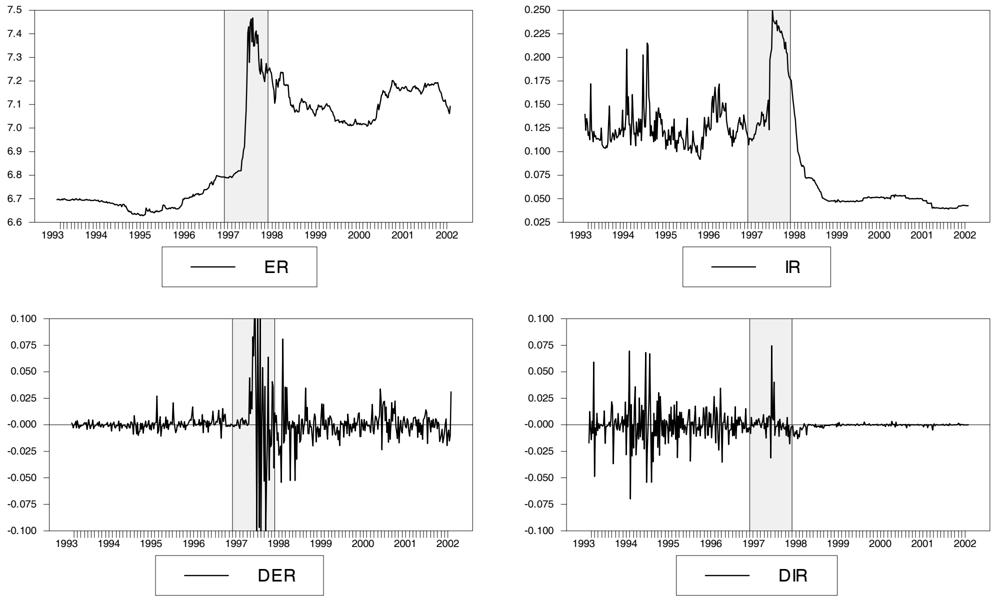
1a: Indonesia



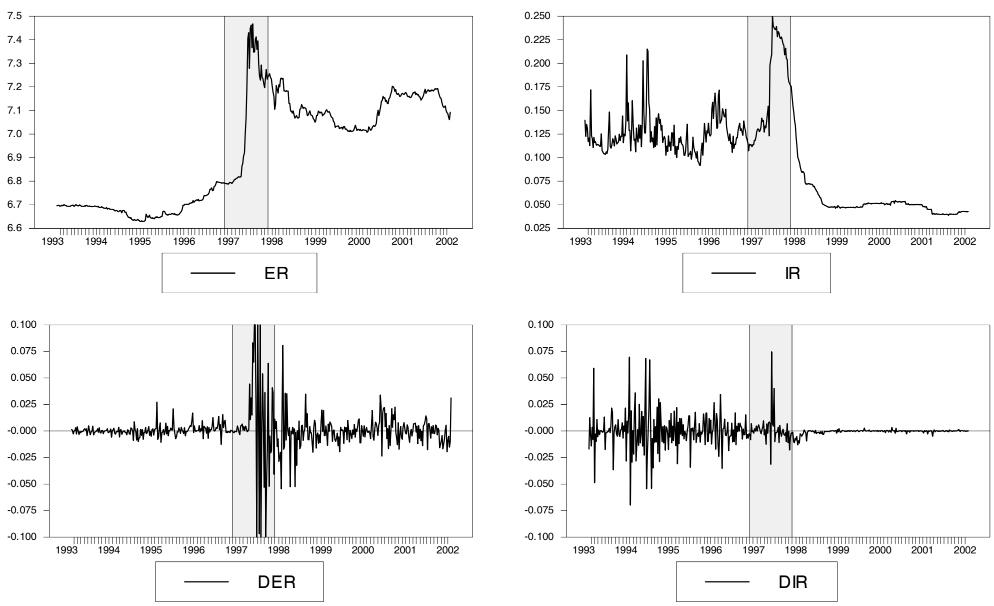
1b: Korea



1c: Philippines



1d: Thailand



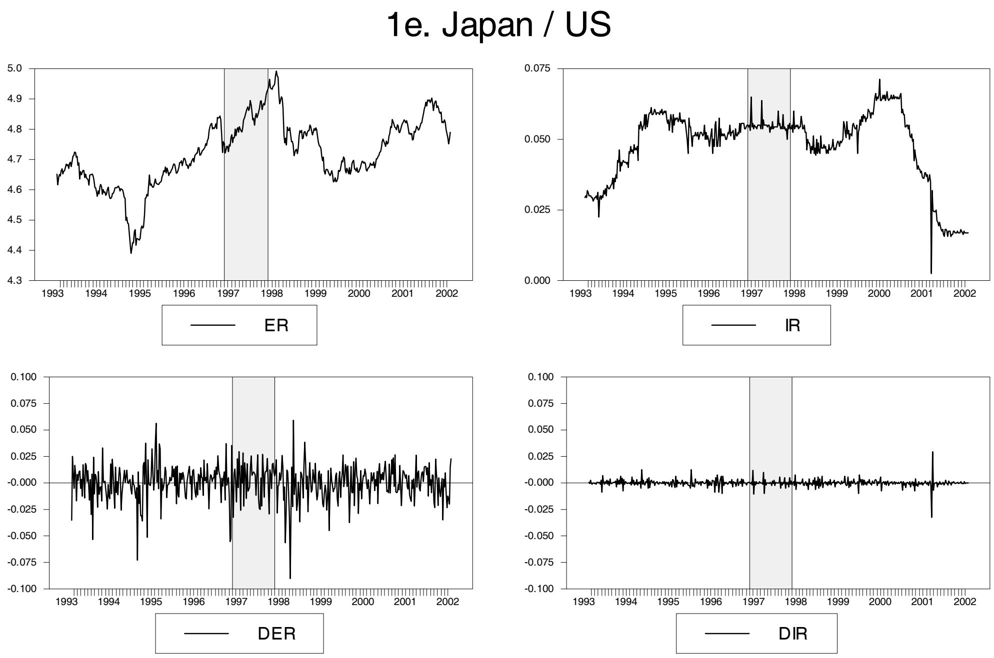


Figure 1. *Exchange Rates and Interest Rates*

Table 1. *Univariate Statistics: Changes in the Exchange Rate (Log) and the Interest Rate*

		Change in the Exchange Rate					Change in the Interest Rate				
		Mean	SE	SK	KT	ARCH	Mean	SE	SK	KT	ARCH
Indonesia	P1	0.20	0.24	0.98*	5.87*	0.02	1.44	1.32	-0.01	0.54	0.60
	P2	8.12	9.58	0.67	2.82*	0.34	8.64	11.2	2.78*	12.7*	0.10
	P3	2.45	3.16	0.71*	9.61*	0.93	2.32	4.99	-0.52	16.5*	25.4*
Korea	P1	0.30	0.36	1.50*	7.27*	0.61	1.12	1.30	0.27	4.71*	5.20*
	P2	4.16	4.53	0.62	2.42*	1.03	0.70	1.15	3.45*	18.5*	7.26*
