Interest And Exchange Rate Shocks On The Capital Market Risk And Capital Mobility: Evidence From Four Asian Countries

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ABSTRACT

This paper investigates how the thinness of foreign-exchange markets causes destabilizing speculations. Using the vector-autoregression model, it is shown that in response to one-standard-deviation shock to interest and exchange rates, the dynamic capital mobility and capital market-risk have increased in the short run. During the crisis, the Asian crisis countries responded by increasing their interest rates and devaluing their currencies to stem capital flight. However, in an environment of protracted financial-sector reform and thin foreign-exchange markets, these standard policies did not stabilize the capital inflows into these countries and this can be attributable to the very thin foreign-exchange markets of these Asian countries.

INTRODUCTION

Since Asia's financial crisis began in 1997 most research has focused on the speculative attacks perpetuated by hedge funds and their impact on the crisis countries' economies (see, e.g., Kray, 1998 and Goldfajn, 1998). However, little effort has been made to examine the role of the microstructure of the foreign-exchange market in the propagation of the crisis and how this microstructure affected capital inflows and capital- market risks. Indeed, only a few studies have focused on the thinness of foreign-exchange markets and its impact on exchange-rate dynamics (Lyons, 1996; Goodhart and Payne, 1996; and Alberto and Francesco, 1985: Min and McDonald, 1999). Since the crisis, borrowing countries adopted exchange-rate flexibility and tightened their monetary policy so that balance-of-payments pressures are reduced. These policy prescriptions are meant to stabilize capital flows in crisis countries because in theory, they provide a strong incentive for foreign investors to keep their money where it is. However, if these policy prescriptions do not change the (self-fulfilling) destabilizing foreign investors' herding behavior, they may not stabilize capital flows in the crisis countries (see, e.g., Avery and Zemsky, 1998; Grinblatt, Titman, and Wermers, 1995; Redding, 1996; and Teh and de Bondt, 1997).

Our primary goal is to investigate the short-run impact of the crisis countries' policy responses on their dynamic capital mobility and capital-market risk. Table 1 indicates the thinness of the foreign-exchange markets of these Asian crisis countries relative to Mexico and advanced economies.

It is reasonable to assume that this extreme degree of foreign-exchange market thinness was an important factor that not only contributed to the crisis but is also constraining the ongoing adjustment to the crisis.

Of the many debates that have intensified since the onset of the Asian crisis, the one devoted to the advisability of capital controls is especially important. As *The Economist* (1998a) recently put it, did Asia's ex-tiger economies collapse because they were too open to international finance or because they weren't open enough?[1] Many prominent economists, including Paul Krugman (1998), James Tobin, and Barry Eichengreen (see IMF, 1998c) have advocated that developing countries should institute some sort of capital control or regulation so as to avoid future crises on the scale of the current crisis. It is beyond the scope of this paper to discuss the various types of capital controls that have been proposed (to deal with future capital inflows and to minimize current capital outflows) and whether or not capital controls are effective (or dangerous)[2]. However, before joining this capital-control debate and deciding, for example, that an *explicit* policy, like the "Tobin tax" is needed to limit short-term speculative inflows, a greater understanding of the current *implicit* or effective degree of capital mobility between countries is necessary. Although explicit capital controls may not exist, capital flows between countries very much depend on factors like transaction costs and risk premia, which therefore implicitly affect the degree of capital mobility.

Table 1: Foreign-Exchange Market Activity Of Asian Crisis Countries And Mexico

Country	GDP[1)]	Average Daily Turnover of Foreign-Exchange Market Activity [2)]	Relative Size (in percent)[3)]
Indonesia	214.6	1.5	**0.69**
Malaysia*	97.9	1.1	**1.12**
S. Korea	442.7	3.5	**1.12**
Thailand	153.9	3.0	**1.9**
Asian Average (Crisis Countries)	909.1	9.1	**1.00**
Mexico	402.7	8.6	**2.14**
Selected Advanced Economies			
United States	8111.0	350.9	**4.33**
United Kingdom	1288.4	637.6	**49.5**
Germany	2102.6	94.3	**4.48**
Japan	4192.3	148.6	**3.54**
Switzerland	254.9	81.7	**32.1**
Selected Advanced Economies Average	15949.2	1313.1	**8.23**

Notes and Sources
1) The GDP data is in billions of nominal US$. Conversion was made using IFS line rf. The GDP data is for 1997 and is from IMF (1998b).
2) This data is in billions of US$. It is for April 1998 and is from BIS (1998).
3) The relative size is calculated as (average daily turnover/GDP).

