FOREIGN EXCHANGE MARKETS IN SOUTH-EAST ASIA 1990-2004:
AN EMPIRICAL ANALYSIS OF SPILLOVERS DURING
CRISIS AND NON-CRISIS PERIODS

Alex Mandilaras¹ and Graham Bird

University of Surrey and SCIES

Abstract

The East Asian crisis of 1997 sparked an extensive literature in an effort to explain the causes and spread of heightened foreign exchange (FX) market pressures in the region. In this paper we model FX movements and calculate spillover effects covering the extended period between 1990 and 2004. Using Markov switching vector autoregressions, we find evidence that FX correlations vary across crisis and non-crisis states, a result that bears implications for international portfolio diversification and reserve pooling. Even though the direction of effects does not follow discernible patterns, it is clear from the data that contagion effects are present.

JEL Classification: F3

Keywords: East Asia, Currency Crisis

¹ Corresponding author: Department of Economics, University of Surrey, Guildford GU2 7XH, UK. Tel.: +44 (0) 1483 682768. Fax: +44 (0) 1483 689548. Email: a.mandilaras@surrey.ac.uk.

Introduction

A 1999 IMF factsheet on the Fund's response to the Asian crisis of 1997 states that "[...] the IMF, along with everyone else, did not foresee the scale of the financial contagion that followed the events in Thailand".² A key event was the devaluation of the Thai baht in July 1997. Even though Thailand was running a current account deficit of almost 8% of GDP and, hence, was susceptible to an exchange rate correction, other countries in the region, that were subsequently affected by speculative attacks in the foreign exchange market were not experiencing equivalently large external imbalances at the time. The region's impressive GDP growth rates in the early 1990s had earned the countries the title 'Asian tigers'. With a reputation for fiscal prudence and reasonably low inflation rates it seemed that little threatened their continued economic advance.

With the liberalization of capital accounts new foreign money was channelled into the south-east Asian economies mainly through the banking system. However, a combination of asymmetric information and moral hazard problems led to excessive borrowing (e.g. Mishkin, 1999, Corsetti *et al.*, 1998). An underestimation of the risks both by bank managers and international investors meant that several firms were burdened with substantial amounts of foreign currency short-term debt. This constituted a serious problem, as most firms' earnings were in local currency, an imbalance that seriously exposed them to the risk of devaluation.

So, the source of the Asian crisis was not related to the macroeconomic fundamentals but rather to the inability of the private sector to allocate funds to the most productive uses through an appropriate assessment of risks. In other words, the region's

² Available at <http://www.imf.org/external/np/exr/facts/asia.htm>.

problem was structural in the sense that financial market regulation, supervision and management were inadequate. The real effects of the crisis were painful, as growth rates in the region were adversely affected. Related speculative pressures in the FX markets eventually led several governments to abolish their currency pegs (at least temporarily) and, as a result, the region's currencies depreciated sharply –a possible reason for the resumption of positive growth rates relatively soon after the crisis.

Since these events took place, a substantial amount of research has examined the mechanisms through which the crisis was dispersed amongst countries in the region. This paper covers similar ground, but uses recently devised econometric tools. It also exploits a more complete set of data running up until 2004. This allows comparisons to be made between crisis and non-crisis periods. More specifically, the paper addresses a number of research questions.

First, is the relationship between currencies as measured by exchange rates different from that between wider FX market pressure indicators? If so, this suggests that different countries may respond to spillover effects in different ways with some allowing the exchange rate to take the strain of adjustment and others opting for rising interest rates and/or reserve decumulation. Second, does the relationship (the extent and nature of the spillovers) differ between crisis and non-crisis periods? This is an important question for the risk management of internationally diversified portfolios. If the relationship changes, then what might be sensible behaviour before a crisis may not be as sensible during (or after) it. Third, are contagion effects present in south-east Asian FX markets and, if yes, which countries are the sources and which the recipients?

The paper is empirical. We do not seek to impose and test any particular model. However, the relationships we examine are informed by the relevant theory. Thus, before moving on to examine the empirical evidence we attempt to place our empirical research in the context of existing analysis of economic and financial crises and contagion.

Crisis, Interdependence and Contagion

The economic crises of the 1990s and early 2000s have generated interest in a range of issues. The first issue is that of why crises occur. The ‘first generation’ model (see e.g. Krugman, 1979) accentuates fiscal and monetary mismanagement leading to currency overvaluation and reserve depletion. The ‘second generation’ model (see e.g. Obstfeld, 1994) emphasises inconsistencies between domestic and external targets at a favoured exchange rate, which induces speculators to anticipate devaluation. The ‘third generation’ model (see e.g. Corsetti *et al.* 1999) focuses on deficiencies in the domestic and foreign financial sectors that then result in a ‘feast and famine’ pattern of capital flows.

