Effects of Exchange Rate Fluctuations on Equity Market Volatility and Correlations: Evidence from the Asian Financial Crisis

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This paper investigates the effect of exchange rate fluctuations on international stock market fundamentals including market volatility and cross-market correlations around the Asian financial crisis. Evidence presented in this paper indicates that exchange rate fluctuations contribute largely to higher equity market volatility and cross-market correlations. Falling (rising) US stock markets are associated with depreciating (appreciating) local currencies for most of the sample markets, i.e., a positive correlation between the US market returns and local currency values. Results from forecast error variance decomposition indicate that exchange rate fluctuations become more important in explaining the time series behavior of equity market volatility and cross-market correlations during the Asian financial crisis

Introduction

The Asian financial crisis that began in Thailand in the summer of 1997 quickly spread across borders to other countries in the region. Market returns on stocks sharply fell, local currencies rapidly depreciated, and the volatility in both stock and foreign exchange markets drastically rose to unprecedented levels during the crisis. While these episodes have been well documented, much less effort has been devoted to studying the role of exchange rate fluctuations in equity markets around the financial crisis.

Several studies recently focused on the role of exchange rate fluctuations in the capital market around the Asian financial crisis. Aquino (2005, 2006) examines the

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foreign exchange exposure faced by Philippine firms around the Asian financial crisis and finds that while stock returns were not significantly affected by foreign exchange fluctuations before the crisis, there was a significant impact of the fluctuations on stock returns after the crisis. Chung (2005) documents that during the period of the financial crisis there was a contagious effect of Thai baht exchange rate fluctuations on Asian ADRs and country fund returns, while there was no contagious effect on non-Asian ADRs and country funds. Yau and Nieh (2006) investigate the interrelationship between new Taiwan dollar/Japanese yen exchange rate and stock prices of Taiwan and Japan for the period of January 1991 to July 2005 and find that there was no long-term linkage between the exchange rate and stock prices of Taiwan and Japan, but the linkage existed only for short durations. Tse and Yip (2006) investigate whether the Asian financial crisis led to changes in the correlation between the US and Singapore/Hong Kong interest rates and find that there was a correlation breakdown for the interest rates during the crisis, although the correlation was restored after the crisis.

It is theoretically apparent that the US dollar returns of local market indexes are influenced by exchange rate movements due to the fact that the conversion process from local market returns into US dollar values already has introduced a direct link between exchange rates and US dollar returns. Yet empirical findings provide conflicting results for the linkage between foreign exchange rate movements and local equity market returns, as returns are expressed in US dollars. Some researchers claim that exchange rate movements provide little or no explanation for US investors making investment decisions (Jorion, 1990 and 1991; Amihud, 1993; Bartov and Bodnar, 1994; and Bernard and Galati, 2000), while others argue that stock returns in US dollars are affected significantly by exchange rate fluctuations (Roll, 1992; Ferson and Harvey, 1994; Dumas and Solnik, 1995; Chow et al., 1997; Choi et al., 1998; De Santis and Gerard, 1998; Doukas et al., 1999; Kaminsky and Schmukler, 1999; and Patro et al., 2002). Although models and empirical methodologies vary widely, these papers explain the relationship between exchange rate movements and stock market returns using various regression models of exchange rate exposure for which exchange rate fluctuations are linked to expected stock returns.

The purpose of this paper is to examine how and to what extent international stock market volatility and US/local market correlations were influenced by exchange rate fluctuations around the Asian financial crisis. This paper contributes to the literature in the following two ways. First, in contrast to the regression-based models of the existing literature, this paper develops an alternative formulation of the model that captures the role of exchange rate fluctuations in a direct and explicit fashion. In our model market volatility, as well as cross-market correlation, is decomposed into fractions that are attributable to local market returns and exchange rate fluctuations. Thus, the role of exchange rate fluctuations relative to local market returns can be identified explicitly in explaining the market volatility and cross-mar-

ket correlations. Second, while previous studies focused their analysis on developed countries or a few emerging markets, our study focuses on a large group of eight Pacific-Basin countries, i.e., Hong Kong, Indonesia, Japan, Korea, Malaysia, the Philippines, Singapore, and Thailand. These countries are heavily dependent on international trade for economic growth, and equity flows into the countries, primarily in the form of foreign direct investment, have remained robust relative to other regions since the 1990s. This situation allows us to conduct a richer analysis on the role of exchange rate fluctuations in the international stock market.

We find that exchange rate fluctuations appear to be only a small fraction of the equity market volatility. When equity markets were highly volatile as observed in the financial crisis, however, exchange rate fluctuations accounted for a substantially larger portion of the equity market volatility. This observation suggests that local stock market volatility increases with exchange rate fluctuations, a result consistent with that of Dumas and Solnik (1995), De Santis and Gerard (1998), Aquino (2005, 2006), and Yau and Nieh (2006). Unlike previous studies, we find that there is no monotonic relation between the US/local market correlation and the exchange rate fluctuation. The US/local market correlation can rise or fall with exchange rate fluctuations. This finding contrasts with the conventional belief that if exchange rate changes make one country better off and the other worse off, the cross-market correlation should be declining with exchange rate fluctuations. We document that the conflicting results stem from the sign of the correlation between US equity market returns and local currency values that changes over time. When the correlation is positive (negative), the exchange rate fluctuation contributes to a higher (lower) US/local market correlation.

An additional insight into the contribution of exchange rate fluctuations also is obtained within the framework of forecast error variance decomposition. Evidence shows that exchange rate fluctuations became more important during the crisis in explaining the time series behavior of volatility and US/local market correlations, a result in line with that of Yau and Nieh (2006). Statistical evidence indicates that US equity market volatility decreased marginally by exchange rate fluctuations before the crisis but increased with exchange rate fluctuations during the crisis for most of the currencies. Also, we find that exchange rate fluctuations affect local equity market volatility to a greater extent than US equity market volatility, due to the fact that exchange rate changes are more strongly correlated with the local equity market than the US equity market.

The Model

To measure directly the extent to which local equity market volatility and correlations with the US market are affected by exchange rate fluctuations, we first

describe the US dollar return in the currency j stock market, R_{jt}^{USD}, as the following:[1]

$$\begin{aligned} R_{jt}^{USD} &= \ln P_{jt}S_{jt} - \ln P_{jt-1}S_{jt-1} \\ &= \left(\ln P_{jt} - P_{jt-1}\right) + \left(\ln S_{jt} - S_{jt-1}\right) \\ &= R_{jt}^{LCD} + Z_{jt} \end{aligned} \tag{1}$$

where:

$R_{jt}^{LCD} \equiv \ln P_{jt} - \ln P_{jt-1}$ = The local-currency denominated (LCD) index return in the currency j equity market at time t;

P_{jt} = The price index in the currency j equity market at time t;

$Z_{jt} \equiv \ln S_{jt} - \ln S_{jt-1}$ = The appreciation rate of local currency j at time t relative to the US dollar. Z_{jt} is also the exchange rate fluctuation (change) for currency j; and

S_{jt} = The exchange rate for currency j (US dollars per unit of local currency) at time t.

Equation (1) shows that the US dollar return on a local market index is comprised of the local-currency return and the exchange rate fluctuation. The proportion of the US dollar local return volatility that can be attributable to exchange rate fluctuations, ψ, can be directly measured as:

$$\psi = 1 - \frac{\mathrm{Var}\left(R_{jt}^{LCD}\right)}{\mathrm{Var}\left(R_{jt}^{USD}\right)} = \frac{\mathrm{Var}\left(Z_{jt}\right) + 2\mathrm{Cov}\left(R_{jt}^{LCD}, Z_{jt}\right)}{\mathrm{Var}\left(R_{jt}^{USD}\right)} \tag{2}$$

because $\mathrm{Var}\left(R_{jt}^{LCD}\right) = \mathrm{Var}\left(R_{jt}^{LCD}\right) + \mathrm{Var}\left(Z_{jt}\right) + 2\mathrm{Cov}\left(R_{jt}^{LCD}, Z_{jt}\right)$.