In what follows, we define capital mobility for a given country as the deviation from uncovered interest parity. It is important to measure the effective capital mobility situation that each crisis country faces and to understand how this capital mobility is (and has been) affected by various macroeconomic policies before deciding whether or not new explicit capital controls would be advisable. As an example of how our measure of capital mobility is affected by macroeconomic policy, we examine how our measure has changed due to recent policies, such as increased flexibility in exchange rates.[3] According to our measure, capital mobility has recently been significantly affected. So, deciding on appropriate explicit capital controls without first looking at how capital mobility has already changed may well lead to inappropriate policy measures.

In section II, we present our definition of capital mobility, capital-market risk, and a vector-autoregression model that is used to analyze the short-run impact of interest-rate increases and devaluation. In section III, we investigate the impact of interest- and exchange-rate changes on the capital mobility of crisis countries. In section IV, we examine the short-run impact of these shocks on the countries' capital-market risk. Section V presents our conclusions.

THE MODEL

The Definition Of Dynamic Capital Mobility

The definition of dynamic capital mobility is based on the uncovered interest parity (UIP) and ex ante PPP conditions as modeled by Bhati and Moosa (1994, 1995, and 1997) and Moosa (1997). If there is perfect capital mobility with no capital controls, transaction costs or risk premia, the expected rate of change of the spot exchange rate will be equal to the nominal interest-rate differential on perfectly comparable financial assets denominated in different currencies across countries. This condition is given by

(1) $(1 + I_t) = (1 + \Delta S^e_t)(1 + I^*_t)$

where ΔS^e_t is the expected rate of change of the spot exchange rate, and I and I* are the nominal interest rates in the home and foreign countries respectively. An alternative specification is derived by solving equation (1) for the expected spot exchange rate, S^e, to obtain

(2) $S^e = F^*$

where $F^* = S[(1+I)/(1+I^*)]$ is the interest parity forward rate which is equal to the forward exchange rate, F, if and only if the CIP holds.

Taking logarithms in equation (2), we obtain equation (3):

(3) $s^e_{t+1} = f^*_t$

where s^e_{t+1} is the logarithm of the expected spot rate and f^*_t is the logarithm of the interest-parity forward rate. Allowing for the existence of a risk premium and assuming that expectations are rational, equation (3) can be written in a testable form as:

(4) $s_{t+1} = \beta_0 + \beta_1 f^*_t + \acute{\omega}_{t+1}$

where $\acute{\omega}_{t+1}$ is an error term reflecting the impact of news and β_0 is a constant term reflecting the value of the risk premium as well as other factors such as transaction costs. The UIP holds in strong form if $\beta_0 = 0$and $\beta_1 = 1$ are not rejected. Assuming that these conditions hold, equation (4) becomes

(5) $s_{t+1} = f^*_t + \acute{\omega}_{t+1}$

However, when capital is not perfectly mobile because of capital and foreign-exchange controls (as is the case in the Pacific Asian developing countries), UIP will not hold. The deviation from UIP (DUIP) can be written as:

(6) $DUIP_t = s_{t+1} - f^*_t + \xi_{t+1}$

where $DUIP_t$ is the deviation from UIP, which will vary over time. We will use DUIP as a measure of dynamic capital mobility. The larger is the deviation from UIP, the greater are capital or foreign-exchange controls in that country, and the lower is capital mobility.

The Definition Of Capital-Market Risk

This section specifies a model of time-varying systematic risk as deviations from uncovered interest parity in the international capital market. Following Bollerslev (1986), a particular parameterization of the multivariate GARCH process is employed to model the conditional variance of covariance matrix of unforecastable components of deviations from UIP. The empirical results indicate substantial conditional systemic risk for all Asian countries. This time-varying risk can be explained by both fluctuations in interest-rate differentials and interest-parity forward rates.

Next, we turn to the model determining the conditional second moments of innovations to UIP. A considerable amount of empirical evidence suggests that deviations from UIP are characterized by ARCH effects (see, e.g., Cumby, 1987; Domowitz and Hakkio, 1985; Enders, 1995; Hamilton, 1994). Since we did not specify a full equilibrium model of the economy, it is impossible to relate the conditional covariance matrix of those innovations to a set of structural variables. Thus, the linear GARCH model is a good candidate for modeling the time-dependence of conditional second moments. In order to ensure positive definiteness, the parameterization of the multivariate GARCH model proposed by Bollerslev (1990) and Bailie and Bollerslev (1990) is adopted. Using equation (6) for DUIP[4], GARCH (1,1) can be specified in the following way:

(6) $DUIP_t = s_{t+1} - f^*_t + \xi_{t+1}$

(7) $\xi_t \sim N(0, h_t)$

(8) $h_t = \varphi_1 + \varphi_2 \epsilon^2_{t-1} + h_{t-1}$

where h_t is the conditional second moment.