The second issue relates to the nature of crisis spillovers between countries. These may reflect economic interdependencies via, for example, foreign trade, but they may also reflect contagion when market psychology changes. Part of the recent literature seeks to disentangle the extent to which country correlations capture interdependencies as opposed to contagion, and to examine the extent to which crises lead to closer correlations than would be expected on the basis of economic interdependencies.³

³ Forbes and Rigobon (2002) highlight the role of heteroscedasticity in testing for contagion, where the latter is defined as a significant change in the real transmission mechanism in crisis states. Empirical studies of contagion adopting various definitions include, among others, Eichengreen *et al.* (1996), Glick and Rose (1999), Caramazza *et al.* (2000), Kaminsky and Reinhart (2000) and Van Rijckeghem and Weder (2001).

Both of the above issues have received a great deal of attention in the literature. A related topic of interest, which we address in this paper, is that of the nature of cross-country correlations involving measures of pressure in the FX market. Imagine that there is a financial crisis in one country which leads to a deterioration in overall market psychology and to increasing market pessimism. Capital markets may then seek to withdraw funds from other countries whose foreign exchange markets will as a result be put under pressure (this is the ‘common lender effect’, where investors holding international portfolios and seeking liquidity will sell assets in a market following an asset price fall in another). The crisis in the first country triggers a FX crisis elsewhere. Of course, some countries may be more vulnerable to crisis than others; the second generation model emphasises the interplay between time-inconsistent policy objectives and vulnerability. But there may also be differences in response. Some affected countries may be more inclined to allow the value of their currencies to fall, others may opt for more rapid decumulation of reserves and still others may be more inclined to raise interest rates. Finally, some countries may attempt to insulate themselves from the crisis by imposing capital controls. The choice will ultimately be affected by views about the effectiveness of alternative responses and the political economy of the distribution of gains and losses associated with them. Given that such views may vary across countries it seems probable that FX pressure will be exhibited in different forms in different countries.

Our paper in part explores this issue. There are two ways in which we could approach it. An ambitious approach would be to establish theoretical priors on the basis

of a formal analysis of the views and preferences discussed above. A second, less ambitious but much more manageable approach, and the one we adopt here, is to examine the nature and structure of FX market correlations. By examining the revealed preferences of countries' authorities we can perhaps infer something about their perceptions of the effectiveness of the various instruments as well as the political economy of gains and losses.

A further issue in the context of crises relates to their spatial distribution. At one level there is the question of whether crises are regionally contained. But beyond this there are the questions of whether, at a more disaggregated level, regional 'neighbours' are differently affected and why they may be differently affected. The concept of 'regionalisation' suggests that there will be little regional differentiation, since regional proximity is sometimes assumed to be the driving force behind contagion. However, this may be unduly simplistic. Instead, it is perhaps more realistic to posit that, even within regions, there will be variations in crisis vulnerability. For this reason capital markets may not regard all 'regional' assets as equally close substitutes for one another.

The above discussion leads to a more subtle issue. Where spillovers incorporate both interdependence and contagion, it may in principle be that the pattern of correlations changes depending on whether or not there is a crisis. Thus, for example, two countries where there are relatively limited economic interdependencies may reveal relatively low FX spillovers in non-crisis conditions. In crisis conditions, however, other factors may come into play, such that the vulnerability to crisis and the degree of substitutability between financial assets. This may then mean that crisis correlations are significantly and relatively higher in a crisis. If this were to be the case, it would have implications for

creditors' portfolio management. Portfolio managers can clearly seek to reduce portfolio risk by means of diversification. But diversification will not help if there is a close positive correlation between the different assets in the portfolio. If, however, the pattern of correlation changes as between crisis and non-crisis periods, the composition of the risk-minimising portfolio will also change. A portfolio that minimises risk in non-crisis conditions may fail to insulate returns in a crisis where minimising risks may be even more important.

In summary, while this paper is essentially empirical, it is motivated by the existing theory and literature on crisis and contagion. In what follows, we seek to determine the extent and nature of spillovers during crisis and non-crisis periods in the occasionally turbulent FX markets of south-east Asia.