Equation (2) indicates that the proportion of local market volatility that can be explained by exchange rate fluctuations changes not only with the volatility in foreign exchange market, but also with covariances between local-currency equity returns and exchange rate changes. The important feature of this representation is that it is not necessarily the case that higher exchange rate volatility implies higher local market volatility, due to the covariance term that can be negative. The numerator of equation (2) suggests that an internationally-diversified investor can get

[1]Our definition of the US dollar local return is in line with that of Roll (1992). As contrasted with local-currency returns, the dollar returns are more useful from foreign investors' perspective and can provide consistence in making comparisons of inter-country equity returns. As such, dollar returns are widely used in studies on international stock markets. See, for example, Roll (1992), Harvey (1995), De Santis and Gerard (1998), Ng (2000), and Johnson et al (2000) among others.

the benefit of volatility reduction for his/her portfolio due to exchange rate fluctuations, if

$$\mathrm{Cov}\left(R_{jt}^{LCD}, Z_{jt}\right) / \mathrm{Var}\,(Z_{it}) \leq -0.5.$$

Conversely, if

$$\mathrm{Cov}\left(R_{jt}^{LCD}, Z_{jt}\right) / \mathrm{Var}\,(Z_{it}) > -0.5,$$

exchange rate fluctuations will contribute an additional source of risk to the portfolio, thus hurting the investor.

We now analyze the correlation coefficient between the US dollar local return, R_{jt}^{LCD}, and the US market return, R_t. The correlation coefficient is written as:

$$\rho\left(R_{jt}^{USD}, R_t\right) = \frac{\mathrm{Cov}\left(R_{jt}^{USD}, R_t\right)}{\sqrt{\mathrm{Var}\left(R_{jt}^{USD}\right)}\sqrt{\mathrm{Var}\left(R_t\right)}} \tag{3}$$

$$= \frac{\mathrm{Cov}\left(R_{jt}^{USD}, R_t\right) + \mathrm{Cov}\left(Z_{jt}, R_t\right)}{\sqrt{\mathrm{Var}\left(R_{jt}^{USD}\right)}\sqrt{\mathrm{Var}\left(R_t\right)}}$$

Breaking up the right side of equation (3) into two parts and manipulating, we obtain:

$$\rho\left(R_{jt}^{USD}, R_t\right) = \rho\left(R_{jt}^{USD}, R_t\right)\sqrt{\frac{\mathrm{Var}\left(R_{jt}^{LCD}\right)}{\mathrm{Var}\left(R_{jt}^{USD}\right)}} + \rho\left(Z_{jt}, R_t\right)\sqrt{\frac{\mathrm{Var}\left(Z_{jt}\right)}{\mathrm{Var}\left(R_{jt}^{USD}\right)}} \tag{4}$$

The first term on the right side of equation (4) represents the contribution of local-currency equity returns to the US/local market correlation, while the second term represents the contribution of exchange rate fluctuations to the US/local market correlation. We define

$$\sqrt{\mathrm{Var}\left(Z_{jt}\right)} \;/\; \sqrt{\mathrm{Var}\left(R_{jt}^{USD}\right)}$$

as the volatility ratio of the foreign exchange market relative to the local equity market. The volatility ratio increases as foreign exchange markets are increasingly volatile relative to local stock markets. It follows that the US/local market correlation increases (decreases) with the volatility ratio as US equity market returns are positively (negatively) correlated with local currency values.[2]

[2]The direction of causality between stock returns and currency values is not the focus of this paper. It is documented that the direction of causality is country and time dependent (see Ma and Kao (1990) and Ajayi et al. (1996) for details).

From equation (4), the proportion of the correlation coefficient between the US and local market returns that can be attributable to exchange rate fluctuations, Φ, can be measured as:

$$\Phi = \frac{\rho\left(Z_{jt}, R_t\right)}{\rho\left(R_{jt}^{USD}, R_t\right)}\sqrt{\frac{Var\left(Z_{jt}\right)}{Var\left(R_{jt}^{USD}\right)}} \tag{5}$$

For given $\rho\left(R_{jt}^{USD}, R_t\right)$, the values of Φ are determined by the correlation of US equity market returns with local currency values and the volatility ratio of the foreign exchange market relative to the local equity market. Note that since $\rho\left(R_{jt}^{USD}, R_t\right)$ is empirically known to be positive for the whole sample of countries, the sign of Φ is fundamentally determined by the sign of the correlation between US market returns and local currency values.

Data

The data set we analyze is based on a newly compiled two-day average series from July 1, 1994 to August 27, 2001. Following Forbes and Rigobon (2002), two-day average data are obtained from the average of two consecutive daily series with adjustment for weekends and holidays in an attempt to avoid the problems of non-synchronous trading between the US and other sample Asian countries. The data consist of closing foreign exchange (FX) rates and stock market indices of eight Pacific-Basin countries: Hong Kong, Indonesia, Japan, Korea, Malaysia, the Philippines, Singapore, and Thailand. These countries were severely affected by the financial crisis or actively involved in monetary intervention to defend their currencies during the financial crisis. The stock market indices used are the S&P 500 Index, the Tokyo Stock Exchange Price Index (TOPIX), the Hang Seng Index of Hong Kong, the Jakarta Stock Exchange Composite Index of Indonesia, the Korean Composite Stock Price Index (KOSPI), the Kuala Lumpur Stock Exchange Composite Index of Malaysia, the Manila Composite Index of Philippines, the Stock Exchange of Singapore All Share Index, and the Bangkok Stock Exchange of Thailand Index. All these stock market indices are value-weighted indices and collected from the Global Financial Data (GFD) database. Two-day index returns are computed as the logarithmic difference of two-day average stock indexes. Exchange rates are expressed as US dollars per unit of local currency and the logs of the nominal rates, which are also collected from the GFD database.

We divide the whole sample into three sub-periods:

(i) Period 1 (Pre-crisis): July 1, 1994 to July 1, 1997 (377 observations);
(ii) Period 2 (In-crisis): July 2, 1997 to September 30, 1998 (161 observations); and
(iii) Period 3 (Post-crisis): October 1, 1998 to August 27, 2001 (377 observations).

Period 1 and period 3 were chosen to have an equal sample size.

Because statistical results may be sensitive to the choice of data points for each period, it is necessary to explain the way the crisis period was selected. There is a general agreement that the Asian financial crisis began in the summer of 1997. The official onset of the crisis occurred on July 2, 1997 when the Bank of Thailand announced that it would follow a managed float of the Thai baht and called on the International Monetary Fund (IMF) for technical assistance. By August 1997, the crisis had engulfed many countries in the region, including the Philippines, Malaysia, Singapore, and Hong Kong, with their central banks intervening to defend their currencies. Korea initially appeared relatively little affected by the crisis; with a high level of foreign short-term debt and modest level of foreign reserves, however, Korea was highly vulnerable to a market contagion.[3]

On the other hand, there is no general consensus as to when the crisis ended. We chose the end of September 1998 as the ending point of the crisis in this paper for the following reasons: (i) IFC's (International Finance Corporation) investable indexes for many of the sample countries reached the lowest point in September 1998 (Johnson et al., 2000); (ii) Financial and economic conditions in the region improved in the fourth quarter of 1998, with output conditions being stabilized and stock markets beginning a sustained upward trend during this period (*Asian Financial Markets,* 1998; *World Economic Outlook and International Capital Markets,* 1998).

The rationale for using these dates for the beginning and end of the crisis period is made clearer by examining the time series movements of local stock market indexes and foreign exchange rates plotted for all the sample countries in Figure 1. The values for the first observation of 1994 are set to 100 as the base point. The solid dark line represents local market indexes and the lighter line represents foreign exchange rates. Two dashed-vertical lines delineate the crisis period (Period 2). Figure 1 shows that in the first week of July 1997, there were a dramatic decline in local market indexes and a concomitant drastic depreciation of local currencies for most of the sample countries; this is the beginning point of the crisis.[4] This situation continued until September 1998. Around the end of September 1998, both stock and foreign exchange markets began to pull out of the trough, thus ending the crisis.