The Vector-Autoregression Model

A three-variable vector-autoregression (VAR) model is used to investigate the dynamic impact of interest- and exchange-rate shocks on capital-market risk and capital mobility in the crisis countries. Consider a vector of stationary variables X and a vector of

structural shocks ϵ. The structural model can be written as equation (9),

(9) $X_t = C(L)\,\epsilon_t$

where C is a non-singular matrix of coefficients and L denotes the lag operator, and ϵ_t is error term. A reduced form of the structural system that can be estimated is given by

(10) $\Gamma(L)\,\Delta X_t = \varphi X_{t-1}\, \epsilon^*_t$

where Γ is a coefficients matrix for the reduced form and φ is a coefficients matrix for the lagged variables, and ϵ^*_t is error terms of the reduced form equations.

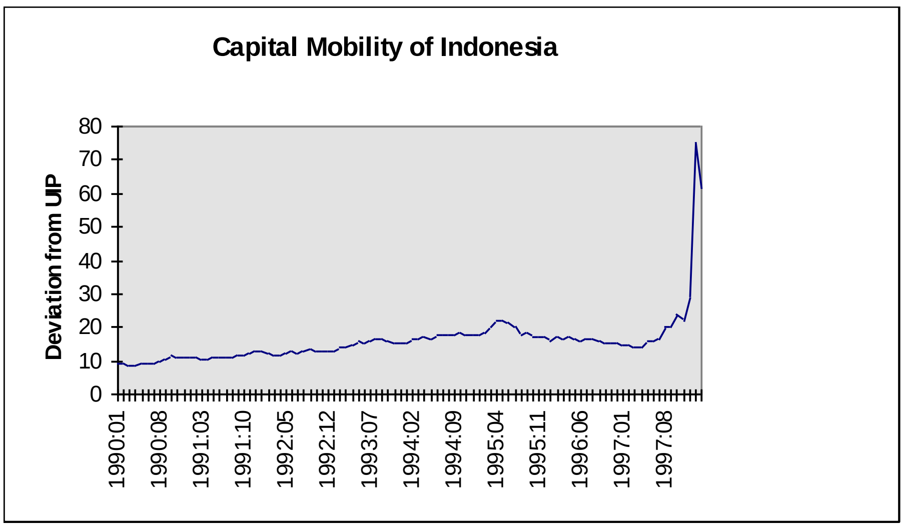
ESTIMATION OF THE IMPACT OF INTEREST- AND EXCHANGE- RATE SHOCKS ON THE CAPITAL MOBILITY

In this section, we investigate the impact of interest- and exchange-rate shocks on the dynamic capital mobility of the four crisis countries. The optimal lag structure is derived using the likelihood-ratio test for each of the Asian crisis countries.

Data

The experiences of four Asian countries are examined: Indonesia, Korea, Malaysia, and Thailand. For these countries, dynamic capital mobility has been estimated with reference to Japan using the London inter-bank offer rate (LIBOR) on three-month Japanese deposits (IFS line 60ea). For the four Asian countries, market interest rates are used (IFS line 60b). To get *predetermined* interest rates for the crisis countries, we use each country's end-of-period discount rate (IFS line 60). To get the nominal Japanese yen exchange rate for each of these four countries' currencies, the U.S. dollar exchange rate (IFS line ae) is converted using the U.S. dollar exchange rate of the Japanese yen. Considering the large liberalization process and possible consequent structural changes in financial structure in each country during the 1980s, monthly data from January 1990 to March 1998 are used in the estimation. All data were extracted from the August 1998 CD-Rom version of the IMF's *International Financial Statistics* (1998b). The values of dynamic capital mobility, DUIP, estimated for each of the four Asian crisis countries are presented in Figure 1.[5]