Data and Variables

Monthly nominal bilateral exchange rates with the US dollar for Indonesia, Korea, Malaysia, the Philippines and Thailand are taken from *International Financial Statistics* published by the IMF. Figure 1 captures the recent history of exchange rate movements in the south-east Asian FX markets. The five countries in our sample had implemented a variety of exchange rate regimes over the sample period, but immediately before July 1997 they were all *de facto* fixing their currencies to the US dollar. When speculative pressures in the region arose, interest rates escalated and international reserves fell in an effort to defend the values of the local currencies. Eventually, the countries abolished their quasi-fixed exchange rate regimes and floated their currencies.⁴

⁴ According to Reinhart and Rogoff (2004) prior to the 1997 events all countries in the sample were running *de facto* pegs against the US dollar (except Malaysia, which was operating a *de facto* moving band

We use nominal exchange rates, interest rates and international reserves in the construction of a foreign exchange (FX) market pressure indicator (*fxmpi*). Our analysis is based on two ‘crisis’ measures: the percent change in the values of the nominal exchange rate (*dlxr*) and *fxmpi*.⁵ Increases in the value of *fxmpi* signify more pressure (hence the negative sign for the reserves component of the indicator):

$$fxmpi_t = [\alpha * dlxr_t + \beta * dir_t - \gamma * dlres_t] * 100 ,$$

where *dir* is the change in the domestic interest rate and *dlres* is the change in the natural logarithm of international reserves minus gold (in dollars). The weights of the variables are determined as follows:

$$\alpha = \frac{\frac{1}{SD_{dlxr}}}{\frac{1}{SD_{dlxr}} + \frac{1}{SD_{dir}} + \frac{1}{SD_{dlres}}} ,$$

$$\beta = \frac{\frac{1}{SD_{dir}}}{\frac{1}{SD_{dlxr}} + \frac{1}{SD_{dir}} + \frac{1}{SD_{dlres}}} , \text{ and}$$

$$\gamma = \frac{\frac{1}{SD_{dlres}}}{\frac{1}{SD_{dlxr}} + \frac{1}{SD_{dir}} + \frac{1}{SD_{dlres}}} ,$$

where *SD* stands for standard deviation. The need to use both measures arises from the fact that it is possible that nominal exchange rate movements do not reveal the extent of speculative pressures. These may be reflected by the use of other policy instruments (e.g.

around the US dollar). Post-crisis all currencies were freely floating (or falling). Eventually some reverted to managed floats (Philippines, Thailand) or established new pegs (Malaysia).

⁵The variable *fxmpi* has its roots in Gorton and Roper (1977). The use of similar indices to capture pressures in the FX market is not unusual (e.g. Eichengreen *et al.*, 1996), even though there have also been criticisms (see Eika *et al.*, 1996 and Willett and Nitithanprapas, 2000).

reserves, interest rates and capital controls). Hence, we can use *fxmpi* to assess the presence of speculative pressures and *dlxr* to determine how successful these have been.⁶

Table 1 provides descriptive statistics and correlations for the two crisis measures. Even though percent changes in exchange rates are highly correlated between countries in the sample, the same cannot be said about the wider pressure indicator. Figures 2a and 2b plot the series over time. The increased volatility in mid 1997 is evident in both. But whereas the volatility of *fxmpi* subdued post-1997 (with the exception of Indonesia), the volatility of *dlxr* increased (with the exception of Malaysia that quickly resorted to a fixed exchange rate regime). This is natural, since following the adoption of flexible exchange rates after the crisis pressures in the FX market were reflected in changes in the exchange rate, hence reducing the need for use of interest rates and/or reserves as policy instruments.

Tranquil and Crisis Regimes

To model the time series we adopt a commonly used strategy for the analysis of structural change: a Markov regime switching model (see e.g. Hamilton, 1989). This approach is appropriate, as the model assumes autoregressive processes in which the parameters depend on the realizations of an unobserved regime variable, which in turn is modelled as a Markov chain. The latter assumes that realizations of the state only depend on their (chronologically) previous realization. The regime variable is discrete and can only take two values: 0 if there is no crisis and the distribution has a low mean and 1 if there is a ‘crisis’ and the distribution has a high mean. In contrast to Hamilton (1989) we assume a heteroscedastic setting in which the variance changes across the two regimes.

⁶ We do not incorporate a measure of capital controls in our estimations because of the unreliability of data.

The model can be written as

$$y_t - \mu(s_t) = \beta_1 y_{t-1} + \dots + \beta_\rho y_{t-\rho} + \varepsilon_t,$$

where ρ denotes the order of the autoregression and μ is the regime-dependent mean conditional on the state variable, s_t . The β s are autoregressive coefficients to be estimated and ε is a normally distributed error term with zero mean and regime-dependent variance. In this setting, we can estimate the matrix of transition probabilities, which contains the probabilities of remaining in one regime and of switching to another. In the case with two regimes we have four such probabilities: p_{11} , p_{12} , p_{21} and p_{22} , where, for example, p_{11} gives the probability of remaining in regime 1 and p_{12} gives the probability of switching from regime 1 to regime 2.⁷