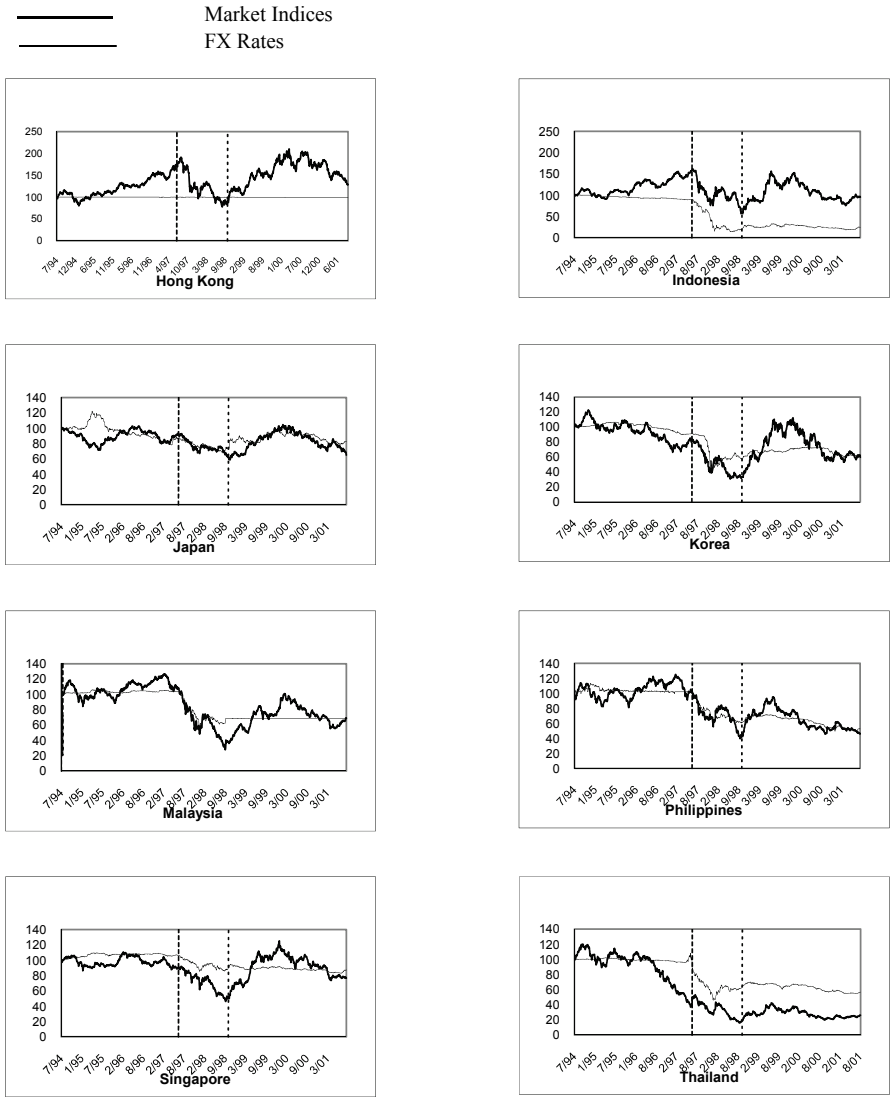
Summary Statistics

Table 1 reports the means, standard deviations, and correlations with the US market for two-day local market returns by period. Mean equity market returns of all the sample countries drastically fell during the financial crisis but bounced back after the crisis. During the financial crisis, the drastic drop in mean returns was accompa-

[3]Stock markets in Korea collapsed on November 18, 1997 as currency jitters shocked Korea and the Bank of Korea abandoned defending the Korean won.

[4]Due to a simultaneous collapse of both equity and FX asset values, the term 'Asian financial crisis' is often used interchangeably with 'Asian currency crisis' in the literature.

Figure 1—Market Indices and FX Rates



nied by a phenomenal increase in return volatility for all the sample countries. For example, the pre-crisis mean two-day market returns of Hong Kong, Indonesia, Japan, Korea, Malaysia, the Philippines, Singapore, and Thailand were 0.07 percent, 0.05 percent, –0.03 percent, -0.04 percent, 0.01 percent, 0.005 percent, -0.006 percent, and –0.12 percent, respectively, but the corresponding returns during the crisis

Table 1—Summary Statistics

		HK	IND	JAP	KOR	MAL	PHIL	SING	THAI
Equity Market Returns									
	I	0.0736	0.0472	-0.031	-0.037	0.0143	0.0049	-0.006	-0.121
		(2.30)	(1.74)	(-1.06)	(-1.12)	(0.49)	(0.13)	(-0.28)	(-2.96)
Mean %	II	-0.203	-0.761	-0.181	-0.422	-0.458	-0.407	-0.221	-0.359
		(-1.75)	(-2.96)	(-2.47)	(-2.04)	(-2.44)	(-3.03)	(-2.34)	(-2.36)
	III	0.0454	0.0902	0.0337	0.0942	0.0821	-0.016	0.0488	0.0214
		(0.96)	(1.13)	(0.83)	(1.30)	(2.00)	(-0.30)	(1.24)	(0.37)
	I	0.8809	0.7428	0.7916	0.9195	0.8016	0.9854	0.5745	1.1290
St Dev. %	II	2.0838	4.6193	1.3128	3.7238	3.3731	2.4131	1.6986	2.7290
	III	1.2958	2.1909	1.1185	1.9941	1.1277	1.4932	1.0827	1.5946
Foreign Exchange Market Returns									
	I	-0.000	-0.015	-0.019	-0.012	0.0041	0.0027	0.0084	-0.008
		(-0.57)	(-3.05)	(-1.05)	(-2.11)	(0.80)	(0.17)	(1.55)	(-0.50)
Mean %	II	-0.000	-0.459	-0.053	-0.139	-0.127	-0.157	-0.051	-0.121
		(-0.08)	(-2.29)	(-1.57)	(-1.18)	(-1.80)	(-2.67)	(-1.68)	(-1.65)
	III	-0.001	0.0275	0.0168	0.0116	0.000	-0.021	-0.005	-0.015
		(-3.51)	(0.60)	(0.79)	(0.88)		(-1.07)	(-0.61)	(-1.24)
	I	0.0133	0.1339	0.4982	0.1620	0.1428	0.4287	0.1496	0.4550
St Dev. %	II	0.0233	3.5965	0.6116	2.1208	1.2611	1.0524	0.5479	1.3184
	III	0.0069	1.2612	0.5812	0.3623	0.000	0.5307	0.2040	0.3386
Return Correlation									
US and	I	0.3211	0.1966	0.0762	0.0741	0.1522	0.1013	0.1717	0.0460
Local		[0.000]	[0.000]	[0.037]	[0.042]	[0.000]	[0.004]	[0.000]	[0.205]
Equity	II	0.3452	0.2442	0.2170	0.1534	0.1583	0.2608	0.2278	0.2041
		[0.000]	[0.000]	[0.000]	[0.004]	[0.003]	[0.000]	[0.000]	[0.000]
	III	0.2893	0.0797	0.3408	0.2596	0.1018	0.1549	0.2338	0.1642
		[0.000]	[0.027]	[0.000]	[0.000]	[0.004]	[0.000]	[0.000]	[0.000]
Local	I	0.1005	0.3577	0.4957	0.2503	0.2036	0.4320	0.1741	0.3508
Equity		[0.005]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
and FX	II	-0.040	0.8661	0.7045	0.8118	0.7009	0.6883	0.6570	0.6886
Market		[0.464]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
	III	-0.009	0.7742	0.4881	0.5104	0.000	0.5851	0.3300	0.4500
		[0.900]	[0.000]	[0.000]	[0.000]	[1.000]	[0.000]	[0.000]	[0.000]
US Equity	I	-0.017	-0.053	-0.090	-0.012	-0.003	-0.058	-0.102	-0.041
and FX		[0.644]	[0.138]	[0.014]	[0.737]	[0.929]	[0.111]	[0.005]	[0.262]
Market	II	-0.051	0.1430	-0.015	0.0828	0.1334	0.0667	0.1078	0.0528
		[0.347]	[0.006]	[0.716]	[0.128]	[0.011]	[0.160]	[0.058]	[0.242]
	III	0.0609	0.0609	-0.059	0.1919	0.000	0.0801	0.0562	0.0994
		[0.081]	[0.081]	[0.136]	[0.000]	[1.000]	[0.028]	[0.074]	[0.004]

I = the pre-crisis period; II = the in-crisis period; III = the post-crisis period
Numbers in parentheses are t-statistics and numbers in brackets are p-values

fell to –0.20 percent, -0.76 percent, -0.18 percent, -0.42 percent, -0.46 percent, -0.41 percent, -0.22 percent, and -0.36 percent, respectively. Standard deviations for the corresponding countries were 0.88 percent, 0.74 percent, 0.79 percent, 0.92 percent, 0.80 percent, 0.99 percent, 0.57 percent, and 1.13 percent in the pre-crisis period, but during the financial crisis the standard deviations increased to 2.08 percent, 4.62 percent, 1.31 percent, 3.72 percent, 3.37 percent, 2.41 percent, 1.70 percent, and 2.73 percent, respectively. At the same time, local currencies suffered substantial value

losses and increases in exchange rate volatility during the financial crisis. In the period following the financial crisis, equity returns and volatility concomitantly took a favorable turn by a considerable amount although the extent varied across countries. Due to increased currency strength after the crisis, the situation on mean currency values and exchange rate volatility also was ameliorated for all the currencies.