Figure 1: Dynamic Capital Mobility Of Indonesia And Korea



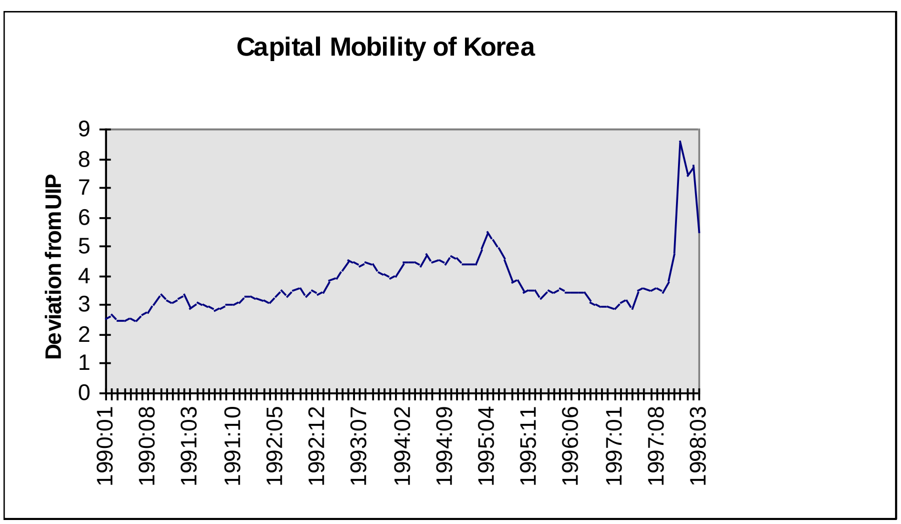
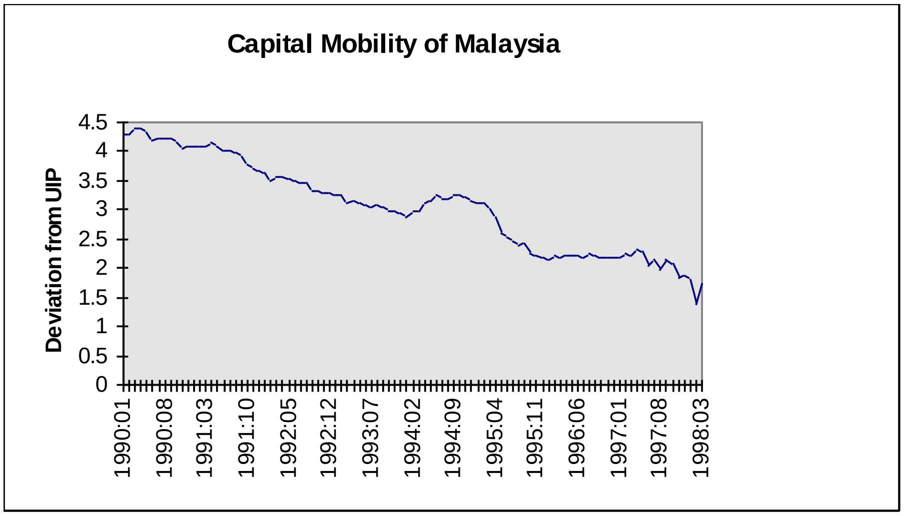
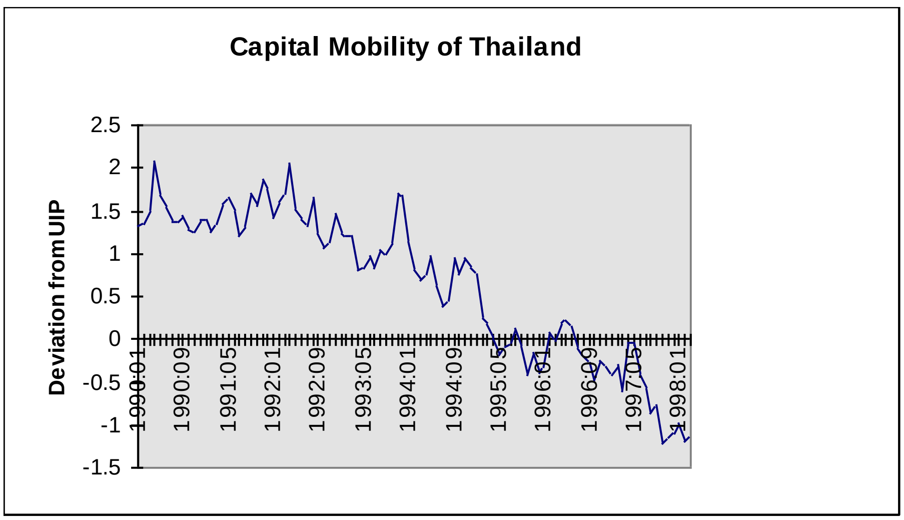


Figure 1: Dynamic Capital Mobility of Malaysia and Thailand (continued)





A chronology that shows how these countries changed their exchange-rate flexibility in an attempt to deal with the growing crisis is found in Table 2.