Table 2a gives the results of the estimations of a heteroscedastic Markov switching (intercept) model with two regimes and three autoregressive terms for *fxmpi*, which is denoted as MSIH(2)-AR(3) using Krolzig's (1997) notation.⁸ It can be seen that for Indonesia, Korea, Malaysia and the Philippines regime 2 is identified as one with higher FX pressures (as captured by the higher mean). In contrast, for Thailand regime 2 is the low pressure regime. In all cases, regime 2 is more volatile (as captured by the higher standard errors). Both regimes are quite persistent, although regime 2 less so than 1, indicating that the probability of switching from a non-crisis to a crisis regime is lower than the probability of switching from a crisis regime to a non-crisis regime. Results for *dlxr* (Table 2b) are quite similar, although regimes are now less persistent. In addition,

⁷ The model of Hamilton assumes that the transition probabilities are constant. This has the implication that exogenous variables cannot affect the probability of switching from one regime to another. Diebold (1994) and Filardo (1994) extend the model to time-varying transition probabilities.

⁸ Setting a different lag length than the reported of three months does not affect the results substantially.

and consistent with the rest of the sample, regime 2 for Thailand is now a crisis regime. Malaysia's distributions of observations across the two regimes are the same.

Visual inspection of the crisis regime probabilities using both measures (not reported) shows that for most countries the period from mid 1997 to early 1998 was characterized by speculative pressures and falls into the category of a crisis regime. The apparent 'synchronicity' of the incidence of crises may reflect regional inter-dependence arising from trade links, a common unobserved shock, or contagion.

In this paper, we do not try to determine the exact classification of the spillovers although we do test several related hypotheses. First, we examine the contemporaneous correlations between the pressure indicators across regimes. This has important implications for portfolio management. The possibility that the correlations may change sign and/or magnitude in different states of the world could affect the risk characteristics of a portfolio with holdings in the different markets. In order to carry out this exercise we need to extend the methodology to a Markov switching vector autoregression (see Kolzig, 1997). Examining the FX market in the context of a system of interrelated economies has the advantage that we are allowing the market in question to be affected by recent movements in other markets as well as by recent movements in the market itself. Hence, we can calculate and compare the (regime-dependent) correlations.

Second, we construct the multivariate version of the Forbes and Rigobon (2002) contagion test, as proposed by Dungey *et al.* (2005). This allows us to examine the effects of each country's FX market on the rest of the countries in the sample, while controlling for the effect of heteroscedasticity. Even though there is no agreed definition of contagion

in the literature (see pp. 96-98 in Chui and Gai, 2006 for a taxonomy of definitions) we will interpret as contagion an increase in conditional correlations in the crisis regime.⁹

Regime-dependent Correlations

Turning to the VAR version of the fixed transition probability model, the system can now be written as

$$y_t - \mu(s_t) = \sum_{j=1}^{\rho} B_j y_{t-j} + \varepsilon_t,$$

where y is a vector of dependent variables and B denotes a matrix of estimated parameters. Matrices B are square matrices with the number of columns and rows equal to the number of series in the autoregression. There are as many B s as the order of the autoregression.

Estimation of this model assuming two regimes and an autoregressive order $\rho = 1$ (consistent with the Schwarz criterion) gives the results reported in table 3. It is evident that, for both measures, regime 1 is classified as a tranquil regime with a low mean and variance, whereas regime 2 is classified as a crisis regime with a high mean (indicating devaluations/pressures in FX) and increased volatility. The tranquil regime continues to be highly persistent implying that switching to a crisis regime is associated with a relatively low probability. Switching back from a crisis regime to a tranquil one is, on the other hand, associated with a higher probability, even though crisis regimes are also fairly persistent.

⁹ Our approach does not include fundamentals given the monthly frequency of our data and the absence of agreement in the literature on what would constitute a universally accepted set of fundamentals.

Figure 3 plots the (smoothed) probabilities of being in crisis across the two measures. Following the turbulence of the second half of 1997 the FX pressures, as captured by *fxmpi*, subsided. Exchange rate depreciation continued for several years after 1997 without being accompanied by higher interest rates or a loss of reserves.