Table 1 also shows that the US/local market correlation increased during the crisis, although the extent varied across the sample countries. Japan, Korea, the Philippines, and Thailand were among the countries to experience the most dramatic increase in the US/local market correlation. Pre-crisis data for the return correlation between equity and foreign exchange markets reveal that while local equity market returns are strongly positively correlated with exchange rate changes, the US equity return is insignificantly negatively correlated with exchange rate changes. During the crisis, however, the correlation between local equity and foreign exchange markets increased sharply in the sample countries (except for Hong Kong). Indonesia has the highest correlation of 0.8661 during the crisis, followed by Korea (0.8118). The correlation between the US equity and foreign exchange market increased and the rejections became stronger during the crisis, although the correlation was still relatively small in magnitude (ranging from -0.015 for Japan to 0.1430 for Indonesia) and continued to be insignificant for the majority of the currencies. This suggests that foreign exchange markets are more strongly associated with local equity markets than the US equity markets.

Volatility and US/Local Market Correlations

In this section, dynamic movements of the stock market volatility and US/local market correlations are examined within an exponential GARCH (EGARCH) framework.[5] First, the conditional volatility of an individual sample market is obtained from the time path of standard deviation of residuals for which individual market returns are regressed on constants within an EGARCH framework developed by Nelson (1991). The model has an error process that is conditionally heteroskedastic with time-varying variance given by:

$$\ln\left(\sigma_t^2\right) = c_1 + a_1\left(\left|\lambda_{t-1}\right| - E\left|\lambda_{t-1}\right| + a_2\lambda_{t-1}\right) + a_3\ \ln\left(\sigma_{t-1}^2\right) \qquad (6)$$

where:

σ_t^2 = The conditional variance of residual;
λ_t = The standardized residual; and

[5]It is widely known that negative stock returns are followed by higher volatility than positive returns of an equal sample size, the so-called asymmetric effect of stock returns. [See, for example, Black (1976), Nelson (1991), and Koutmos and Booth (1995).] The asymmetric effect of innovation on volatility can be effectively captured by the EGARCH model.

a_0, a_1, a_2, and a_3 = Parameters.

Similarly, the conditional correlation of an individual market return with the US return is obtained from the time path of conditional covariance matrix of residuals by estimating the following format of a bivariate EGARCH model:

$$r_{i,t} = \alpha_i + \varepsilon_{it} \text{ for } i = 1,2; \tag{7}$$

$$\ln(\sigma_{i,t}^2) = c_i + \sum_{j=1}^{2} c_{i,j} f_j(\lambda_{j,t-1}) + d_i \ln(\sigma_{i,t-1}^2) \text{ for i,j = 1,2;}$$

$$f_j(\lambda_{j,t-1}) = \left|\lambda_{j,t-1}\right| - E\left|\lambda_{j,t-1}\right| + \delta_j \lambda_{j,t-1} \text{ for j = 1,2; and}$$

$$\sigma_{ij,t} = \rho_{ij,t}\sigma_{i,t}\sigma_{j,t} \text{ for i,j = 1,2 and } i \neq j .$$

where:

$r_{i,t}$ = The return at time t for market i (i =1, 2 where 1 = the local market and 2 = the US market);

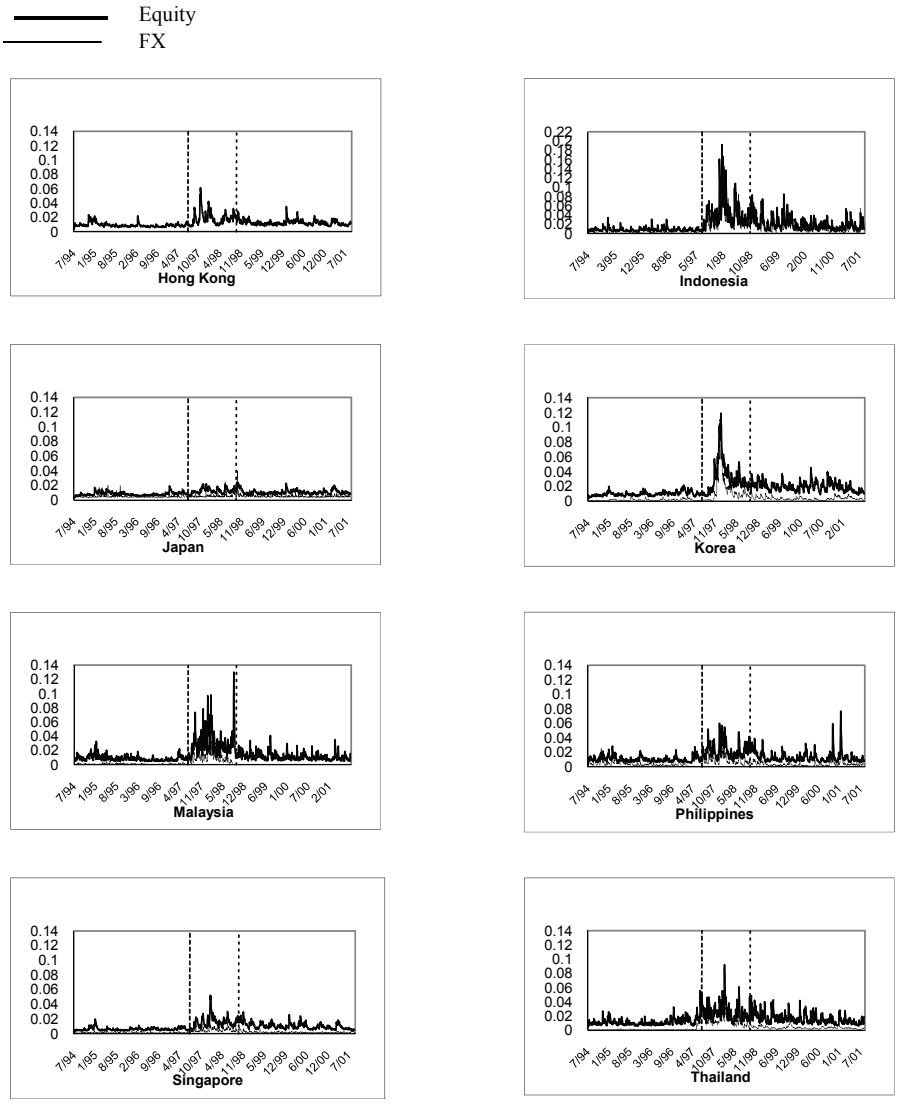
α_i = The conditional mean return for market i; and

$\lambda_{i,t} = \dfrac{\varepsilon_{i,t}}{\sigma_{i,t}}$.

To visually observe the dynamics of conditional volatility and correlations around the crisis, time series movements of these variables are plotted in Figure 2 and Figure 3 by country. Two dashed-vertical lines delineate the crisis period as defined in the previous section. Figure 2 reveals that while there was no conspicuous change in equity return volatility before the crisis, there was a drastic rise in the volatility during the crisis for all the sample countries. Figure 2 also shows movements of exchange rate volatility in a light line. Like equity markets, foreign exchange markets, except Hong Kong and Japan, suffered a drastic increase in return volatility during the crisis. It appears that an increase in exchange rate volatility is accompanied by an increase in stock market volatility. It is notable that while the volatility ratio of the foreign exchange market relative to the local equity market appears to be small before and after the crisis, it increases dramatically during the crisis except for Hong Kong and Japan.

Figure 3 exhibits the conditional correlation of an individual local market return with the US market return. The correlation coefficient of an individual equity market return with the US market return is time varying, with a fair amount of switching between positive and negative. The correlation coefficient appears to be on average positive and to rise in the crisis period relative to the pre-crisis period for all the sample countries, although the extent varies across countries.

