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Published in:
Emerging Markets Finance and Trade

DOI:
10.1080/1540496X.2014.998560

Publication date:
2016

Emerging Markets Finance & Trade, 52:382–399, 2016

ISSN: 1540-496X print/1558-0938 online
DOI: 10.1080/1540496X.2014.998560

Routledge
Taylor & Francis Group

Correlation Dynamics in East Asian Financial Markets

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ABSTRACT: We examine the dynamic relationship between stock returns and exchange rate changes using daily data from January 1994 to September 2013 for six East Asian countries. We use the multivariate GARCH-DCC model in order to disclose the relationship between stock markets and foreign exchange markets which is important for understanding financial stability. The estimation results reveal time varying correlations in the pre- and post-Asian crisis and the Global Financial Crisis periods for all countries. The correlations are stronger when the crisis intensifies. The degree of interdependence between both markets reflects a mutual markets response to shocks and changes in policy.

KEYWORDS: stock market, foreign exchange market, currency crisis, dynamic conditional correlation, interdependence

Introduction

Over the last decades, financial stability has been at the top of the agenda of many central banks and financial supervising authorities around the world. The dramatic increase in the number of financial crises and the serious adverse economic and social effects in the wake of the crises seems to be one of the main reasons. Although there is still no widely accepted definition of financial stability, many economists confirm that some degree of asset price stability is required for a condition of financial stability (Allen and Wood 2006; IMF 2012). Interrelations between asset markets reflect the process of pricing and transferring risk that have a potential to undermine financial stability. Moreover, identifying interrelations between asset markets sheds light on some widely debated spillovers to the financial system amplified and transferred by shocks.

In this article, we focus on interrelations between the returns on the stock market and the market for foreign exchange in six East Asian countries in the period before, during, and after the Asian financial crises in the period 1997–1998 and the Global Financial Crisis in 2008–2009 that originated in the United States. Since the growing significance of the Asian share in world trade and capital mobility, and the rapid growth in their domestic market capitalization over the past few decades (see Kohsaka 2004), Asian financial markets has prompted researchers, policy makers as well as analysts to carry out detailed analysis of the relationship between the stock market and the exchange rate market. The importance of modeling currency and equity markets simultaneously is supported by Dungey and Martin (2007), Lin (2012), and Tsai (2012). Rapidly increasing international equity investments creates a higher supply and demand for currencies, leading to some degree of interdependence between both markets. The wide fluctuations in the value of the currencies heightened the interest in the potential vulnerability of internationally active firms to foreign exchange risk. Moreover, positive spillovers of volatility between both markets may increase the international portfolio risk faced by international investors. This reduces the opportunities from international diversification and disturbs the asset allocation decisions. Therefore, the relationship between stock and foreign exchange markets is important to investigate especially in the case of highly volatile and unstable markets, that are typical of emerging economies.

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In an effort to shed light on how conditional correlations between the stock market and the foreign exchange market evolve over time we employ the class of multivariate GARCH models developed by Engle (2002). This dynamic conditional correlation (DCC) model has a number of advantages over alternative models. Unlike most studies in the literature that estimate the contemporaneous relationship among time series, this model enables us to explore the dynamic relationship between the financial markets. An additional advantage is that we do not have to split the sample in noncrisis and crisis periods as in most static models of contagion. Nor do we have to impose restrictions on the conditional variance system—as in Caporale et al. (2005)—in order to identify the model. In addition, many straightforward multivariate extensions of the univariate GARCH model are often not parsimonious since the number of parameters to be estimated is increasing rapidly as the number of assets included grows. This is a serious shortcoming of these models, but not of the DCC model where the number of parameters increase only linearly with the number of assets. To our knowledge there are only a few studies using the DCC model to investigate the links between the stock market and the foreign exchange market in the Asian countries.

The remainder of the article is organized as follows. The next section discusses the theoretical and empirical studies on the relationship between exchange rate fluctuations and stock returns. The "Data and Properties" section presents the properties of stock and foreign exchange rate markets data in our sample, followed by the Estimation Results. The article concludes with a discussion of the implications and a summary of the main conclusions.

A Survey of the Literature

The association between the movements in exchange rates and stock prices has long been an unresolved issue in the finance literature. Theoretical models arrive at different conclusions about the causality between the two financial markets and the sign of their correlations. The portfolio balance model, developed by Branson (1983), Frankel (1983), and others, expects the stock prices to effect exchange rates. An increase in stock returns due to higher stock prices raises domestic wealth, which in turn leads to higher domestic demand for money and interest rates. The higher interest rates encourage capital inflows, leading to an appreciation of the domestic currency.

An alternative explanation for the relationship between stock prices and exchange rates is provided by the so-called traditional approach, like the model of Dornbusch and Fischer (1980). In this view, exchange rates affect stock prices positively. A depreciation of the domestic currency increases international competitiveness and therefore improves the current account. Consequently, rising real output in turn positively influences the profitability and the value of firms, and therefore their stock prices. The response of stock prices to fluctuations in the exchange rate depends on their degree of exposure to exchange rate risks through channels like the degree of openness both in international trade and international capital mobility, the degree of foreign competition for firms with no international business activity and the degree of competition for factors of production (Dominguez and Tesar 2001).

The events of the emerging market financial crisis of the 1990s motivated many economists to explain how exchange rate movements can affect emerging market firms through the foreign-currency debt on their balance sheets. Bordo with various co-authors studied financial crises from a macroeconomic viewpoint. Examples are Bordo and Schwartz (1996), Bordo and Eichengreen (1999), and Bordo et al. (2001). Aghion et al. (2000, 2001, 2004) argue that if domestic firms hold a lot of foreign currency dominated debt, then output reacts negatively to an increase in the debt burden induced by a sharp currency depreciation. A deterioration of the net worth of firms—which resulted in many bankruptcies and loan defaults—is a primary cause of a sharp decline in lending and economic contraction. Moreover, countries with a less developed financial system are more prone to an output decline after an exchange rate shock. Calvo (2001, 2002) and Cristina and Jonathan (2010) reach similar conclusions, but they emphasize that the prevalence of foreign-currency liabilities in emerging markets limits the desirability of flexible exchange rates.

In line with theoretical expectations, empirical research on the existence of a relationship between stock prices and exchange rates appears conflicting, and is mixed at best. An extensive range of empirical studies employ various statistical and econometric methods to provide evidence for a link between the two financial markets. These studies use different time spans, different frequencies of data, different geographical coverage, and different levels of the analysis: firm level, industry level, or national level. In this overview we focus on research applied to Asian countries.