Table 4 shows the estimated correlations for the five countries across the two regimes. It can be seen that, for both measures, the magnitude of the correlations change from one regime to the other. In some instances, the sign of *fxmpi* correlations changes as well. For example, Thailand's correlations with the rest of the countries in the sample change sign across the two regimes. However, an investor with no sophisticated information about the prevailing state of the world at each observation would potentially base his/her fund allocation strategy on non-regime dependent (constant) correlations like those reported in Tables 1c and 1d. Even though the differences between the constant correlations and the crisis ones are less pronounced, it is still possible for the constant correlations to convey misleading information. For example, Thailand's *fxmpi* correlation with Korea is -2.6% increasing to 3.5% during crises. The implication is that an investor with assets in Thailand and Korea, who may have allocated funds based on the small negative correlation between the two countries, will find that the benefits from such diversification are slightly reduced during times of crisis, as the devaluation probability and associated default risks increase simultaneously in both countries in times of FX turbulence. However, some of the correlations move in the opposite direction, i.e. from a positive correlation to a negative one during a crisis period. Even so, in most cases the differences in magnitude are not dramatic, a fact that limits the usefulness of the extra

information contained in regime-dependent correlations. The same conclusion can be reached from an analysis of exchange rate correlations.

Contagion

We now turn to the issue of contagion. Forbes and Rigobon (2002) have shown that an increase in correlations in a crisis state does not necessarily represent contagion. Even without a change in the real transmission mechanism the increased volatility in one market will result in higher correlation with another market in a crisis state. Forbes and Rigobon (2002) construct a correlation coefficient that controls for the effects of heteroscedasticity. Dungey *et al.* (2005) have extended the test in a multivariate setting. For country 1, e.g., we have

$$\frac{\omega_{1,t}}{\sigma_{nc,1}} = \phi'_1 \Lambda + \chi'_1 (\Lambda \otimes \delta_t) + \nu_{1,t},$$

where $\omega_{1,t}$ contains the stacked values of *fxmpi* or *dlxr* for country 1 (the observations that correspond to the tranquil periods stacked on top of the observations that correspond to the crisis periods), σ_{nc} denotes the (non time-varying) standard deviation of the non-crisis observations, ϕ and χ are vectors of estimated coefficients, Λ is a matrix containing scaled, stacked observations of *fxmpi* or *dlxr* for the rest of the countries, i.e.

$$\left[\frac{\omega_{2,t}}{\sigma_{nc,2}} \dots \frac{\omega_{n-1,t}}{\sigma_{nc,n-1}} \right], \text{ and } \delta_t \text{ is a stacked dummy variable taking the value 0 if the system is}$$

in a tranquil state and 1 if it is in a crisis state. Similar equations are constructed for the rest of the countries.

The classification of observations as crisis or non-crisis is based on the estimation of a MSIH(2)-VAR(1) model. The system of equations is estimated with the seemingly unrelated regression (SUR) method. The estimates contained in χ capture contagion effects (if any) so that we can examine the direction and magnitude of spillovers arising from a particular country during a crisis. Table 5 presents results for *fxmpi* and *dlxr*.

Focusing on the FX market pressure indicator it turns out that Korea, Malaysia and the Philippines seem to ‘export’ their FX pressures to Indonesia and Thailand, both of which appear to be victims of contagion during the sample period. Thailand on the other hand, which was the first country to devalue in 1997, only seems to affect Korea. Focusing on exchange rate changes, there is no clear direction of contagion effects. Indonesia affects and is affected by Thailand. It also affects the Philippines, which in turn affects Thailand and Korea. Korea affects Malaysia.

These results seem to affirm that no one country in particular is responsible for infecting the others. Over the period of the sample (1990-2004) several of the featured countries seem to have exported their shocks regionally at some stage affecting neighbouring countries to a varying extent. Identifying these shocks requires an extensive case-by-case study and is the next step of this research. In addition, the results between *fxmpi* and *dlxr* are strikingly different, a fact that highlights the different types of information that the two measures convey: *fxmpi* is a wider measure and can indicate a crisis even in the absence of an actual devaluation, whereas *dlxr* only indicates a crisis when there is a substantial loss in the value of the currency (in terms of \$US) but can miss speculative pressures where the use of reserves and the interest rate has been successful.

Concluding Remarks

In this paper, we have used recent advances in econometric techniques to answer questions about the interrelationships between south-east Asian foreign exchange markets during the period 1990-2004 with a view to gaining a better understanding of a number of issues to which the recent literature directs us. South-east Asia is particularly interesting given the opportunity to examine countries that are frequently and somewhat loosely classified together, as well as the transition sequence from periods that may be characterised as non-crisis to crisis and back to non-crisis.

As we anticipate from our consideration of the relevant theory, we find that the pattern of spillovers varies across countries in the region in terms of their effects on exchange rates, interest rates and reserve levels. This implies that monetary authorities respond in different ways to FX market pressures. Some are less prepared to see currency depreciation than others, even in the context of crises. However, in this paper we do not explore in detail what accounts for these differences although we do briefly discuss possible explanations.