	P3	0.77	0.68	0.41*	1.29*	0.02	0.05	0.08	-1.11*	6.70*	0.06
Philippines	P1	0.47	0.70	-0.57*	6.77*	1.25	2.46	6.01	-1.66*	25.0*	14.3*
	P2	2.98	3.48	1.09*	2.70*	0.75	5.81	11.2	0.84*	9.02*	0.01
	P3	0.87	1.11	-0.98*	8.63*	9.52*	0.27	0.65	1.75*	31.1*	16.6*
Thailand	P1	0.21	0.35	-5.45*	53.3*	8.27*	0.35	0.55	1.93*	9.99*	0.00
	P2	3.34	3.39	0.71*	2.73*	0.33	0.95	0.92	-0.28	0.33	1.29
	P3	0.81	0.97	-0.07	7.01*	6.41*	0.19	0.39	-1.67*	14.8*	0.86
Japan/US	P1	1.20	1.20	-0.75*	2.98*	6.01*	0.20	0.22	0.29	3.70*	26.5*
	P2	1.44	0.85	-0.50	-0.63	0.13	0.21	0.29	0.25	4.06*	0.22
	P3	1.21	1.09	-0.93*	4.53*	0.92	0.19	0.33	-0.73	38.0*	0.20

Note: P1 = pre-crisis (before July 1, 1997), P2 = crisis (after June 30, 1997), P3 = post-crisis (after June 30, 1997), SE = standard error, SK = skewness, KT = kurtosis