Figure 2—Conditional Volatility

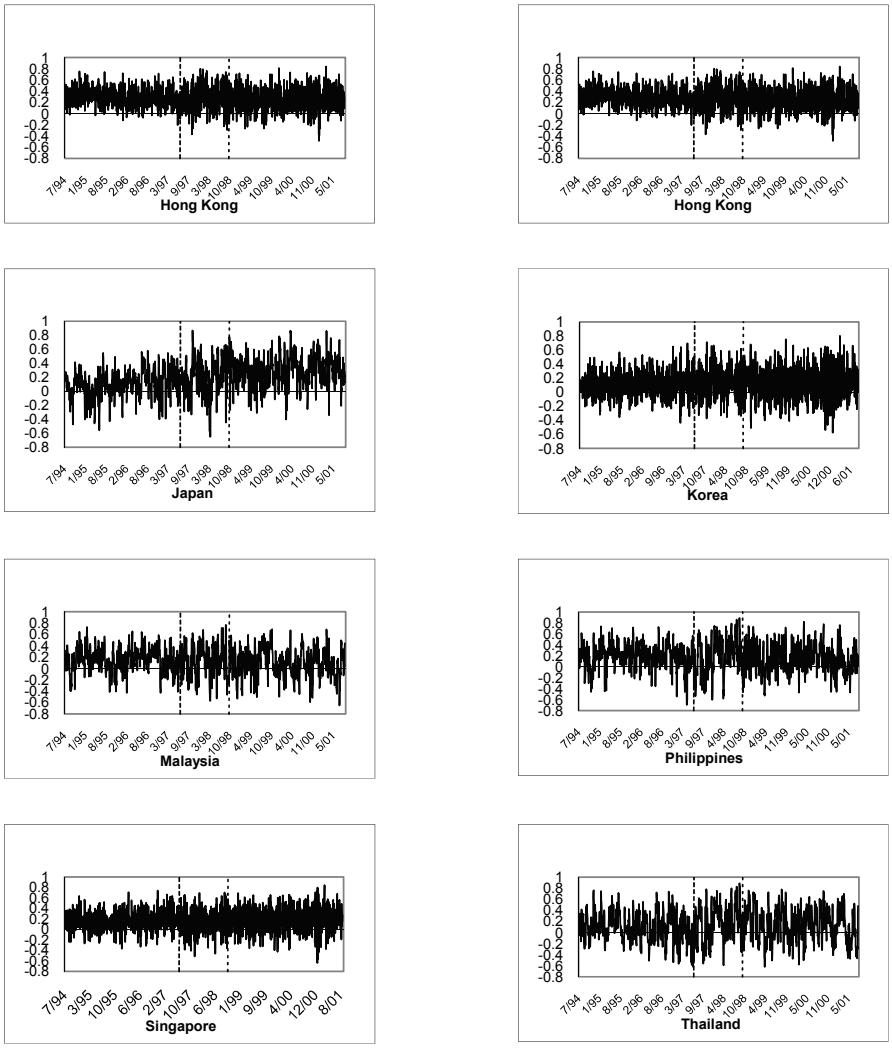


Empirical Results

The results from the direct model for ψ and Φ are presented in Table 2 for both conditional and unconditional values by period.[6]

[6] Conditional values for ψ and Φ are obtained from the time path of covariances and standard deviations of residuals for which the variables in equations (2) and (5) are regressed on constants within a multivariate EGARCH process similar to equation (7).

Figure 3—Conditional Correlation



The fraction of the local market volatility that is attributable to exchange rate fluctuations, ψ, is all positive and varies considerably over periods. The fluctuation in exchange rates against the US dollar appears to be only a small fraction of the equity market volatility in the pre-crisis period for all the sample countries. As predicted in our model, this stems from the fact that, in the pre-crisis period, local currencies pegged to the US dollar were relatively stable as seen in Figure 1, thus affecting local equity markets to a lesser extent. Some interesting patterns are uncovered by analyzing the crisis period. During the crisis, the values of ψ exhibit a

Table 2—Volatility and Correlations Attributable to Exchange Rate Fluctuations

Country	Period	Volatility Attributable to Exchange Rate Fluctuations (%): [ψ] Unconditional	Volatility Attributable to Exchange Rate Fluctuations (%): [ψ] Conditional	Correlation Coefficients Attributable to Exchange Rate Fluctuations (%): [Φ] Unconditional	Correlation Coefficients Attributable to Exchange Rate Fluctuations (%): [Φ] Conditional
	I	0.08	0.06 (1.02)	-0.09	-0.15 (-0.23)
HONG	II	0.02	0.08 (0.81)	-0.16	-0.19 (-0.50)
	III	0.01	0.003 (0.42)	0.11	0.93 (1.37)
	I	6.67	3.98 (9.69)**	-3.96	-0.34 (0.29)
IND	II	54.17	50.46 (26.80)**	36.32	29.36 (17.5)**
	III	25.98	29.41 (14.45)**	13.96	10.28 (7.92)**
	I	7.78	5.85 (7.11)**	-2.07	-2.10 (-1.47)
JAP	II	33.81	25.24 (20.89)**	-3.12	-2.92 (-1.83)
	III	13.72	14.25 (16.92)**	-2.28	-2.73 (-0.91)
	I	5.72	3.78 (12.49)**	-0.25	-0.32 (-0.87)
KOR	II	49.92	38.67 (28.12)**	30.60	26.73 (11.3)**
	III	15.24	6.26 (15.81)**	13.42	8.91 (5.28)**
	I	4.08	5.95 (11.02)**	-0.95	-1.16 (1.52)
MAL	II	38.33	36.90 (23.80)**	31.35	24.78 (12.30)**
	III	0.00	0.00	0.00	0.00
	I	18.66	10.01 (7.20)**	-3.77	-0.80 (-0.95)
PHIL	II	40.95	39.15 (25.77)**	31.13	27.90 (12.10)**
	III	28.97	20.13 (14.75)**	8.34	6.79 (4.10)**
	I	2.28	2.76 (7.78)**	-3.75	-0.23 (-0.99)
SING	II	31.89	26.15 (23.78)**	5.20	3.52 (9.54)**
	III	8.88	4.27 (14.33)**	3.82	0.77 (3.65)**
	I	12.06	1.40 (2.98)**	-2.01	-0.19 (-0.88)
THAI	II	43.11	37.26 (34.67)**	7.45	8.30 (11.76)**
	III	14.61	8.49 (15.51)**	2.87	2.91 (6.14)**

Numbers in parentheses are t-statistics

* (**) indicates statistical significance at the 5 percent (1 percent) level

dramatic increase for all the sample markets (except Hong Kong). For example, before the crisis, the values of conditional ψ were 3.98 percent for Indonesia, 5.85 percent for Japan, 3.78 percent for Korea, 5.95 percent for Malaysia, 10.01 percent for the Philippines, 2.76 percent for Singapore, and 1.40 percent for Thailand. The corresponding values of ψ during the crisis rose to 50.46 percent for Indonesia, 25.24 percent for Japan, 38.67 percent for Korea, 36.90 percent for Malaysia, 39.15 percent for the Philippines, 26.15 percent for Singapore, and 37.26 percent for Thailand. Although our results can be contrasted in magnitude to those of Kaminsky and Schmukler (1999) who claim that exchange rate movements explain about 50 percent of the daily fluctuations of the local stock market index in dollars during the crisis, it is apparent that the local market return volatility is attributable increasingly to fluctuations in exchange rates during the crisis. This suggests that the volatility of local

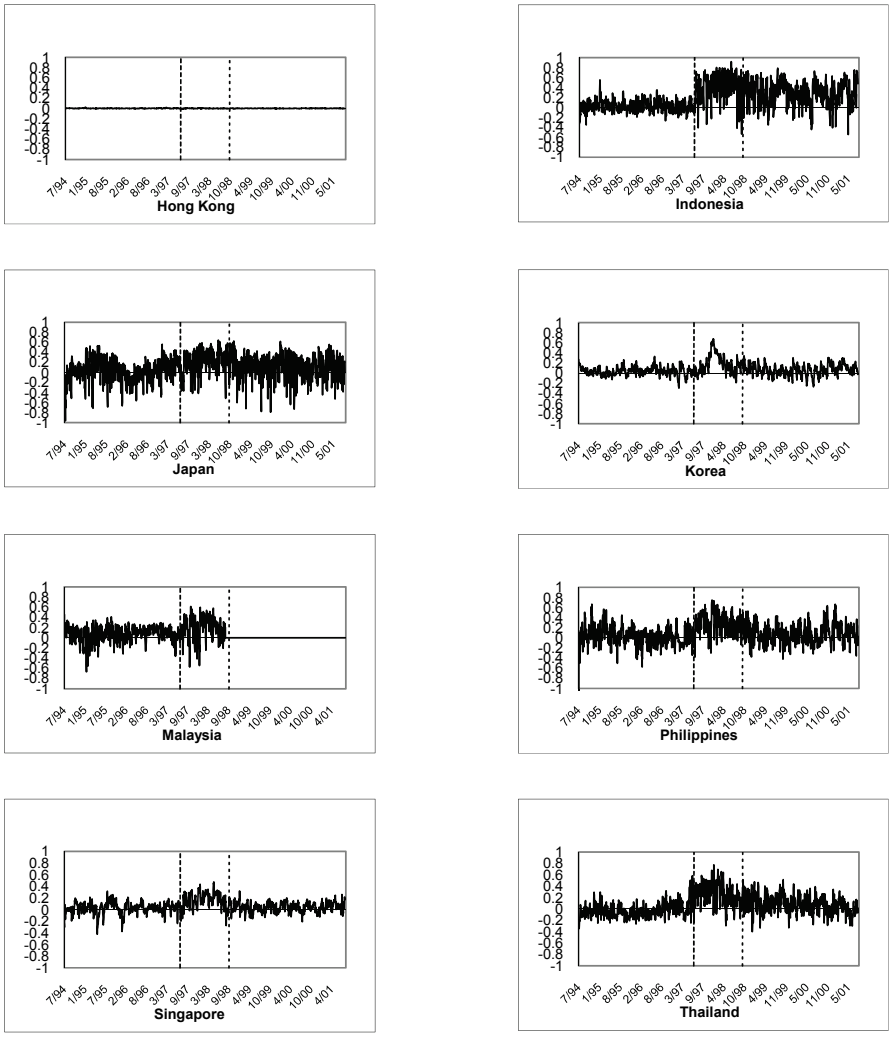
equity markets increased with exchange rate fluctuations, a result consistent with those of Dumas and Solnik (1995), Bartov et al (1996), De Santis and Gerard (1998), Aquino (2005, 2006), and Yau and Nieh (2006).