Table 2: Chronology of Exchange-Rate Movements of Four Asian Crisis Countries: Indonesia, Korea, Malaysia, and Thailand

Date		
1997		
May	14-15	Thai baht hit by a massive speculative attack
July	2	Bank of Thailand moved to managed floating regime (15-20%)
	11	Indonesia increased trading band from 15% to 24%
	14	Malaysian central bank abandon defense of ringgit
August	14	Indonesia allows floatation of ruphia and recorded 2.655 per US$
October	6	Indonesia ruphia devalued to 3.848 per US$
November	6	Bank of Korea intervened in foreign exchange market, won 973/US$
	17	Bank of Korea abandoned defense of won, won 1000/US$
	18	Thai baht lost 3.5%, Malaysia ringgit lost 2.8% of its value
	19	Korea expanded daily band from 2.5% to 10%, recording 1035.5/US$
	26	Korea won 1122/US$, Malaysia ringgit lost 3.5% of its value, and Indonesia ruphia 4020/US$.
December	5	Korean won 1290/US$, Malaysia ringgit 3.865/US$, and Indonesia ruphia 4020/US$.
	11	Korean won 1719.8/US$, Indonesia ruphia lost 12% of its value, Thailand baht 47.35/US$, and Malaysia ringgit lost 3.7% of its value
	26	Korean won 1836/US$, Indonesia ruphia 6300/US$.
1998		
January	30	Thailand lifts currency restrictions reunifying the spot market
February	13	Korean won 1621/US$, Indonesia ruphia 7000/US$, Thailand baht 48.01/US$ and Malaysia ringgit 3.735/US$.
	20	Indonesia rupiah 9200/US$, announced plan for currency board.
	23	Korean won 1654/US$, Indonesia ruphia 9400/US.
March	6	Indonesia ruphia recorded 12300/US$
	13	Thailand baht 41.6/US$
	16	Korean won recorded 1460/US$
	26	Indonesia ruphia recorded 8600 per US$

Sources: IMF (1998d) and www.stern.nyu.edu/~nroubini/asia/AsiaChronology1.htm

Estimation

Indonesia

The optimal lag length for Indonesia according to the likelihood-ratio test is 6 periods. While a lag length of 6 is not a restriction on lag length 7, a lag length of 5 is binding on lag length 6, i.e., probability [Chi-squared (lag 7 vs lag 6) = 9.66] is 0.37, whereas the probability [Chi-squared (lag 6 vs lag 5) = 19.06] is 0.00. The ordering of variables in the VAR model is based on the block causality test reported in the note at the bottom of Table 3.

Table 3: Indonesia: Variance Decomposition

A. Dynamic Capital Mobility

Step	Interest Rate (Int)	Exchange Rate (Ex)	DUIP
1	6.42	93.24	0.33
4	5.82	91.70	2.47
8	55.73	43.65	0.60
12	47.05	52.34	0.60
16	58.94	40.74	0.28
20	56.86	42.53	0.59
24	60.47	38.95	0.56

Note: Block causality test. Dependent variable appears first and Prob denotes significance probability of F statistic.
1) Interest rate: Int, Prob[(F=5.15)]=.00; Ex, Prob[(F= 2.33)]=.04; Duip, Prob[(F=1.91)]=.08
2) Exchange rate: Int, Prob[(F=30.06)]=.00; Ex, Prob[(F= 7.09)]=.00; Duip, Prob[(F=6.57)]=.00
3) DUIP: Int, Prob[(F=31.49)]=.00; Ex, Prob[(F= 7.01)]=.00; Duip, Prob[(F=7.12)]=.00

B. Capital-Market Risk

Step	Interest Rate (Int)	Exchange rate (Ex)	Variance (Var)
1	0.003	38.13	61.86
4	3.756	96.08	0.15
8	5.527	94.36	0.11
12	7.929	92.04	0.02
16	7.933	92.04	0.02
20	7.998	91.98	0.02
24	7.998	91.98	0.02