Table 2. *GARCH Model of Exchange Rate and Interest Rate (Levels Equations)*

	$\begin{pmatrix} G_{11}^1 & G_{11}^2 & G_{11}^3 \\ G_{21}^1 & G_{21}^2 & G_{21}^3 \end{pmatrix}$			$\begin{pmatrix} G_{12}^1 & G_{12}^2 & G_{12}^3 \\ G_{22}^1 & G_{22}^2 & G_{22}^3 \end{pmatrix}$			$\begin{pmatrix} C_{11} & C_{12} & C_{13} \\ C_{21} & C_{22} & C_{23} \end{pmatrix}$		
Indonesia		(1) Pre-crisis							
Δe	-0.216 (3.050)*	-0.073 (0.832)	0.143 (1.734)	0.004 (0.306)	-0.020 (1.184)	-0.002 (0.163)	0.543 (2.302)*	-0.019 (1.374)	0.036 (1.960)
Δr	-0.251 (0.423)	0.530 (1.394)	0.391 (0.904)	-0.542 (6.888)*	-0.216 (2.354)*	-0.213 (2.375)*	0.099 (0.054)	0.044 (0.335)	0.011 (0.102)
		(3) Post- Crisis							
Δe	0.081 (0.995)	0.045 (0.816)	0.128 (2.047)*	0.067 (0.581)	-0.034 (0.293)	-0.065 (0.796)	-1.771 (1.215)	0.005 (0.036)	0.326 (4.860)*
Δr	0.013 (0.271)	0.043 (0.614)	0.003 (0.064)	-0.170 (1.964)	-0.175 (2.171)*	-0.062 (1.200)	-0.703 (0.483)	0.017 (0.206)	0.004 (0.109)
Korea		(1) Pre-crisis							
Δe	0.044 (0.433)	0.079 (1.114)	0.015 (0.214)	0.029 (0.856)	0.025 (0.841)	0.021 (1.350)	-0.693 (-1.562)	0.008 (0.311)	0.011 (0.893)
Δr	0.226 (1.045)	-0.168 (0.695)	-0.231 (1.247)	-0.455 (6.572)*	-0.274 (5.022)*	-0.240 (4.247)*	0.068 (0.081)	0.038 (1.236)	0.017 (1.904)
		(3) Post-crisis							
Δe	0.118 (1.713)	-0.012 (0.170)	-0.015 (0.199)	0.384 (0.349)	0.897 (1.0490	-0.416 (0.573)	-1.087 (1.743)	0.147 (2.210)*	0.060 (3.039)*
Δr	0.000 (0.052)	-0.009 (1.307)	0.011 (1.876)	-0.160 (1.340)	0.022 (0.201)	0.019 (0.202)	0.011 (0.179)	-0.003 (0.546)	0.002 (1.208)
Philippines		(1) Pre-crisis							
Δe	-0.188 (1.903)	0.012 (0.156)	0.321 (6.609)*	-0.011 (0.308)	-0.004 (0.219)	-0.011 (1.282)	-1.961 (3.350)*	0.010 (0.245)	0.032 (0.572)
Δr	-0.160 (0.452)	0.186 (0.515)	1.150 (3.256)*	-0.220 (2.508)*	-0.083 (0.874)	-0.092 (0.988)	2.482 (0.483)	-0.042 (0.188)	-0.158 (0.612)
		(3) Post-crisis							
Δe	-0.115 (1.407)	0.013 (0.180)	0.095 (1.604)	0.103 (0.407)	0.172 (1.029)	0.103 (0.697)	-0.062 (0.148)	0.057 (0.840)	0.121 (5.248)*
Δr	0.074 (1.811)	0.048 (0.760)	0.000 (0.005)	-0.189 (1.084)	-0.061 (0.321)	-0.054 (0.372)	0.481 (0.670)	-0.010 (0.192)	0.019 (0.869)
Thailand		(1) Pre-crisis							
Δe	-0.082 (1.188)	0.019 (0.269)	0.036 (0.589)	0.007 (0.359)	0.011 (0.547)	-0.019 (0.854)	0.160 (1.109)	0.112 (10.375)*	0.019 (2.162)*
Δr	-0.143 (0.536)	-0.064 (0.245)	0.009 (0.042)	-0.024 (0.198)	-0.109 (0.972)	-0.065 (0.536)	-0.260 (0.407)	-0.068 (1.500)	0.048 (1.560)
		(3) Post-crisis							
Δe	-0.113 (1.573)	0.037 (0.534)	0.138 (2.533)*	-0.117 (0.600)	-0.077 (0.4710	0.013 (0.0720	0.609 (1.031)	0.111 (2.903)*	0.118 (7.649)*
Δr	0.046 (1.201)	-0.014 (0.441)	0.040 (1.694)	0.220 (1.928)	0.097 (1.209)	0.056 (0.758)	0.031 (0.129)	-0.019 (0.743)	-0.001 (0.096)

Note: t-statistics (absolute values) in parentheses; * denotes statistical significance at 5% level

Table 3. *GARCH Model of Exchange Rate and Interest Rate*

(Variance Equations)