Table 2 also presents an impact of exchange rate fluctuations on the US/local stock market correlation. While conditional values for Φ in the pre-crisis period appeared to be negative and statistically insignificant, the corresponding values during the crisis increased dramatically to large positive values for most of the sample countries. This suggests that the US/local market correlation decreased marginally with exchange rate fluctuations in the pre-crisis period, but increased significantly with exchange rate fluctuations during the crisis. After the crisis, the US/local market correlation was explained, to a much lesser extent, by exchange rate fluctuations due mainly to a stability regained in the foreign exchange market. Yet the positive sign for values of Φ after the crisis indicates that the exchange rate fluctuation contributes to a higher US/local market correlation. The conventional wisdom suggests that if exchange rate changes make one country better off and the other worse off, the cross-market correlation should be declining with exchange rate fluctuations. We find that the cross-market correlation can rise or fall with exchange rate fluctuations, depending on the sign of the correlation between US equity market returns and exchange rate fluctuations that changes over time.

Cross-period comparisons for ψ and Φ reveal that except for Hong Kong and Japan, the fraction of the local market volatility attributable to exchange rate fluctuations drastically rose during the crisis and fell after the crisis. The same pattern or trend can be observed for the US/local equity market correlation attributable to exchange rate fluctuations. That is, when more of the local stock market volatility is accounted for by exchange rate fluctuations, the extent to which the US/local equity market correlation can be explained by exchange rate fluctuations increases (decreases) if the US equity market returns are positively (negatively) correlated with exchange rate changes. This result is in line with predictions made by our model.

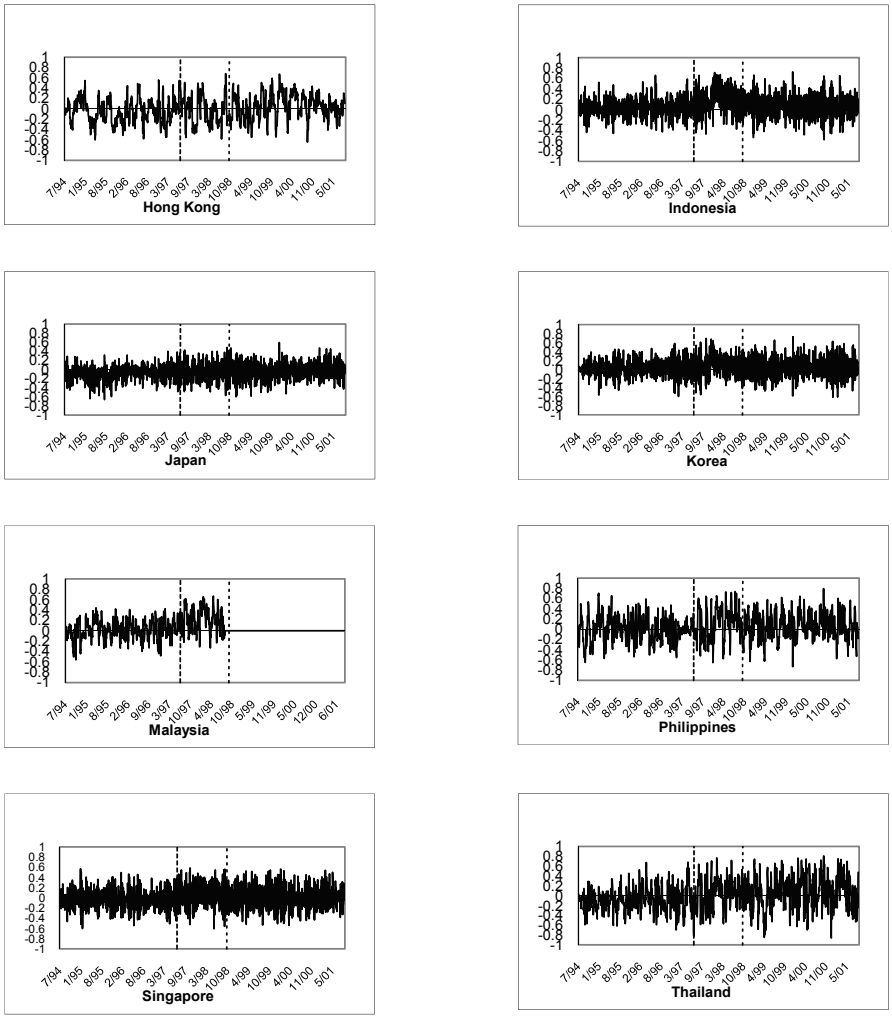
To visually observe the dynamics of ψ and Φ around the crisis, we provide time series movements of conditional volatility and correlation coefficients that can be attributable to exchange rate fluctuations. Figure 4 plots the proportion of the local equity market volatility that can be attributable to exchange rate fluctuations by country. In Figure 4, the time series behavior of ψ varies considerably over periods. The exchange rate fluctuation appears to account for only a small fraction of the local equity market volatility when we look at the pre-crisis period. During the crisis, there was a dramatic increase in the fraction of the market volatility that could be attributable to exchange rate changes for all the sample countries (except Hong Kong). In the post-crisis period, the values of ψ reverted downward mostly to levels similar to the pre-crisis period. The proportion of correlation coefficients that can be attributable to exchange rate fluctuations, Φ, is plotted in Figure 5 by country. The plots reveal that Φ is time-varying, with a large amount of switching between posi-

Figure 4—Volatility Attributable to FX Fluctuations



tive and negative. This is not wholly unexpected, given that the correlation could be driven by both local equity market return factors and exchange rate fluctuations, whose influence changes over time. Also, movements of Φ exhibit that the US/local equity market correlation was more heavily influenced by exchange rate fluctuations during the crisis.

Figure 5—Correlations Attributable to FX Fluctuations



Forecast Error Variance Decomposition

In this section, the relative importance of exchange rate fluctuations in explaining the dynamic behavior of volatility and correlation coefficients is investigated using the method of forecast error variance decomposition. The VAR (vector autoregression)-based forecast error variance decomposition often has been applied to examine how much movement in one variable can be explained by innovations in another variable. [See, for example, Campbell and Ammer (1993), Tse et al. (1996), and Kim (2002), among others.] We thus consider a VAR system of two variables, denoted by the column vector

$$x_t = [Z_{it},\ R_{it}^{USD}]' \text{ or } [Z_{jt},\ \rho(R_{it}^{USD}, R_t)]'.$$

The VAR system is specified in the following form:

$$x_t = A_0 + A_i x_{t-1} + A_2 x_{t-2} + \ldots A_P x_{t-P} + \varepsilon_t \quad (8)$$

where:

A_0 = The (2×1) vector of constants;
A_i = The (2×2) matrices of coefficients $(i = 1, 2, \ldots, p)$; and
ε_t = The error vector.

Three lags were chosen in the estimation, as this lag length minimizes the Schwartz Bayesian criterion (SBC). A Choleski decomposition is used to orthogonalize the underlying errors using the ordering as defined above. Placed first in the ordering, the exchange rate change is implicitly assumed to be exogenous in the VAR.

Table 3 presents the decomposition of k-day ahead forecast error variances (k = 1, 4, 8) of the local market return as well as its correlation with the US market return into fractions that are attributable to its own innovations and to innovations in exchange rate changes. The column for local returns reveals that an exchange rate innovation accounted for a relatively small portion of variations in local market returns in both pre- and post-crisis period, while the corresponding portion increased dramatically during the crisis for all the sample countries (except Hong Kong). For example, at a one-day horizon, the proportion of forecast error variance in the local market return that can be explained by exchange rate fluctuations ranges from 4.37 percent for Malaysia to 17.45 percent for Thailand in the pre-crisis period. During the crisis, the corresponding proportions rose sharply to the range of 37.10 percent for Japan and 50.67 percent for Thailand.