Some recent studies use the concept of Granger causality and cointegration techniques to examine interactions between stock and foreign exchange markets in Asia. Granger et al. (2000), among others, apply unit root tests and cointegration models to determine the appropriate Granger-causal relations between stock prices and exchange rates using recent data for nine East Asian countries. During tranquil periods, that is before and after the Asian financial crisis in 1997–1998, the results reveal no definitive pattern of interaction between the two markets. However, there exists an interaction between the two markets during the Asian crisis. In the case of South Korea, changes in the exchange rates lead to that in stock prices. The reverse direction is found for Hong Kong and the Philippines. The other markets (Malaysia, Singapore, Thailand, and Taiwan) are characterized by bi-causal interactions. Using a similar methodology and sample of countries, Ramasamy and Yeung (2005) and Liang et al. (2013) reach slightly different conclusions.

In the literature on foreign exchange rate exposure, empirical studies by Dominguez and Tesar (2001) and Chue and Cook (2008) apply a two-factor regression specification with instrumental variables to examine the relationship between excess stock returns and the change in the exchange rates. Using a wide range of firm level data for fifteen emerging markets, Chue and Cook (2008) reveal that emerging market firms are mostly negatively exposed to exchange rate changes during the turbulent episodes of the Asian crisis. This negative exposure disappears shortly after the crisis. Focusing on non-U.S. industrialized countries, Dominguez and Tesar (2001) confirm that a depreciation of the Thai baht generally led to a decrease in the value of the share of firms in Thailand. Using the same methodology, Parsley and Popper (2006) focus on the exchange rate exposure of stock returns to various foreign currencies (U.S. dollar, euro, UK pound, and Japanese yen) under pegged and nonpegged exchange rate arrangements. Their results show that in Malaysia, the Philippines, and Thailand many firms exhibit a statistically significant exposure to the dollar with a peg. Under a peg, a certain number of firms in all nine countries in the sample show a significant exposure to fluctuations in the yen. Without a peg, only Taiwanese firms show a notable exposure to the yen. There is seemingly less exposure against the euro and the UK pound with or without a currency peg. A recent study by Bartram and Bodnar (2012), using cross-sectional regression in thirty-seven developed and emerging markets including Asia, reveal that a relationship between exchange rate exposure and stock returns exists conditionally on the realized change in the exchange rate itself. The relation is more significant among emerging market firms. Examples for the relationship between Chinese stock prices and the renminbi are Nieh and Yau (2010) and Cao (2012).

Unlike Granger et al. (2000), Caporale et al. (2002) focus on causal links among variances by means of multivariate GARCH (Generalized Autoregressive Heteroskedasticity) model in four East Asian countries. They find that in the precrisis sample stock prices lead exchange rates negatively in Japan and South Korea and positively in Indonesia and Thailand. After the onset of the 1997 East Asian crisis the spillover effects are found to be bi-directional in the latter two countries. Related studies are Muller and Verschoor (2007), Zhao (2010) and Kuper and Lestano (2007). In this article we use the same multivariate GARCH-DCC specification as in Kuper and Lestano (2007) to analyze the relationship between the stock market, the money market, and the market for foreign exchange, but for more East Asian countries, and for a longer time span including the Global Financial Crisis.

Data and Properties

The aim of this article is to explore the interdependency between stock returns and exchange rate changes before, during, and after the Asian crises of the late 1990s and the Global Financial Crisis

(GFC) in 2008–2009. The two crises have brought about strains on world financial markets across the board. We focus on the stock market and the market for foreign exchange—Dungey and Martin (2007) argue that it is important to model these markets simultaneously—in six Asian countries: Indonesia, Malaysia, the Philippines, Singapore, South Korea, and Thailand. These countries have in common that the rates of GDP growth before the Asian crisis were high, and that they have been affected by the Asian crisis. We use the exchange rates (value of the national currency per U.S. dollar) and the Dow Jones global price indices in terms of the U.S. dollar. Our choice of the exchange rates is supported by the fact that the United States is one of the most important trading partners of the Asian market. We excluded Hong Kong because the HK dollar has been pegged to the U.S. dollar since October 1983.

All data is obtained from Thomson-Datastream. The sample period is from January 3, 1994 to September 27, 2013. We only include trading days (Monday–Friday), excluding holidays. This produces 5,510 observations. The sample period is selected to include the Asian financial crisis in 1997–1998 and the GFC in 2008–2009. We prefer daily date over low frequency data because low frequency data obscures transient responses to innovations that may last for a few days only. Moreover, daily data are more adequate for capturing the effects of rapid capital movements. Figure 1 plots the returns of the stock market and the foreign exchange market series, respectively. Continuously compounded stock returns and exchange rate changes are calculated as the difference of the natural logarithms for two consecutive trading days. In terms of the exchange rate regime, all economies maintained a stable relationship with the U.S. dollar or gradually depreciated the home currency against the U.S. dollar until moving to a managed float system against a basket of currencies. During the Asian financial crisis we saw pronounced depreciations for all currencies. The outbreak of the financial crisis forced most countries to switch to a floating exchange rate regime. An exception is the Malaysian ringgit that maintained its peg to the U.S. dollar. The GFC also results in an increase in exchange rate depreciation, although the magnitude has been much less than the Asian crisis. Similar falls in stock prices during the Asian crisis have occurred. In general, stock markets in all countries were stable until 1996 when the Thai market started to deteriorate. In the following period, all market returns plunged as the financial crisis shook the economies in the region. The magnitude of the negative effect of the Asian crisis in 1997–1998 is huge as the data clearly show. Although the markets have made a modest recovery after the crisis, the market returns remained below the 1990s level. Following the GFC, all Asian stock markets declined during 2008, particularly at the time just after the investment

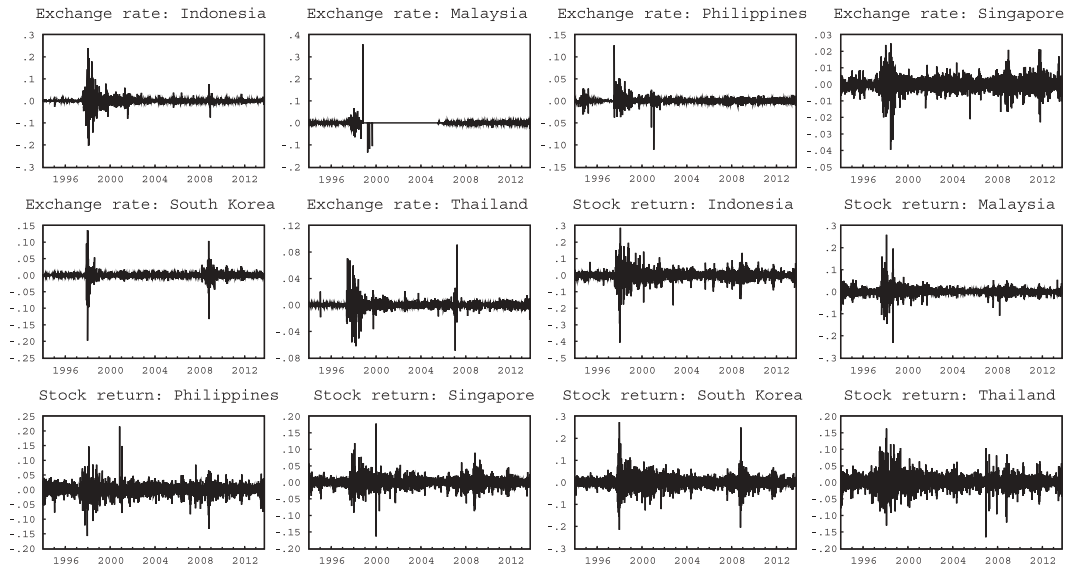

Figure 1. Relative changes in the exchange rate and stock market returns: January 3, 1994–September 27, 2013.