	ρ	$\begin{pmatrix} h_{11} \\ h_{22} \end{pmatrix}$	$\begin{pmatrix} A_{11} & A_{12} \\ A_{21} & A_{22} \end{pmatrix}$		$\begin{pmatrix} B_{11} & B_{12} \\ B_{21} & B_{22} \end{pmatrix}$		$\begin{pmatrix} C_{11} & C_{12} & C_{13} \\ C_{21} & C_{22} & C_{23} \end{pmatrix}$		
Indonesia		(1) Pre-crisis							
Δe	-0.181 (1.836)	-0.013 (0.174)	0.826 (1.249)	0.012 (0.8000	-0.014 (0.657)	-0.002 (1.985)	-0.335 (0.901)	-0.001 (0.673)	0.000 (0.376)
Δr		6.850 (1.597)	46.568 (1.009)	-0.576 (0.918)	3.245 (1.219)	0.026 (0.307)	10.338 (0.438)	0.081 (1.140)	-0.053 (0.968)
		(2) Post-crisis							
Δe	0.051 (0.536)	2.171 (2.225)*	0.200 (0.679)	0.310 (1.164)	0.059 (1.347)	0.141 (1.906)	-0.939 (0.091)	0.097 (1.161)	0.028 (1.259)
Δr		-2.480 (1.396)	0.950 (1.894)	-0.185 (0.622)	-0.025 (2.727)*	0.320 (2.884)*	31.290 (3.118)*	-0.013 (0.617)	-0.011 (5.912)*
Korea		(1) Pre-crisis							
Δe	-0.034 (0.334)	0.171 (3.879)*	0.317 (1.635)	-0.065 (3.667)*	0.071 (1.034)	0.036 (2.474)*	-0.652 (0.569)	0.000 (0.161)	0.000 (3.903)*
Δr		0.627 (1.783)	-2.640 (1.911)	0.746 (5.574)*	0.362 (1.275)	0.133 (1.676)	5.049 (1.256)	-0.009 (0.869)	-0.001 (1.484)
		(3) Post-crisis							
Δe	-0.071 (0.739)	0.307 (1.691)	0.461 (1.779)	0.419 (0.050)	0.042 (1.410)	0.569 (0.081)	-1.421 (3.906)*	0.032 (1.400)	0.004 (1.410)
Δr		0.009 (2.596)*	-0.009 (2.089)*	0.258 (0.987)	0.000 (0.367)	0.299 (2.396)*	0.001 (0.101)	0.000 (0.683)	0.000 (2.328)*
Philippines		(1) Pre-crisis							
Δe	0.149 (1.319)	0.282 (3.507)*	0.007 (0.060)	-0.001 (0.275)	0.432 (2.325)*	0.020 (1.860)	-3.414 (0.749)	-0.007 (2.050)*	-0.005 (2.067)*
Δr		1.021 (0.912)	1.614 (0.842)	0.216 (1.986)	-0.511 (3.474)*	0.421 (2.769)*	431.694 (5.160)*	0.284 (1.360)	-0.076 (0.198)
		(3) Post-crisis							
Δe	0.051 (0.393)	0.279 (1.395)	0.028 (0.162)	0.134 (0.172)	0.202 (3.932)*	0.083 (0.228)	-0.003 (0.002)	0.072 (1.595)	0.011 (2.676)*
Δr		0.276 (3.654)*	-0.024 (0.552)	0.053 (0.191)	-0.004 (0.150)	0.074 (1.017)	-0.124 (0.108)	0.005 (0.371)	0.004 (1.909)
Thailand		(1) Pre-crisis							
Δe	-0.230 (2.394)*	0.004 (0.924)	0.589 (5.652)*	-0.004 (0.361)	0.155 (2.933)*	-0.001 (0.216)	-0.081 (1.101)	0.003 (3.196)*	-0.001 (1.766)
Δr		0.194 (4.011)*	-0.684 (1.498)	0.472 (2.801)*	-0.223 (1.388)	0.100 (1.334)	-3.580 (3.173)*	0.018 (1.973)	-0.008 (1.680)
		(3) Post-crisis							
Δe	0.021 (0.213)	0.209 (2.322)*	-0.027 (0.164)	-0.004 (0.005)	0.312 (3.104)*	0.092 (0.357)	0.841 (0.343)	0.010 (0.616)	0.011 (2.268)*
Δr		0.050 (4.327)*	-0.027 (1.487)	0.115 (0.902)	0.052 (2.355)*	0.255 (2.582)*	-0.146 (0.677)	0.009 (2.365)*	0.000 (0.245)

Note: t-statistics (absolute values) in parentheses; * denotes statistical significance at 5% level