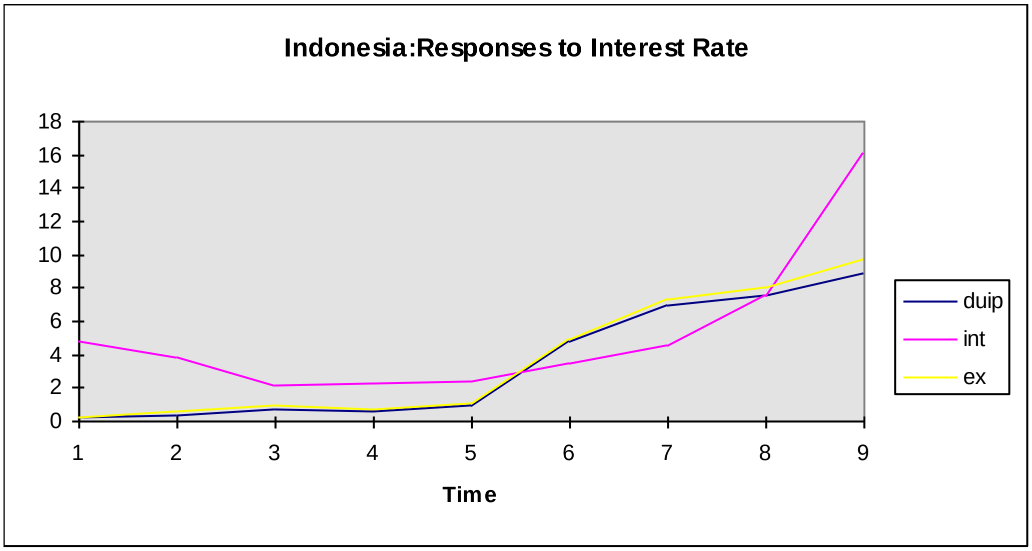
Note: Block causality test. Dependent variable appears first and Prob denotes significance probability of F statistic.
1) Interest rate: Int, Prob[(F=21.6)]=.00; Ex, Prob[(F= 2.52)]=.04; Var, Prob[(F=1.65)]=.16
2) Exchange rate: Int, Prob[(F=48.7)]=.00; Ex, Prob[(F= 51.5)]=.00; Var, Prob[(F=19.2)]=.00
3) VAR: Int, Prob[(F=31.49)]=.00; Ex, Prob[(F= 7.01)]=.00; Var, Prob[(F=7.12)]=.00

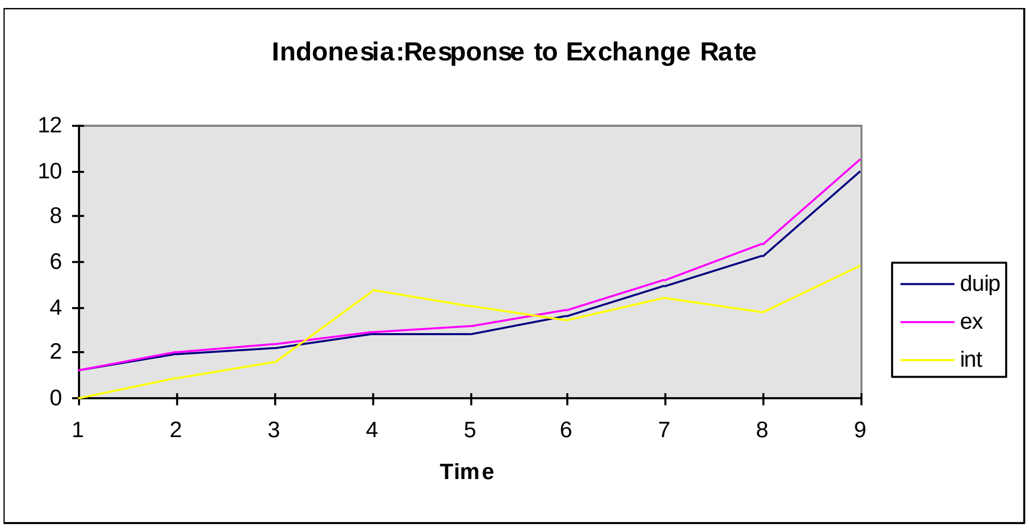
The block causality tests indicate that the direction of causality is from interest rates to exchange rates. Exchange-rate changes affect interest rates and the degree of capital mobility. Additionally, capital mobility causes interest rate and exchange rate. So, the ordering of interest rate, exchange rate, and capital mobility (DUIP) is used. Different orderings were tried, but the results did not change substantially.

Figure 3-1 shows the impulse response function of dynamic capital mobility in Indonesia with one-standard-deviation shocks of foreign exchange and interest (i.e., discount) rates. This figure shows that both shocks increase the deviation from uncovered interest parity, i.e., dynamic capital mobility decreases. Also, a one-standard-deviation shock to the interest-rate differential decreases the dynamic capital mobility of Indonesia in the short run.

The variance decomposition of Indonesia's capital mobility reported in Table 3. In the short run (up to six months), exchange-rate effects dominate; consequently, the combined effect of both shocks has been to decrease Indonesia's dynamic capital mobility since January 1998. Figure 1 confirms these results.