Table 1. Descriptive statistics for the relative changes in the foreign exchange rates and stock market prices: January 3, 1994–September 27, 2013

	Mean	Std. dev.	Skewness	Kurtosis	Jarque-Bera
Exchange rate changes					
Indonesia	3.30×10^{-4}	0.01	1.98	78.92	124,005.00
Malaysia	3.70×10^{-5}	0.01	18.03	1012.37	219,000.00
Philippines	8.69×10^{-5}	0.01	1.28	106.86	231,583.00
Singapore	-4.85×10^{-5}	0.00	–0.41	14.08	26,465.15
South Korea	5.51×10^{-5}	0.01	–0.75	104.36	204,787.00
Thailand	3.95×10^{-5}	0.01	0.91	56.18	607,362.10
Stock market returns					
Indonesia	-5.45×10^{-5}	0.03	–0.87	32.70	189,921.90
Malaysia	7.30×10^{-6}	0.02	0.77	43.57	353,548.90
Philippines	2.53×10^{-5}	0.02	0.17	16.46	38,910.66
Singapore	2.30×10^{-5}	0.01	0.00	17.29	43,829.80
South Korea	6.50×10^{-5}	0.02	0.16	17.30	43,915.40
Thailand	-3.99×10^{-5}	0.02	0.13	10.48	12,032.38

Note: The critical value of the Jarque-Bera statistic with two degrees of freedom is 5.99.

bank Bear Stearns failed (March 16, 2008) and Lehman Brothers collapsed (September 16, 2008). The crisis had a negative effect on the Asian stock markets but the degree is smaller compared to the effect of the Asian crisis in the 1990s.

Table 1 reports descriptive statistics for the stock market prices and the exchange rates. All stock markets have low positive average daily returns, except Thailand and Indonesia. The table implies that the changes in the exchange rates and the stock returns exhibit high dispersion (measured as the absolute value of the percentage coefficient of variation); the coefficient of variation exceeds 3,000 percent in absolute value for the changes in the series. The skewness coefficients indicate that most of the series are positively skewed. The stock market return series and the changes in the exchange rates for all countries are leptokurtic (peaked relative to the normal distribution and fat tails). Consequently, all series display strong evidence of non-normality as is also illustrated by the Jarque-Bera statistic.

Figure 1 shows that fluctuations tend to cluster together separated by periods of relative tranquility. This seems consistent with the volatility clustering phenomenon where large stock returns tend to be followed by large returns and small returns by small returns leading to contiguous periods of volatility and stability. If this is true, then an autocorrelation test should be taken into account. Table 2 reports test results of serial correlation and ARCH effects for all series at 12 and 24 lags. The Ljung-Box Q-statistics at 12 and 24 lags are computed for both the series and squared series. The results of the Q tests show that there is significant autocorrelation in the residuals. This is seen as evidence for linear and nonlinear dependencies. Linear dependencies may be caused by some form of market inefficiency or market structure, and nonlinear dependencies may lead to autoregressive conditional heteroskedasticity. The ARCH tests also indicate that the null hypothesis of no autoregressive conditional heteroskedasticity is rejected at the 5 percent significance level.[1]

Estimation Results

In this section, we analyze the association between stock returns and exchange rate changes in Indonesia, Malaysia, the Philippines, Singapore, South Korea, and Thailand using the multivariate GARCH and DCC approach. We focus on the relationship between financial markets within each country. The parameters of the multivariate GARCH and DCC models are estimated in a two-step procedure. In the first step we estimate a univariate GARCH(1,1) model[2] for each asset with an AR(2) filter in the mean equation to remove serial correlation in the return series.[3]

Table 2. Serial correlation and ARCH effect tests for the changes in the foreign exchange rates and the stock market returns: January 3, 1994–September 27, 2013

	Ljung-Box Q-statistics					
	Series		Squared series		ARCH-LM test	
	12 lags	24 lags	12 lags	24 lags	12 lags	24 lags
Exchange rate changes						
Indonesia	255.54	329.88	4,333.50	7,294.30	1,264.97	1,718.46
Malaysia	34.24	63.49	0.06	0.01	0.06	0.10
Philippines	132.62	165.93	64.43	105.55	53.76	72.74
Singapore	46.90	72.68	1,899.11	2,920.70	826.92	912.77
South Korea	524.03	713.09	3,842.00	5,086.20	1,399.30	1,482.70
Thailand	116.14	192.48	787.81	1,163.20	368.27	514.39
Stock market returns						
Indonesia	212.82	264.51	2,403.70	4,207.60	1,176.89	1,459.25
Malaysia	144.33	211.83	1,776.20	2,328.40	850.22	970.22
Philippines	156.41	179.33	293.72	445.16	180.51	219.60
Singapore	50.68	83.49	120.15	1,444.00	845.30	871.26
South Korea	155.33	191.50	3,160.90	4,916.00	1,173.55	1,204.15
Thailand	87.29	130.49	1,778.90	2,543.90	794.22	850.27

Note: The Ljung-Box Q-statistic tests the null hypothesis of no autocorrelation; ARCH-LM (Lagrange multiplier) tests the null hypothesis of conditional homoskedasticity. All these test statistics are χ^2-distributed with the degrees of freedom equal to the number of lags. The critical values at the 5% level for these tests with 12 and 24 lags are 21.03 and 36.42, respectively.

The AR(2) model for the mean equation takes the form

$$r_t = \varphi_0 + \varphi_1 r_{t-1} + \varphi_2 r_{t-2} + u_t,$$

where r_t are changes in the exchange rate or stock market returns. Using the standardized residuals obtained from the univariate GARCH(1,1) models in the first step, the parameters describing the correlation between asset returns are estimated from the DCC(1,1) dynamic correlation structure.