We also find that there are significant differences in the strength of spillovers suggesting that contagion is not simply a matter of regionalisation. This finding could, however, be consistent with a number of potential explanations involving different degrees of interdependence, capital market imperfections, and vulnerability to crisis. Further research would be needed to tease out the relative importance of these factors in explaining the different spillover patterns observed in the region. In this paper we do discover that the pattern of correlation between countries sometimes varies across crisis and non-crisis periods, even though not dramatically. Importantly, some types of

diversification that may be risk-reducing during a non-crisis period may not be risk-reducing during a crisis. This finding also suggests that reserve pooling arrangements that depend on negative correlations amongst participants may be ill-informed if non-crisis periods are used to identify correlations that are, in practice, contingent on whether crises exist.

In short the findings reported here counsel against simplistic analyses of contagion. Even at the regional level the nature of spillovers is quite complex and the responses to them are diverse. We are therefore able to reject stories that emphasise uniformity. However, at this stage we are only offering potential explanations of the diversity we observe. The next stage in research is to seek a richer and evidence-based explanation of these differences.

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Table 1a: Descriptive statistics *fxmpi*.

	<i>fxmpi_IND</i>	<i>fxmpi_KOR</i>	<i>fxmpi_MAL</i>	<i>fxmpi_PHI</i>	<i>fxmpi_THA</i>
Mean	0.926	0.872	0.79	1.271	0.601
Median	0.841	0.727	0.595	0.305	0.697
Maximum	38.069	8.141	27.597	41.194	13.328
Minimum	-12.581	-6.346	-18.019	-16.39	-8.076
Std. Dev.	5.081	2.258	3.96	6.798	2.357
Skewness	2.281	0.218	1.272	1.946	0.351
Kurtosis	19.518	4.291	16.483	13.242	9.428
Jarque-Bera	2190	13	1404	895	311
Observations	179	179	179	179	179

Table 1b: Descriptive statistics *dlxr*

	<i>dlxr_IND</i>	<i>dlxr_KOR</i>	<i>dlxr_MAL</i>	<i>dlxr_PHI</i>	<i>dlxr_THA</i>
Mean	0.913	0.240	0.19	0.512	0.234
Median	0.358	0.088	0.0	0.144	-0.025
Maximum	67.722	36.95	15.679	13.775	17.237
Minimum	-26.884	-8.856	-14.1	-7.126	-15.377
Std. Dev.	7.861	3.579	2.4	2.331	3.063
Skewness	3.824	6.241	1.15	1.497	1.609
Kurtosis	34.622	64.704	23.33	10.774	18.345
Jarque-Bera	7894	29559	3122	517	1833
Observations	179	179	179	179	179

Table 1c: Correlations *fxmpi*

	<i>fxmpi_IND</i>	<i>fxmpi_KOR</i>	<i>fxmpi_MAL</i>	<i>fxmpi_PHI</i>	<i>fxmpi_THA</i>
MPI_IND	1				
MPI_KOR	0.117	1			
MPI_MAL	-0.012	0.057	1		
MPI_PHI	-0.042	-0.023	0.135	1	
MPI_THA	0.193	-0.026	-0.069	0.020	1

Table 1d: Correlations *dlxr*

	<i>dlxr_IND</i>	<i>dlxr_KOR</i>	<i>dlxr_MAL</i>	<i>dlxr_PHI</i>	<i>dlxr_THA</i>
dlxr_IND	1				
dlxr_KOR	0.479	1			
dlxr_MAL	0.618	0.441	1		
dlxr_PHI	0.545	0.432	0.584	1	
dlxr_THA	0.623	0.607	0.718	0.655	1

Table 2a: MSIH(2)-AR(3) results for *fxmpi*

	IND	KOR	MAL	PHI	THA
Mean	0.6548	0.4949	0.4310	0.4674	0.7504
(regime 1)	(0.1639)	(0.1376)	(0.1771)	(0.3090)	(0.1484)
Mean	2.5872	0.6120	0.8311	2.6101	-0.0423
(regime 2)	(1.354)	(0.2689)	(1.0186)	(1.3535)	(0.8815)
SE	1.9511	0.84107	1.6194	2.9063	1.3478
(regime 1)					
SE	10.109	2.6033	6.8225	10.227	4.6150
(regime 2)					
Observations	137.5	65.4	124.6	113.0	145.6
(regime 1)					
Observations	38.5	110.6	51.4	63.0	30.4
(regime 2)					
p_{11}	0.9463	1	0.9405	0.9811	0.9655
p_{12}	0.0537	0	0.0595	0.0189	0.0345
p_{21}	0.1935	0.0089	0.1463	0.0482	0.1697
p_{22}	0.8065	0.9910	0.8537	0.9518	0.8303

Notes: Results are presented for a heteroscedastic Markov switching specification with two regimes and three autoregressive terms. The dependent variable is a foreign exchange market pressure indicator, which has been constructed for Indonesia, Korea, Malaysia, the Philippines and Thailand.