Figure 3-1: Indonesia: Impulse Response Function of Capital Mobility





Korea

An optimal lag length of two periods is chosen for the estimation. This is because a lag length of 2 is not a restriction on lag length 3, but a lag length of 1 is binding on a lag length of 2, i.e., the probability [Chi-squared (lag 3 vs lag 2)=7.3] is 0.605 and the probability [Chi-squared (lag 2 vs lag 1)=13.8] is 0.00. The ordering of variables in the VAR model is based on the block exogeneity test reported in the note at the bottom of Table 4.

Block causality tests indicate that the interest causes itself, the exchange rate causes capital mobility and itself, and capital mobility causes only itself. So, the appropriate ordering is to have the exchange rate followed by the interest rate and then capital mobility (DUIP). Different orderings were tried, but the results were not substantially different.

Table 4: Korea: Variance Decomposition

A. Dynamic Capital Mobility

Step	Interest Rate (Int)	Exchange Rate (Ex)	DUIP
1	0.81	81.10	18.08
4	0.26	72.03	27.70
8	1.46	70.88	27.65
12	2.62	69.99	27.37
16	2.71	69.65	27.62
20	2.72	69.56	27.72
24	2.74	69.53	27.72

Note: Block causality test. Dependent variable appears first and Prob denotes significance probability of F statistic.
1) Exchange rate: Int, Prob[(F=79.3)]=.00; Ex, Prob[(F= 0.32)]=.81; Duip, Prob[(F=2.53)]=.06
2) Interest rate: Int, Prob[(F=29.6)]=.00; Ex, Prob[(F= 1.27)]=.29; Duip, Prob[(F=4.75)]=.00
3) DUIP: Int, Prob[(F=0.54)]=.65; Ex, Prob[(F= 0.97)]=.41; Duip, Prob[(F=35.9)]=.00