The estimated coefficients and t-values for the univariate GARCH(1,1) with AR(2) and DCC (1,1) models are presented in Table 3. The last two rows in Table 3 present the estimates of the DCC(1,1) parameters. The parameter estimates of the GARCH (1,1) and DCC(1,1) models are statistically significant at 1 percent. The estimates of β are larger than those of α and the sum $\alpha + \beta$ is very close to unity but significantly smaller than unity. This evidence is supported by Wald test that hypothesis of $\alpha + \beta = 1$ is rejected. This implies that the conditional variance processes is stable and highly persistent, but not leading to either non-stationary or have an infinite variance. The patterns in the conditional variance coefficients are not substantially different for the six Asian countries. The Ljung-Box Q-statistics and the ARCH-LM test in Table 4 show—with some exceptions[4]—no evidence of autocorrelation and autoregressive conditional heteroskedasticity up to order 24 in the standardized residuals. Given the results of the Q tests, we may conclude that the GARCH(1,1) model with an AR(2) filter model is quite successful in capturing volatility clustering. Overall, we can conclude that the volatility models are properly specified.

Discussion

Figure 2 shows the conditional correlations of stock market returns and changes in the exchange rates for each country. For sake of exposition, we applied the Hodrick-Prescott filter to obtain a

Table 3. Estimation results of the GARCH(1,1) model with an AR(2) filter and the DCC(1,1) model

	AR(2) Parameters (*t*-values)			GARCH(1,1) Parameters (*t*-values)			
	φ_0	φ_1	φ_2	ω	α	β	Wald test *F*-values
Exchange rates							
Indonesia	8.11×10^{-5}*	0.074*	−0.0332**	4.69×10^{-8}***	0.07***	0.92***	465.14***
	(2.89)	(7.37)	(−3.14)	(21.90)	(63.74)	(413.23)	
Malaysia	1.69×10^{-6}***	0.045***	−0.0001*	1.91×10^{-5}***	0.15***	0.59***	277.69***
	(0.13)	(1.55)	(−0.01)	(14.72)	(9.12)	(20.53)	
Philippines	-6.33×10^{-5}*	0.005*	−0.0509***	2.52×10^{-6}***	0.15***	0.76***	791.75***
	(−0.86)	(0.28)	(−2.88)	(35.51)	(22.62)	(108.74)	
Singapore	-8.98×10^{-5}***	−0.003***	−0.0310***	5.46×10^{-8}***	0.06***	0.93***	4.95**
	(−2.60)	(−0.22)	(−2.19)	(7.17)	(19.71)	(314.45)	
South Korea	-6.01×10^{-5}***	0.026*	0.0070**	1.77×10^{-7}***	0.11***	0.88***	28.22**
	(−1.35)	(1.81)	(0.49)	(17.49)	(31.49)	(295.83)	
Thailand	-5.61×10^{-6}*	0.046**	−0.0018**	2.91×10^{-7}***	0.14***	0.84***	113.75***
	(−0.17)	(3.30)	(−0.13)	(10.81)	(41.38)	(256.92)	
Stock market returns							
Indonesia	5.94×10^{-4}***	0.140***	0.0176*	5.32×10^{-6}***	0.12***	0.87***	9.77***
	(2.81)	(9.38)	(1.23)	(11.77)	(24.37)	(213.48)	
Malaysia	4.32×10^{-4}***	0.142***	0.0286*	1.64×10^{-6}***	0.10***	0.89***	10.90***
	(3.65)	(9.77)	(2.16)	(13.74)	(22.33)	(215.60)	
Philippines	6.49×10^{-4}***	0.145*	0.0084***	8.45×10^{-6}***	0.11***	0.86***	35.27***
	(3.64)	(9.54)	(0.55)	(10.39)	(18.79)	(121.39)	
Singapore	2.72×10^{-4}***	0.067***	0.0137*	1.66×10^{-6}***	0.09***	0.89***	6.18**
	(2.07)	(4.73)	(0.94)	(7.55)	(18.15)	(94.11)	
South Korea	5.87×10^{-4}***	0.062***	−0.0036*	2.38×10^{-6}***	0.07***	0.91***	6.24**
	(2.75)	(4.72)	(−0.25)	(5.37)	(16.01)	(216.25)	
Thailand	6.57×10^{-4}**	0.084***	0.0671***	8.94×10^{-6}***	0.12***	0.85***	25.10***
	(3.39)	(5.75)	(4.58)	(14.12)	(24.11)	(205.42)	
DCC(1,1)							
Parameters					0.02***	0.95***	20.10***
t-values					(11.51)	(22.38)	

Note: The AR(2) takes the form $r_t = \varphi_0 + \varphi_1 r_{t-1} + \varphi_2 r_{t-2} + u_t$, where r_t is changes in the exchange rate or stock market returns. *t*-values are given between brackets. The marks *, **, and *** denote a significant rejection of the null hypothesis at 10%, 5%, and 1% level, respectively.

Table 4. Serial correlation and ARCH effect tests for the filtered series of the changes in foreign exchange rates and the stock market returns: January 3, 1994–September 27, 2013

	Ljung-Box Q-statistics						ARCH-LM		
	Residuals			Squared residuals			Residuals		
	1 lag	12 lags	24 lags	1 lag	12 lags	24 lags	1 lag	12 lags	24 lags
Exchange rates									
Indonesia	21.64	54.76	89.18	0.19	21.26	29.14	0.18	19.17	27.57
Malaysia	0.01	3.69	9.91	0.01	0.01	0.02	0.01	0.01	0.02
Philippines	1.63	11.59	14.33	0.01	0.02	1.29	0.02	0.02	1.28
Singapore	3.54	20.84	34.76	0.27	6.86	13.39	0.25	6.78	13.51
South Korea	3.51	20.28	31.99	2.99	13.62	29.15	3.01	13.33	25.49
Thailand	6.23	60.59	78.08	0.22	2.53	9.82	0.21	2.50	9.83
Stock market returns									
Indonesia	9.97	19.43	32.14	1.68	16.77	26.39	1.62	16.39	25.31
Malaysia	6.08	29.42	40.94	0.05	7.29	11.11	0.06	7.11	11.32
Philippines	1.79	20.90	35.24	0.05	1.27	2.06	0.06	1.27	2.08
Singapore	1.67	31.52	44.77	3.55	6.13	10.40	3.54	6.02	10.23
South Korea	2.04	17.80	23.06	0.05	6.73	13.94	0.05	6.72	14.17
Thailand	5.01	20.81	36.01	3.45	18.50	25.52	3.40	17.92	21.10

Note: The diagnostics are computed for the standardized residuals. The Ljung-Box Q-statistic tests the null hypothesis of no autocorrelation; the ARCH-LM (Lagrange multiplier) tests the null hypothesis of conditional homoskedasticity. Both test statistics are χ^2-distributed with degrees of freedom equal to the number of lags. The critical values at the 5% level for these tests with 1, 12, and 24 lag(s) are 3.84, 21.03, and 36.42, respectively.