Similar results are presented for the variance decomposition of the US/local stock market correlation. For all the sample countries, exchange rate changes accounted for a relatively trivial fraction of variation in the correlations in the pre-crisis period but accounted for a conspicuously larger fraction during the crisis period, although the extent varied across countries. This suggests that more of the US/local stock market correlation can be explained by exchange rate fluctuations during the crisis, a result in line with that of Yau and Nieh (2006). Innovations in exchange rate changes, for instance, account for only 7.70 percent of the forecast error variances of Korea's correlation with the US at a one-day horizon in the pre-crisis period but increases to 25.14 percent during the crisis. The results here are in line with previous findings.

Table 3—Forecast Error Variance for Local Returns and Cross-Market Correlations

			Equity Market Returns			Cross-Market Correlations		
Country	Period	Day	Standard Error (%)	Own Shock (%)	FX Shock (%)	Standard Error (%)	Own Shock (%)	FX Shock (%)
		1	0.726	99.326	0.674	1.524	99.975	0.025
	I	4	0.875	99.009	0.991	1.531	99.935	0.065
		8	0.880	98.976	1.024	1.531	99.935	0.065
		1	1.854	99.728	0.272	1.840	99.950	0.050
HK	II	4	2.079	98.228	1.772	1.950	99.955	0.045
		8	2.081	98.202	1.798	1.950	99.955	0.045
		1	1.102	99.529	0.471	2.122	99.803	0.197
	III	4	1.291	99.351	0.649	2.187	99.748	0.252
		8	1.295	99.289	0.711	2.187	99.748	0.252
		1	0.579	85.178	14.822	1.537	96.961	3.039
	I	4	0.734	85.484	14.516	1.682	96.766	3.234
		8	0.743	85.505	14.495	1.683	96.766	3.234
		1	3.821	57.360	42.640	2.556	71.925	28.075
IND	II	4	4.590	57.352	42.648	2.700	71.231	28.769
		8	4.612	57.352	42.648	2.700	71.221	28.779
		1	1.778	73.531	26.469	2.082	89.978	10.022
	III	4	2.175	72.639	27.361	2.369	89.845	10.155
		8	2.189	72.559	27.441	2.373	89.845	10.155
		1	0.677	92.270	7.730	1.630	95.736	4.264
	I	4	0.788	92.128	7.872	2.425	95.657	4.343
		8	0.791	92.029	7.971	2.591	95.510	4.490
		1	1.156	62.899	37.101	1.206	91.886	8.114
JAP	II	4	1.310	66.754	33.246	1.752	91.894	8.106
		8	1.312	66.837	33.163	1.848	91.854	8.146
		1	0.946	86.227	13.773	1.407	92.868	7.132
	III	4	1.113	88.662	11.338	2.017	92.828	7.172
		8	1.117	88.785	11.215	2.117	92.478	7.522
		1	0.753	91.481	8.519	1.362	92.304	7.696
	I	4	0.910	93.585	6.415	1.630	92.430	7.570
		8	0.915	93.574	6.426	1.637	92.430	7.570
		1	3.145	54.577	45.423	1.743	74.861	25.139
KOR	II	4	3.706	49.114	50.886	2.046	74.891	25.109
		8	3.718	48.955	51.045	2.052	74.891	25.109
		1	1.689	88.299	11.701	1.634	89.001	10.999
	III	4	1.985	85.109	14.891	2.207	88.866	11.134
		8	1.992	84.894	15.106	2.265	88.864	11.136
		1	0.666	95.630	4.370	1.204	93.997	6.003
	I	4	0.798	96.722	3.278	1.870	93.900	6.100
		8	0.801	96.743	3.257	2.047	93.855	6.145
		1	2.730	60.224	39.776	1.633	69.623	30.377
MAL	II	4	3.341	46.341	53.659	2.571	69.292	30.708
		8	3.367	45.649	54.351	2.842	69.138	30.862
		1	0.000	0.000	0.000	0.000	0.000	0.000
	III	4	0.000	0.000	0.000	0.000	0.000	0.000
		8	0.000	0.000	0.000	0.000	0.000	0.000
		1	0.813	74.260	15.740	1.395	90.950	9.050

Table 3 (cont.)—Forecast Error Variance for Local Returns and Cross-Market Correlations

			Equity Market Returns			Cross-Market Correlations		
Country	Period	Day	Standard Error (%)	Own Shock (%)	FX Shock (%)	Standard Error (%)	Own Shock (%)	FX Shock (%)
	I	4	0.972	77.672	12.328	2.018	90.450	9.550
		8	0.977	77.880	12.120	2.120	90.312	9.688
		1	1.899	60.990	39.010	1.837	79.710	20.290
PHIL	II	4	2.384	61.220	38.780	2.896	79.127	20.873
		8	2.409	61.241	38.759	3.199	78.879	21.121
		1	1.231	64.288	25.712	1.631	89.832	10.168
	III	4	1.490	51.761	28.239	2.303	89.909	10.091
		8	1.492	51.627	28.373	2.401	89.916	10.084
		1	0.481	94.078	5.922	1.556	97.857	2.143
	I	4	0.569	95.557	4.443	1.760	97.839	2.161
		8	0.572	95.579	4.421	1.762	97.839	2.161
		1	1.329	62.823	37.177	1.863	89.926	10.074
SING	II	4	1.683	52.119	47.881	2.244	89.330	10.670
		8	1.697	51.449	48.551	2.255	89.333	10.667
		1	0.919	89.710	10.290	1.837	96.968	3.032
	III	4	1.078	86.846	13.154	2.238	96.640	3.360
		8	1.081	86.642	13.358	2.251	96.640	3.360
		1	0.917	82.551	17.449	1.405	98.996	1.004
	I	4	1.139	85.260	14.740	2.556	98.927	1.073
		8	1.151	85.087	14.913	2.521	98.698	1.302
		1	2.242	49.332	50.668	1.716	94.849	5.151
THAI	II	4	2.706	55.394	44.606	2.792	94.030	5.970
		8	2.723	55.888	44.112	3.160	94.629	5.371
		1	1.294	83.868	16.132	1.557	98.290	1.710
	III	4	1.584	78.820	21.180	2.511	98.548	1.452
		8	1.594	78.434	21.566	2.821	98.283	1.717

Effects of Exchange Rate Fluctuations

Testing for the effect of exchange rate fluctuations on the volatility and cross-market correlations is conducted using equation (7) with the following variance-covariance dynamics:

$$f_i(\lambda_{i,t-1}) = |\lambda_{i,t-1}| - E|\lambda_{i,t-1}| + \delta_i \lambda_{i,t-1} + d_i|Z_{t-1}| \quad (9)$$

$$f_j(\lambda_{j,t-1}) = |\lambda_{j,t-1}| - E|\lambda_{j,t-1}| + \delta_j \lambda_{j,t-1} + d_j|Z_{t-1}|$$

$$\sigma_{ij,t} = [\rho_{ij,t} + d_{ij}|Z_{t-1}|] (\sigma_{i,t} \sigma_{j,t})$$

where:

$\rho_{ij,t}$ = The correlation coefficient between the local and US market returns (i = the local market and j = the US market); and

$|Z_{t-1}|$ = The exchange rate fluctuation.

The estimation of coefficients $d_i(d_j)$ should capture the effect of exchange rate fluctuations on the conditional variance of the local (US) market return. The estimation of coefficient d_{ij} should capture the effect of exchange rate fluctuations on correlations. The hypothesis that a higher exchange rate volatility contributes to a higher local (US) stock market volatility will be accepted if the coefficient $d_i(d_j)$ is

significantly positive. Similarly, the hypothesis that a higher exchange rate volatility contributes to a higher correlation will be accepted if the coefficient, d_{ij}, is significantly positive.

Table 4 provides the parameter estimates for the variance-covariance process with t-statistics and test results for the hypothesis that exchange rate fluctuations have no impact on volatility and/or US/local market correlations. The t-statistics for the estimated coefficient for d_i are significantly positive at the 5 percent level across periods for all of the sample countries (except for Hong Kong). This suggests that a higher exchange rate variability contributes significantly to a higher local equity market volatility across periods. Furthermore, the estimated coefficients for d_i increased drastically in magnitude and rejections became stronger during the crisis, providing strong evidence that the local equity market volatility increased to a much larger degree due to exchange rate fluctuations. Table 4 also presents that the estimated coefficients for d_j are all negative before the crisis but positive during and after the crisis, although the extent is not significant for some countries. This implies that the exchange rate fluctuation contributed by and large to a lower US equity market volatility before the crisis but contributed significantly to a higher US equity market volatility during the crisis. This result provides strong evidence for the role of exchange rate fluctuations in the US equity market volatility. Interestingly, the estimated coefficients for d_i are all greater in absolute values than those for d_j, indicating that the exchange rate variability affects the local equity market volatility to a greater extent than the US equity market volatility. This can be attributed to the fact that exchange rate changes are more strongly correlated with the local equity market than the US equity market (Table 1).