Table 2b: MSIH(2)-AR(3) results for *dlxr*

	IND	KOR	MAL	PHI	THA
Mean	0.2738	0.0495	0.1280	-0.0035	-0.1152
(regime 1)	(0.0342)	(0.1014)	(4.0660)	(0.0688)	(0.0669)
Mean	1.3227	1.6585	0.1280	0.6837	1.5112
(regime 2)	(1.2033)	(2.1383)	(4.0660)	(0.3334)	(1.2203)
SE	0.17942	1.1660	2.3295	0.50134	0.73633
(regime 1)					
SE	11.197	8.7569	2.3295	2.9652	6.5375
(regime 2)					
Observations	89.3	157.7	88	88.3	145.2
(regime 1)					
Observations	86.7	18.3	88	87.7	30.8
(regime 2)					
p_{11}	0.9292	0.9657	0.7472	0.8733	0.9333
p_{12}	0.0708	0.0343	0.2528	0.1267	0.0667
p_{21}	0.0636	0.2920	0.2528	0.1310	0.3172
p_{22}	0.9364	0.7080	0.7472	0.8690	0.6828

Notes: Results are presented for a heteroscedastic Markov switching specification with two regimes and three autoregressive terms. The dependent variable is the percent change in the nominal exchange rate for Indonesia, Korea, Malaysia, the Philippines and Thailand.

Table 3a: MSIH(2)-VAR(1) results for *fxmpi*

	IND	KOR	MAL	PHI	THA
Mean R1	0.597619	0.503195	0.489161	0.712728	0.573284
Mean R2	1.960138	0.641517	1.771888	0.939300	0.696158
Stan. Err. R1	3.101309	1.702228	2.308724	3.607553	1.563642
Stan. Err. R2	8.424579	3.172912	6.822248	10.728820	3.633208
Obs. In R1			129.2		
Obs. In R2			43.8		
p_{11}			0.9635		
p_{12}			0.0365		
p_{21}			0.1128		
p_{22}			0.8872		

Notes: Results are presented for a heteroscedastic Markov switching vector autoregression of order 1 with two regimes. The dependent variable is a foreign exchange market pressure indicator, which has been constructed for Indonesia, Korea, Malaysia, the Philippines and Thailand.

Table 3b: MSIH(2)-VAR(1) results for *dlxr*

	IND	KOR	MAL	PHI	THA
Mean R1	0.320101	-0.007432	-0.087561	0.140583	-0.021424
Mean R2	1.755504	0.749433	1.143743	0.892240	0.867608
Stan. Err. R1	1.836415	1.314356	0.629406	1.559233	0.934443
Stan. Err. R2	17.274242	7.378275	5.211998	3.966274	6.599764
Obs. In R1			141.2		
Obs. In R2			31.8		
p_{11}			0.9411		
p_{12}			0.0589		
p_{21}			0.2683		
p_{22}			0.7317		

Notes: Results are presented for a heteroscedastic Markov switching vector autoregression of order 1 with two regimes. The dependent variable is the percent change of the nominal exchange rate for Indonesia, Korea, Malaysia, the Philippines and Thailand.

Table 4a: Correlations in tranquil and crisis regimes *fxmpi*

	<i>fxmpi_IND</i>	<i>fxmpi_KOR</i>	<i>fxmpi_MAL</i>	<i>fxmpi_PHI</i>	<i>fxmpi_THA</i>
<i>fxmpi_IND</i>	1	0.1854	-0.0974	-0.1058	0.2809
<i>fxmpi_KOR</i>	0.0416	1	0.1999	-0.1314	0.0350
<i>fxmpi_MAL</i>	0.0767	-0.0771	1	0.1797	-0.1883
<i>fxmpi_PHI</i>	0.0837	0.0895	0.1890	1	-0.0020
<i>fxmpi_THA</i>	-0.0116	-0.0267	0.0383	0.0855	1

Notes: Contemporaneous correlations in regime 1 (tranquil) are reported below the diagonal and contemporaneous correlations in regime 2 (crisis) are reported above the main diagonal.

Table 4b: Correlations in tranquil and crisis regimes *dlxr*

	<i>fxmpi_IND</i>	<i>fxmpi_KOR</i>	<i>fxmpi_MAL</i>	<i>fxmpi_PHI</i>	<i>fxmpi_THA</i>
<i>fxmpi_IND</i>	1	0.3796	0.6450	0.7283	0.5870
<i>fxmpi_KOR</i>	0.2524	1	0.3602	0.4701	0.5557
<i>fxmpi_MAL</i>	-0.0005	0.0221	1	0.7886	0.7034
<i>fxmpi_PHI</i>	0.1907	0.2685	0.0217	1	0.8423
<i>fxmpi_THA</i>	0.5004	0.5796	0.0780	0.2670	1

Notes: Contemporaneous correlations in regime 1 (tranquil) are reported below the diagonal and contemporaneous correlations in regime 2 (crisis) are reported above the main diagonal.