smooth estimate of the conditional correlations. The shaded areas in this figure indicate the period of the Asian financial crisis and the GFC. The correlation coefficients are clearly time varying, with relatively high negative values throughout the sample period for all countries. Two crisis episodes mark declining trend of correlations, i.e., the Asian crisis and the GFC, and in between the episodes, the 2001 recession in the United States contributes marginally to the downward trend. Table 5 provides dates in which negative correlations hit its peak values during the episodes of crises and recession. The figure reveals that at the start of the Asian crisis the correlations start to trend downward for all countries, except for the Philippines. The correlations are stronger during the period of the Asian crisis. Indonesia reaches the highest negative correlation with a value of −0.72, followed by South Korea (−0.69), Singapore (−0.68), Thailand (−0.64), Malaysia (−0.62), and the Philippines (−0.58). For all countries, the correlations show a jump in the early stage of the crisis episode. Figure 2 also reveals a stronger downward trend of negative correlations in 2001 especially for Indonesia, South Korea, and the Philippines, with the highest negative values of −0.66, −0.59, and −0.56, respectively. This trend is mainly characterized by the 2001 recession initially been most visible in the United States associated with the bursting of the information technology (IT) bubble resulting in the sharp declines in most major stock market indices and drops in business investment around the world. The attack of September 11, 2001 on the World Trade Center affected financial markets, directly and indirectly, deepening the recession. Malaysia, Singapore, and Thailand appeared to be somewhat insulated from the adverse shocks of the 2001 recession. At the start of the GFC, correlations deteriorate for all countries. While the initial shock of the Asian crisis had its epicenter in Southeast Asia, the origins of the GFC lay outside the region. Figure 2 witnesses the intensification of the GFC spillovers to Asia. South Korea reaches the highest negative correlation with a value of −0.75, followed by Indonesia (−0.70), Singapore (−0.57), the Philippines (−0.57), Thailand (−0.51), and Malaysia (−0.47).

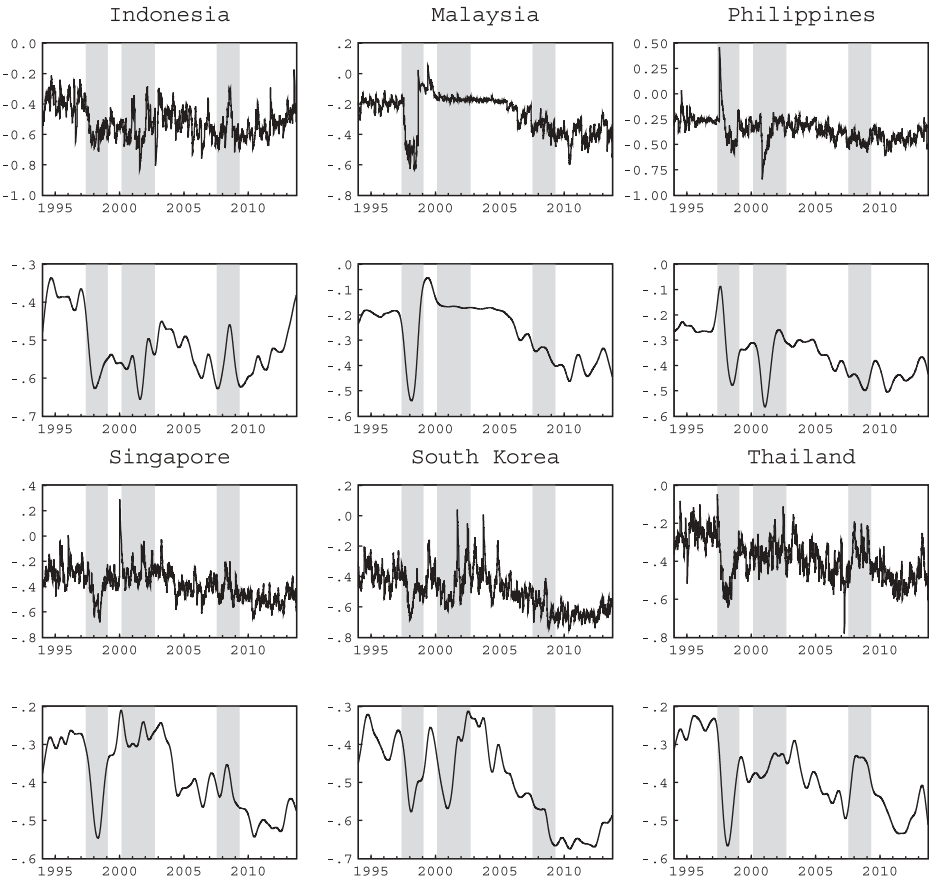

Figure 2. Dynamic conditional correlations between stock market and foreign exchange market.
Note: The smoothed line depicts the Hodrick-Prescott filter of the estimates of dynamic conditional correlations reflected by the volatile line. The shaded area indicates the period of the Asian financial crisis: June 2, 1997 to December 31, 1998; the 2001 recession: March 10, 2000 to August 30, 2002; and the GFC: August 1, 2007 to March 31, 2009. The choice of the crisis period is based on official time lines for the Asian crisis dated by Baig and Goldfajn (1999) and Nagayasu (2001); the 2001 recession by Scherbina (2013) and for the GFC by Federal Reserve Board of St. Louis (2009) and Filardo et al. (2010).

Table 5. Peak value of correlations: January 3, 1994–September 27, 2013

	Asian financial crisis		2001 recession		GFC	
	June 2, 1997–December 31, 1998		March 10, 2000–August 30, 2002		August 1, 2007–March 3, 2009	
	Correlation	Date	Correlation	Date	Correlation	Date
Indonesia	–0.72	May 14, 1998	–0.66	November 13, 2001	–0.70	December 10, 2008
Malaysia	–0.62	October 7, 1998	–0.18	February 28, 2001	–0.47	December 19, 2008
Philippines	–0.58	September 9, 1998	–0.56	January 26, 2001	–0.57	January 9, 2009
Singapore	–0.68	June 18, 1998	–0.31	September 6, 2001	–0.57	October 29, 2008
South Korea	–0.69	December 31, 1998	–0.59	April 23, 2001	–0.75	October 31, 2008
Thailand	–0.64	March 16, 1998	–0.35	January 9, 2001	–0.51	August 28, 2007

Note: The choice of the crisis period is based on official time lines for the Asian crisis dated by Baig and Goldfajn (1999) and Nagayasu (2001); the 2001 recession by Scherbina (2013) and for the GFC by Federal Reserve Board of St. Louis (2009) and Filardo et al. (2010).

The extreme negative correlations during the crisis years reflect an escalation of a deeper regional foreign exchange risk exposure toward Asian firms. Our results reflected in Figure 2 are supported by foreign exchange rate exposure studies of Muller and Verschoor (2007) and Lin (2011). If we compare the correlation coefficients between the two crises, the length of the downward trend of negative correlations in the GFC are longer than in the Asian crisis. All countries experience more sudden declining jumps in correlations during the Asian crisis compared to the GFC. This implies that the spillovers from the recession and financial turmoil in the United States and Europe are too strong to be avoided by all Asian countries, despite the fact that the region was more resilient during the GFC compared to the Asian crisis. The pattern of the conditional correlations presented in Figure 2 reflects a reaction of the stock markets and the foreign exchange markets to changes in the underlying conditions in the markets caused by shocks and policy changes. We address this issue in detail next by focusing on the Asian crisis and the GFC since the two crises have worldwide spillovers. Later, we exam the implications of changing correlations among financial asset returns for international portfolio selection.