Table 4—Effects of Exchange Rate Fluctuations on Equity Market Volatility and US/Local Market Correlation

The following variance-covariance dynamics is estimated using equation (7):

$$f_i(\lambda_{i,t-1}) = |\lambda_{i,t-1}| - E|\lambda_{i,t-1}| + \delta_i\ \lambda_{i,t-1} + d_i|Z_{t-1}|$$

$$f_j(\lambda_{j,t-1}) = |\lambda_{j,t-1}| - E|\lambda_{j,t-1}| + \delta_j\ \lambda_{j,t-1} + d_j|Z_{t-1}|$$

$$\sigma_{ij,t} = [\rho_{ij,t} + d_{ij}|Z_{t-1}|]\ (\sigma_{i,t}\ \sigma_{j,t})$$

where $|Z_{t-1}|$ is the exchange rate fluctuation. The hypothesis that a higher FX volatility implies a higher local (US) stock market volatility will be accepted if the coefficient $d_i(d_j)$ is statistically significantly positive. Similarly, the hypothesis that a higher FX volatility implies a higher correlation will be accepted if the coefficient, d_{ij}, is statistically significantly positive

Country	Period	$\hat{d}_i$	$\hat{d}_j$		H_0: $d_i = d_j = 0$ χ^2 (2)	H_0: $d_i = d_j = d_{ij} = 0$ χ^2 (3)
		0.0018	-0.0016	-0.0037	2.24	2.49
	I	(0.76)	(-1.22)	(-0.12)		
		0.0080	0.0218	-0.0089	15.35*	16.19*
HONG	II	(1.48)	(2.85)**	(-0.38)		
		0.0071	0.0826	0.0063	14.62*	15.66*
	III	(1.35)	(3.95)**	(0.20)		

Table 4 (cont.)—Effects of Exchange Rate Fluctuations on Equity Market Volatility and US/Local Market Correlation

Country	Period	$\hat{d}_i$	$\hat{d}_j$		H_0: $d_i = d_j = 0$ χ^2 (2)	H_0: $d_i = d_j = d_{ij} = 0$ χ^2 (3)
		0.0067	-0.0001	-0.0041	12.06*	12.09*
	I	(3.45)**	(-0.43)	(-0.26)		
		0.0355	0.0000	0.0223	26.83**	36.83**
IND	II	(6.84)**	(0.73)	(2.75)**		
		0.0215	0.0004	0.0160	28.38**	34.91**
	III	(5.39)**	(4.28)**	(1.97)*		
		0.0050	-0.0003	-0.0118	25.95**	30.79**
	I	(5.30)**	(-2.50)*	(-0.83)		
		0.0153	0.0009	-0.0343	30.16**	31.66**
JAP	II	(6.35)**	(2.84)**	(-1.36)		
		0.0114	0.0019	-0.0261	30.12**	38.53**
	III	(5.80)**	(4.74)**	(-1.22)		
		0.0079	-0.0006	-0.0085	9.45*	9.72*
	I	(2.20)*	(-2.26)*	(-0.41)		
		0.0448	0.0001	0.0292	30.84**	38.42**
KOR	II	(5.54)**	(0.69)	(3.23)**		
		0.0356	0.0023	0.0133	26.75**	31.36**
	III	(4.84)**	(5.25)**	(2.67)**		
		0.0023	-0.0013	-0.0011	16.90*	17.19*
	I	(1.98)*	(-9.27)**	(-0.38)		
		0.0449	0.0001	0.0278	30.62**	36.16**
MAL	II	(5.73)**	(1.46)	(2.90)**		
	III	-	-	-	-	-
		0.0079	-0.0003	-0.0023	26.58**	33.19**
	I	(5.67)**	(-2.93)**	(-1.46)		
		0.0338	0.0002	0.0293	24.87**	35.24**
PHIL	II	(5.83)**	(1.17)	(4.51)**		
		0.0165	0.0013	0.0125	35.53**	52.68**
	III	(4.47)**	(4.04)**	(2.24)*		
		0.0025	-0.0005	-0.0041	7.52*	8.97*
	I	(2.09)*	(-1.09)	(-1.52)		
		0.0185	0.0011	0.0086	21.65**	27.10**
SING	II	(7.30)**	(2.90)**	(2.49)*		
		0.0087	0.0069	0.0054	22.74**	28.33**
	III	(4.81)**	(5.56)**	(1.97)*		
		0.0120	-0.0003	-0.0013	11.10*	12.74*
	I	(3.64)**	(-0.42)	(-1.19)		
		0.0295	0.0003	0.0060	27.34**	32.38**
THAI	II	(5.91)**	(2.24)*	(2.28)**		
		0.0173	0.0027	0.0042	30.52**	35.34**
	III	(3.98)**	(5.81)**	(1.96)*		

Numbers in parentheses are t-statistics

* (**) indicates statistical significance at the 5 percent (1 percent) level

Table 4 also provides the parameter estimates with t-statistics for the impact of the exchange rate variability on the US/local market correlation. The estimated coefficients for d_{ij} in equation (9) are all negative but insignificant in the pre-crisis period, indicating that a higher exchange rate fluctuation can cause a decline in the US/local equity market correlation although statistically insignificant. Yet, during and after the crisis, the estimated coefficients turned into a positive sign except for Hong Kong and Japan, suggesting that the US/local market correlation significantly increased with exchange rate fluctuations. As predicted in our model, this result statistically provides supportive evidence for earlier findings: a higher exchange rate variability contributed to a lower US/local market correlation before the crisis, but to a higher US/local market correlation during and after the crisis.

Test results for the hypothesis that the exchange rate variability has no impact on the volatility and/or US/local market correlations are provided in the last two columns of Table 4. The hypothesis of no impact of exchange rate variability on the equity market volatility, i.e., $d_i = d_j = 0$, is strongly rejected for all the sample countries (except for Hong Kong in the pre-crisis period). The null hypothesis that the exchange rate variability has no impact on the volatility and US/local market correlations, i.e., $d_i = d_j = d_{ij} = 0$, is also strongly rejected for all the sample countries. Test results for the hypotheses provide evidence that there is a significant contribution of exchange rate fluctuations to the international stock market volatility and US/local market correlations, in particular when markets are highly volatile.

Conclusions

In this paper we investigate how and to what extent exchange rate fluctuations contribute to the international stock market volatility and US/local market correlations around the Asian financial crisis.

As an alternative to the regression-based models that are typically used in the existing literature, we develop a model that captures the contribution of exchange rate fluctuations in a direct and explicit fashion. Empirical results based on this model indicate that the exchange rate fluctuation contributes significantly to a higher local equity market volatility and the contribution becomes larger in times of high market volatility. This stems from the fact that a stable foreign exchange market implies a lower covariance risk with the local equity market, which in turn leads to a lower extent to which exchange rate fluctuations can influence the local equity market, whereas a volatile foreign exchange market will lead to the converse effect. The result that the local stock market volatility increases with exchange rate fluctuations is consistent with that of Dumas and Solnik (1995), Bartov et al. (1996), De Santis and Gerard (1998), Aquino (2005, 2006), and Yau and Nieh (2006).

We also find that the exchange rate fluctuation contributed to a lower US/local market correlation (albeit insignificant) before the crisis but contributed significantly to a higher US/local market correlation during and after the crisis except for Hong

Kong and Japan. The contribution was dramatically high during the crisis and reverted backward after the crisis, a result at odds with the conventional belief. The conventional wisdom suggests that if exchange rate changes make one country better off and the other worse off, the cross-market correlation should be declining with exchange rate fluctuations. However, evidence presented here indicates that there is no monotone relation between the cross-market correlation and the exchange rate fluctuation. The US/local market correlation can rise or fall with exchange rate fluctuations. The direction of the correlation depends on the sign of the correlation between US equity market returns and local currency values that changes over time.

Results from forecast error variance decomposition indicate that the variation not only in local stock market returns but also in the US/local market correlation can be explained, to a much greater extent, by innovations in exchange rate changes during the crisis. This suggests that exchange rate fluctuations became more important during the crisis in explaining the time series behavior of volatility and US/local market correlations, a result in line with that of Yau and Nieh (2006).

Statistical results reveal that the local equity market volatility is influenced by the exchange rate variability to a greater extent than the US equity market volatility is, probably because exchange rate changes are more strongly correlated with the local equity market than the US equity market. We also find that the exchange rate fluctuation contributed by and large to a lower US equity market volatility before the crisis but contributed significantly to a higher US equity market volatility during the crisis for most of the sample countries.

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