Table 5a: Multivariate contagion test $fxmpi$

	$fxmpi_IND$	$fxmpi_KOR$	$fxmpi_MAL$	$fxmpi_PHI$	$fxmpi_THA$
Constant	0.10 (0.09)	0.44* (0.10)	0.12 (0.13)	0.15 (0.12)	0.34* (0.11)
Delta coef.	0.35 (0.24)	0.45** (0.21)	0.28 (0.33)	0.62** (0.30)	-0.78* (0.30)
ϕ_{IND}		0.04 (0.10)	0.06 (0.12)	0.02 (0.11)	0.23* (0.10)
ϕ_{KOR}	0.06 (0.06)		0.15 (0.09)	-0.16** (0.08)	-0.05 (0.08)
ϕ_{MAL}	0.01 (0.06)	0.11*** (0.06)		0.25* (0.07)	-0.04 (0.07)
ϕ_{PHI}	-0.02 (0.06)	-0.14*** (0.07)	0.29* (0.08)		0.11 (0.07)
ϕ_{THA}	0.30* (0.06)	-0.03 (0.07)	-0.01 (0.08)	0.10 (0.08)	
χ_{IND}		0.09 (0.13)	-0.36 (0.23)	-0.13 (0.17)	1.13* (0.19)
χ_{KOR}	0.21* (0.02)		0.06 (0.05)	0.02 (0.04)	-0.29* (0.04)
χ_{MAL}	0.13* (0.04)	0.03 (0.05)		0.05 (0.04)	-0.19* (0.05)
χ_{IPHI}	-0.18* (0.03)	0.04 (0.04)	-0.05 (0.04)		0.17* (0.04)
χ_{THA}	-0.01 (0.01)	0.03 (0.01)*	-0.01 (0.01)	0.01 (0.01)	

Notes: Method of estimation: seemingly unrelated regressions. Standard errors are reported in parentheses.

* indicates significance at the 1% level, ** indicate significance at the 5% level and *** indicate significance at the 10% level.

Table 5b: Multivariate contagion test $dlxr$

	$fxmpi_IND$	$fxmpi_KOR$	$fxmpi_MAL$	$fxmpi_PHI$	$fxmpi_THA$
Constant	0.13 (0.23)	0.05 (0.17)	-0.15 (0.17)	0.27 (0.20)	-0.12 (0.12)
Delta coef.	-0.93 (0.58)	0.34 (0.42)	0.43 (0.44)	0.88*** (0.46)	-0.62** (0.30)
ϕ_{IND}		-0.12 (0.20)	-0.14 (0.21)	0.60** (0.23)	0.28** (0.13)
ϕ_{KOR}	0.07 (0.28)		-0.28 (0.21)	0.14 (0.24)	0.56*** (0.12)
ϕ_{MAL}	0.20 (0.22)	-0.10 (0.16)		0.25 (0.19)	0.23** (0.11)
ϕ_{PHI}	0.25** (0.10)	0.04 (0.07)	0.14*** (0.07)		0.15*** (0.05)
ϕ_{THA}	0.39 (0.29)	0.84* (0.19)	0.37 (0.24)	0.39 (0.27)	
χ_{IND}		0.34 (0.21)	0.42 (0.21)	-0.42*** (0.24)	-0.33** (0.14)
χ_{KOR}	0.34 (0.30)		0.11*** (0.23)	-0.20 (0.26)	-0.16 (0.13)
χ_{MAL}	0.30 (0.24)	-0.08 (0.18)		-0.10 (0.21)	0.09 (0.13)
χ_{IPHI}	0.27 (0.20)	-0.28*** (0.15)	0.12 (0.15)		0.32*** (0.09)
χ_{THA}	-0.57*** (0.32)	-0.07 (0.22)	0.30 (0.26)	0.14 (0.29)	

Notes: Method of estimation: seemingly unrelated regressions. Standard errors are reported in parentheses.

* indicates significance at the 1% level, ** indicate significance at the 5% level and *** indicate significance at the 10% level.

Figure 1a: Nominal exchange rates in East Asia

Figure 1b: Nominal interest rates in East Asia

Figure 1c: International reserves in (\$US) in East Asia

Figure 2a: Time series plots *fxmpi*

Figure 2b: Time series plot *dlxr*

Figure 3: Regime 2 (crisis) probabilities for *fxmpi* (top) and *dlxr* (bottom)