Shocks and Policy Responses

In this section we describe the causes of the Asian crisis in the late 1990s and the GFC in the late 2000s, and we analyze how the crises developed, and what the policy responses were. We also relate these events to the relationship between the stock market and the foreign exchange market implied by the dynamic correlations shown in Figure 2.

The Asian Financial Crisis

The negative correlations between the stock market and foreign exchange market during the period before the Asian crisis is related to the Asian miracle. The world capital markets over invested in the Asian economies. This investment boom represented a significant positive shock to these economies, contributing to asset price increases, especially in the stock market. Corsetti et al. (1999) conclude that, despite the liberalization of internal and external financial control in the 1990s that triggered this boom, most of the Asian economies pursued a policy of an effective peg to the U.S. dollar in order to facilitate and maintain external financing of domestic investments. The peg reduced the currency risk premium charged by international investors. When the U.S. dollar strengthened, the value of the Asian currencies per U.S. dollar soared in 1996. This domestic currency appreciation eroded competitiveness in the traded-goods sector causing a shift in the composition of capital inflows from foreign direct investment to more liquid portfolio investment. The financial institutions in Asia were not capable in intermediating this increased capital inflow into productive capacity, but the capital inflow rather exacerbated the underlying structural weaknesses of domestic financial systems. Such a system is fragile and vulnerable to real and financial shocks.

The stronger correlations during the crisis indicate heavy losses in the stock markets and massive currency depreciation. Furman and Stiglitz (1998) argue that the heavy losses on the stock markets reflect the effects of the currency depreciation and higher domestic interest rates on highly leveraged firm and financial sector balance sheets. At least two factors played a role in deepening the Asian financial crisis in 1997–1998. These are the private investor's expectations about the economic situation and the policy actions. As a result of the exchange rate appreciation in 1996, Asian export growth deteriorated rapidly. Moreover, the world prices of Asian key exports began to fall which resulted in negative terms of trade shocks. Expectations of firm's earnings were revised downward, and nearly all stock markets in developing Asia began to drop sharply. Foreign speculators began to withdraw their funds in search of higher returns elsewhere. This capital outflow depleted international reserves in the countries with strictly pegged exchange rates. Most of the Asian currencies came under downward pressure. The main immediate concern was to sustain the peg in the face of a large current deficit, high short-term foreign debt, a collapse of property prices, and an erosion of international

competitiveness. Asian monetary authorities intervened in the exchange market by selling international reserves at pegged rates and raised the interest rates temporarily. The latter policy is a reflection of the IMF policy recommendation. This measure was taken to reduce the downward pressure on the currency. The already weak financial sector and the loss in confidence of domestic and foreign agents in the ability of central banks to maintain the peg much longer, pushed most of the Asian exchange rates on the edge of collapse. In turn, the substantial currency depreciation fed back to the stock market. Expectations of financial and nonfinancial corporate failures built up as the foreign currency denominated debt rose fast in terms of domestic resources. Consequently, investors in the stock market panicked and rushed to sell their holdings, causing stock prices to fall further and international lenders to reject the roll over of maturing loans.

The Asian financial crisis was costly both in terms of lost output and the fiscal outlays to shore up the fragile financial sector. The crisis not only forced the IMF and the G-7 to decide on how to respond to a request for help, but also called for a regional initiative to promote financial and exchange rate stability. Through the IMF's rescue package programs, some East Asian countries, especially Indonesia, the Philippines, South Korea, and Thailand, requested international financial assistance to limit the impact of the crises. On the other hand, Malaysia—where the IMF program was not followed—pursued a policy of capital controls and fixed the exchange rate to reduce foreign exchange exposure of domestic financial markets. The IMF's initial response supported by domestic policy adjustment for mitigating the crisis hinged substantially upon restoring confidence to the economies. The IMF claimed that financial markets stabilized and the exchange rates began to recover (see IMF 1998, 2003). Despite criticism by many economists about the IMF's program to limit the crisis, Figure 2 clearly shows that the negative interdependence between the stock market and the foreign exchange market becomes lower toward the end of 1998.

The Global Financial Crisis

Many different perspectives have been put forward in the literature on the development of the GFC, the strength of the spillover effects, and the challenges for policy. However, many studies agree on the time lines of the crisis development (see Financial Crisis Inquiry Commission 2011).

Although the crisis originated in the United States, its effects are global. As a byproduct of the GFC some European countries faced sovereign debt servicing difficulties requiring financial assistance from the IMF, the ECB and the EU. In the aftermath of the sovereign debt crisis the financial system in the Eurozone turned out to be undercapitalized leading to a recession. The GFC also had serious implications for the emerging markets (see also Yiu et al. 2010). Compared with the EU, the impact of U.S. spillovers on Asia may feed via different channels. The International Monetary Fund (2008) points at economic openness and business cycle links between emerging Asia and the United States. These studies conclude that Asia's trade and financial links with the United States remain intense, and moreover, that financial links have become even stronger over time. In addition, the Asian business cycle is more correlated with the U.S. business cycle. Although the growth of intra-regional trade's share in total Asian exports is higher compared to the Unites States, the United States still remains the main export destination for final goods for Asia. Therefore, growth of U.S. demand appears to be a main factor for Asian export growth. For emerging Asia, the crisis is not one of low credit but of falling demand in the U.S. markets. Increased Asian financial openness since the 1990s with financial deregulation and capital account liberalization, makes Asia's stock markets track changes in the U.S. market very closely. The stronger financial integration with the United States has increased Asia's cross-border holdings of U.S. financial assets. Moreover, growing foreign involvement in local capital markets increased the vulnerability of Asian financial markets to swings in the U.S. market. This led to spillovers of the global financial crisis to the Asian regional market. The process of deleveraging during the crisis—in which many U.S. financial institutions have difficulties in securing liquidity, forcing them to sell foreign currency denominated assets and repatriate the proceeds—led to a substantial liquidation of assets in emerging Asian markets and considerable capital outflows

(Didier et al. 2012). These processes have resulted in abrupt declines in stock and other asset prices across Asia. The sell-off of local currencies accompanying the sudden changes in capital outflows resulted in depreciating Asian currency, especially the South Korean won. Time-varying correlations between stock returns and changes in exchange rate exhibited in Figure 2 corroborate these facts. Downward patterns of negative correlations between the two asset markets in all Asian countries during the GFC episode illustrate that Asia was not immune to the crisis.

Nonetheless, some studies (International Monetary Fund 2008; Didier et al. 2012; Gourinchas and Obstfeld 2012; Frankel et al. 2013, among others) conclude that the Asian exposure and losses to the GFC to date are low and that it is not plausible that the crisis led to systemic banking crises and sovereign defaults. In spite of the financial market turbulence and weakness in exports, Asian economic growth performed soundly. The relative resilience of the Asian economies to the effects of the GFC had many causes. First, most Asian economies have strengthened their external position and their banking system since the aftermath of the Asian crisis as a result of a combination of factors: well-capitalized balance sheets, low loan-to-deposit ratios coupled with little off-balance-sheet financing, and better regulation and supervision reinforced by more prudent practices by financial intermediaries. These factors explain why depositors did not run the banks when the financial environment in the United States and Europe deteriorated sharply. In relation to the external position, many Asian countries run current account surpluses partly due to major terms-of-trade improvements and sound structure of external assets and liabilities. Another reason behind the Asian resilience is the ability to conduct countercyclical monetary and fiscal policies allowing Asian economies to some extent counteract the GFC shock. Most Asian countries reduced interest rates via inflation targeting and improved the fiscal stance via designing and executing fiscal packages to cushion the effects of the global shock. A final strength of most emerging Asian countries has been the role of the flexible exchange rate regime adopted since the Asian crisis. This makes central banks more credible and increased the ability to reduce interest rates and to minimize the risks of currency mismatch via deepening local-currency financial instruments and debt markets. The strength of the Asian financial system and their sound macroeconomic policies explains part of the post-crisis Asian economic performance where the countries recovered fast. This is supported by Figure 2 that shows that the negative correlations between stock and exchange rate rebounded after the crisis.

International Portfolio Investment

A key feature of portfolio selection is the correlation structure of the assets in the portfolio, and these correlations tend to change over time when accommodated in DCC models where correlations are updated in GARCH recursions. Accurate forecasts of volatilities and correlations are therefore critical, and GARCH models and DCC models are powerful instruments in international asset allocation. The Black-Litterman model would imply that in crisis periods—in which correlations increase—the expected return of the portfolio increases assuming that the weights of the assets in the portfolio do not change. However, modern portfolio theory breaks down both in the case of non-normality and in crisis periods when the weights of the assets in the portfolio do change.

In this article the portfolio is limited to stocks and currency. Longin and Solnik (1995) and Kearney and Lucey (2004) argue that deepening international financial integration tends to be associated with rising across border correlations between financial markets. High international capital mobility—due to interest rate differentials and deeper domestic financial development signaling a higher degree of financial integration—may affect the relationship between stock returns and exchange rates and, thereby, benefits from diversification between the two assets for international investors. When international investors are offered higher stock returns this may increase the value of the currency. This argument is line with Branson (1983) and Frankel (1983) (see also previous section). Moreover, Moore and Wang (2014) conclude that international competitiveness of commodities may influence the relationship between stock returns and exchange rates. Changes in exchange rates affects exports,

which in turn may affect the market value of firms and stock prices. This is in line with Dornbusch and Fischer (1980) as discussed in the previous section.

Figure 2 reveals that correlations between stock market and exchange rate market are negative for all countries throughout the sample period. These negative values of correlation are intensified during the Asian and Global financial crises, and the 2001 recession (see Table 5). Reduced international competitiveness may be responsible for the negative correlations between the stock market and the exchange rate market. The depreciation of the exchange rate degenerates price competitiveness worsening the current account, and lowers real output, and current and future cash flows of firms. Ultimately, stock prices fall. This effects become stronger in the presence of a financial crisis in which a free fall of the exchange rate occurs, or capital outflows are lowered in case of a fixed exchange regime as operated by Malaysia following the Asian financial crisis. In addition, in well-developed financial markets like Singapore, the linkage between the stock market and the foreign exchange markets may be sensitive to international capital mobility and financial market deepening. In this case, a rise in interest rate differential leads to a higher negative correlation between stock returns and exchange rate. In countries like Thailand, the Philippines, and Malaysia, there are still some obstacles that prevent capital mobility and free movement of exchange rates. Asset portfolios in these countries may be less sensitive to correlations between the stock market and the foreign exchange rate market. Thus, there are limited opportunities and benefits for international investors and markets in the region to allocate capital more efficiently.

Table 6 provides descriptive statistics for the dynamic conditional correlations (DCCs) between stock market and foreign exchange markets over the entire sample period, and for both the financial crisis recession and tranquil periods. Table 6 reveals that in most countries on average the range (maximum minus minimum) of DCC values is high in turmoil periods compared to tranquil periods. The GFC period is an exception. Entering turmoil periods the maximum values increase gradually, while the minimum values of the correlations show jump-like behavior. These findings are confirmed by Figure 2 that shows that DCCs during turmoil periods are more volatile than in the tranquil periods. The correlations between markets considered in this article strongly vary over time. This implies the relevance of the DCCs when evaluating the effectiveness and stability of asset diversification. For all countries we report negative values of the correlations changing substantially during turmoil periods and correlations that are less volatile in tranquil periods. This implies a reduced benefit from portfolio diversification between stock markets and foreign exchange markets in turmoil periods. Moreover, this implicitly shows that Asian markets are relatively well integrated.

Conclusion and Policy Implications

In this article we use daily data of stock returns and exchange rate changes of six East Asian countries, namely Indonesia, Malaysia, the Philippines, Singapore, South Korea and Thailand, in order to analyze the dynamic relationships between stock markets and foreign exchange markets. We implement the multivariate GARCH model with the DCC specification proposed by Engle (2002). The model is general enough to describe the data used for estimating dynamic conditional correlations. The correlations between stock returns and exchange rate changes are negative and change over time, the correlations become stronger particularly during the episodes of the Asian crisis and the GFC. However, downward patterns of negative correlations are more pronounced in the episodes of the Asian crisis than the GFC. Sound macroeconomic policies and healthier financial sectors make the stock and foreign exchange markets better prepared to cope with the effects of the GFC compared to devastating effects of the Asian crisis. The correlations also show that most Asian countries are able to recover faster during the GFC in comparison to the post-crisis recovery performance after the Asian crisis. This article also reveals that overall negative correlations between the stock market and foreign exchange market implicitly indicate limited opportunities for investors to reach a higher degree of risk diversification and a lower probability of asymmetric shocks. In addition, international investors benefiting from asset diversification is reduced from tranquility periods to turmoil periods.

Table 6. Descriptive statistics of dynamic conditional correlations between stock market and foreign exchange market for the period January 3, 1994–September 27, 2013 and crisis and noncrisis periods

	Entire Sample Period						Pre-Asian Financial Crisis					
	IND	MAL	PHI	SIN	KOR	THA	IND	MAL	PHI	SIN	KOR	THA
Mean	–0.52	–0.27	–0.36	–0.38	–0.50	–0.39	–0.39	–0.20	–0.26	–0.29	–0.39	–0.25
Maximum	–0.17	0.05	0.46	0.29	0.04	–0.05	–0.21	–0.11	0.04	0.01	–0.20	–0.05
Minimum	–0.84	–0.63	–0.85	–0.68	–0.75	–0.78	–0.65	–0.31	–0.38	–0.48	–0.55	–0.52
Std. Dev.	0.11	0.12	0.12	0.12	0.13	0.11	0.07	0.03	0.05	0.08	0.07	0.06
Skewness	0.34	–0.59	0.88	0.56	0.48	0.07	–0.46	–0.43	1.27	0.77	0.11	–0.20
Kurtosis	2.76	2.59	9.48	4.32	3.06	2.66	3.75	3.53	7.88	3.81	2.74	4.39
Jarque-Bera	108.55	338.37	9665.44	648.30	200.37	28.60	51.63	38.11	1117.34	113.23	4.17	76.92
Asian Financial Crisis, Jun. 2, 1997–Dec. 31, 1998							Between Asian Financial Crisis–2001 recession					
Mean	–0.58	–0.38	–0.31	–0.45	–0.50	–0.46	–0.55	–0.10	–0.33	–0.28	–0.41	–0.36
Maximum	–0.42	0.02	0.46	–0.20	–0.33	–0.15	–0.42	0.05	–0.16	0.29	–0.16	–0.24
Minimum	–0.72	–0.63	–0.58	–0.68	–0.69	–0.64	–0.66	–0.18	–0.43	–0.44	–0.57	–0.51
Std. Dev.	0.07	0.19	0.23	0.11	0.09	0.11	0.05	0.05	0.06	0.15	0.10	0.06
Skewness	0.18	0.67	1.52	–0.09	–0.32	0.76	0.02	0.70	0.53	1.93	0.63	–0.47
Kurtosis	2.38	1.94	4.91	2.35	2.25	3.19	2.51	3.43	2.52	5.95	2.65	2.33
Jarque-Bera	8.88	50.08	223.15	7.81	16.99	40.05	3.05	28.05	17.59	305.74	22.16	17.52
2001 recession, Mar. 10, 2000–Aug. 30, 2002							Between 2001 recession–Global Financial Crisis					
Mean	–0.57	–0.17	–0.38	–0.29	–0.45	–0.35	–0.53	–0.21	–0.35	–0.37	–0.45	–0.40
Maximum	–0.28	–0.12	–0.19	–0.04	0.04	–0.11	–0.29	–0.15	–0.20	–0.02	0.01	–0.15
Minimum	–0.84	–0.19	–0.85	–0.43	–0.62	–0.50	–0.81	–0.41	–0.53	–0.61	–0.64	–0.78
Std. Dev.	0.10	0.01	0.15	0.08	0.14	0.07	0.09	0.06	0.07	0.09	0.11	0.09
Skewness	0.44	0.90	–1.26	0.79	1.21	0.72	–0.25	–1.47	–0.39	0.36	1.16	–0.35
Kurtosis	3.34	3.72	3.97	3.07	4.01	3.52	3.00	4.23	3.05	3.72	4.71	4.79
Jarque-Bera	23.63	101.17	195.55	67.30	184.14	62.30	13.14	543.89	31.95	56.00	442.91	198.19

(*Continued*)

Table 6. Descriptive statistics of dynamic conditional correlations between stock market and foreign exchange market for the period January 3, 1994–September 27, 2013 and crisis and noncrisis periods (Continued)

	Entire Sample Period						Pre-Asian Financial Crisis					
	IND	MAL	PHI	SIN	KOR	THA	IND	MAL	PHI	SIN	KOR	THA
Global Financial Crisis, Aug. 1, 2007–Mar. 31, 2009							Post-Global Financial Crisis					
Mean	–0.55	–0.35	–0.47	–0.42	–0.60	–0.35	–0.54	–0.40	–0.43	–0.50	–0.65	–0.48
Maximum	–0.30	–0.23	–0.33	–0.20	–0.41	–0.19	–0.17	–0.25	–0.23	–0.32	–0.53	–0.25
Minimum	–0.72	–0.47	–0.58	–0.57	–0.75	–0.51	–0.70	–0.60	–0.61	–0.66	–0.75	–0.61
Std. Dev.	0.10	0.04	0.05	0.09	0.08	0.07	0.08	0.06	0.06	0.06	0.04	0.06
Skewness	0.86	0.00	0.39	0.58	0.29	0.18	0.97	–0.41	–0.17	–0.12	0.30	0.55
Kurtosis	3.10	2.99	2.67	2.65	2.53	2.42	4.90	3.69	2.80	2.78	3.02	3.71
Jarque-Bera	53.30	0.00	13.17	26.62	10.04	8.62	362.58	56.28	7.78	5.17	17.26	82.98

Note: IND, MAL, PHI, SIN, KOR, and THA stand for Indonesia, Malaysia, Philippines, Singapore, South Korea, and Thailand.

The policy implications of our findings are important, as they suggest that exchange rate policies should not be implemented without taking into account the repercussions on the stock market, and vice versa. Monitoring the trade and financial channels of internationally active (non)financial firms over time has to be considered. This strengthens transparency and accountability of financial markets by achieving the most favorable prudential or supervisory standards. Combined with a prudent exchange rate policy, this would help to minimize volatility in the stock prices as well as the erratic movements of the currency values. More complex trade-offs between higher growth and other positive spillover effects, and increased sensitivity to adverse global shocks, requires stronger cooperation between financial and macroeconomic policies at both the regional and global level to avoid aggravating cross-border strains and to contribute to higher co-movement of output in increasingly more integrated global trade and financial markets.

Notes

1. The Malaysian exchange market is an exception in these tests: the Q-test in levels shows autocorrelation, while the Q-test in squared series reveals the opposite; the ARCH-test suggests no ARCH effect in both financial markets. The pegged exchange rate system in Malaysia following Asian crisis may be responsible for these test outcomes.

2. Hansen and Lunde (2005) conclude that the relatively simple GARCH(1,1) performs extremely well compared to the more advanced alternative models in terms of in-sample performance as well as its predictive ability.

3. We set lags up to five and check what value of order minimizes the AIC (Akaike Information Criterion) and SC (Schwarz criterion) criteria. The SC suggests that we choose order of one whereas the AIC suggests a longer lag length of two. We retain to the AR(2) model. In addition, coefficient of r_{t-2} is significantly different from zero, suggesting we do need at least two lags of r. See Lestano and Kuper (2014) for more information.

4. The exceptions are the Q tests for the residuals for the foreign exchange rate changes in Indonesia and Thailand for 1, 12 and 24 lags, for stock returns for Thailand for 1 lag, and for Malaysia and Singapore for 12 lags and 24 lags.

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