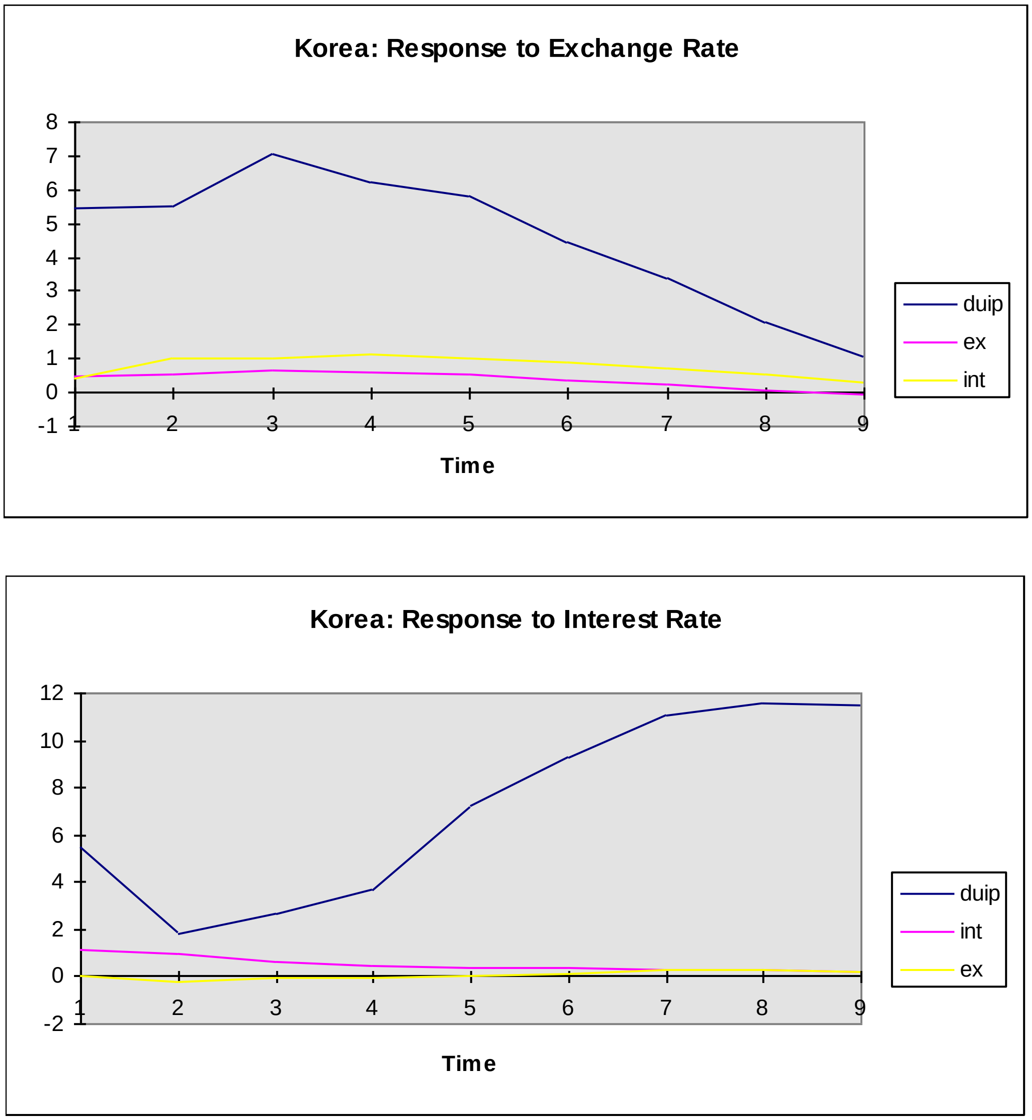
B. Capital-Market Risk

Step	Interest Rate (Int)	Exchange rate (Ex)	Variance (Var)
1	0.18	14.32	85.49
4	17.08	63.53	19.37
8	18.84	24.31	56.83
12	25.25	63.63	11.11
16	28.03	51.12	20.84
20	29.27	40.52	30.21
24	29.03	55.11	15.85

Note: Block causality test. Dependent variable appears first and Prob denotes significance probability of F statistic.
1) Interest rate: Int, Prob[(F=15.8)]=.00; Ex, Prob[(F= 2.99)]=.00; Var, Prob[(F=1.33)]=.25
2) Exchange rate: Int, Prob[(F=1.07)]=.39; Ex, Prob[(F= 42.9)]=.00; Var, Prob[(F=2.99)]=.00
3) VAR: Int, Prob[(F=1.59)]=.15; Ex, Prob[(F= 30.46)]=.00; Var, Prob[(F=8.71)]=.00

Figure 4-1 shows Korea's impulse response functions. An exchange-rate shock of one standard deviation decreases capital mobility in the short run (up to 9 months). Also, an interest-rate differential shock of one standard error deviation decreases dynamic capital mobility in both the short and medium runs (up to 14 months). Figure 1 indicates that capital mobility has decreased (or the deviation from UIP has increased) in Korea. After the Korean exchange rate was allowed to float and interest rates were increased, foreign investment into Korea decreased significantly in the short run. In January 1998, foreign investment into Korea decreased by 85.1 percent compared to January 1997 and in February 1998 it decreased by 45.2 percent compared to February 1997. This trend lasted for four months in Korea.[6] Table 4 shows the variance decomposition of Korea's dynamic capital. The forecast error variance of Korea's capital mobility is mostly explained by the change in exchange rates -- the role of the interest-rate differential is minor. A policy implication of this finding is that Korea's high interest-rate/tight monetary policy did not prevent foreign capital from leaving. Nor did the free floatation of Korea's exchange rate contribute to the inflow of foreign capital. Figure 1 confirms this finding: since December 1997 the deviation from UIP has been increasing, which means that dynamic capital mobility has been decreasing.

Figure 4-1: Korea: Impulse Response Function of Capital Mobility



Malaysia

An optimal lag length of seven periods is chosen based on the likelihood-ratio test. This is because a lag length of 7 is not a restriction on lag length 8, but a lag length of 6 is binding on a lag length of 7, i.e., the probability [Chi-squared (lag 8 vs lag 7) = 14.53] is 0.104 and the probability [Chi-squared (lag 7 vs lag 6) = 19.06] is 0.024. The ordering of variables in the VAR model is based on the block causality test reported in the note of Table 5.

Table 5: Malaysia: Variance Decomposition

A. Dynamic Capital Mobility

Step	Interest Rate (Int)	Exchange Rate (Ex)	DUIP
1	0.83	47.44	51.72
4	49.23	15.38	35.38
8	62.72	12.36	24.92
12	67.02	14.17	18.81
16	53.35	31.33	15.31
20	43.05	41.15	15.79
24	40.78	43.93	15.28

Note: Block causality test. Dependent variable appears first and Prob denotes significance probability of F statistic.
1) Exchange rate: Int, Prob[(F=4.54)]=.00; Ex, Prob[(F= 71.03)]=.00; Duip, Prob[(F=1.19)]=.31
2) Interest rate: Int, Prob[(F=48.7)]=.00; Ex, Prob[(F=1.06)]=.41; Duip, Prob[(F=1.59)]=.15
3) DUIP: Int, Prob[(F=16.8)]=.00; Ex, Prob[(F= 1.51)]=.17; Duip, Prob[(F=52.06)]=.00

B. Capital-Market Risk

Step	Interest Rate (Int)	Exchange Rate (Ex)	Variance (Var)
1	1.66	4.67	93.66
4	21.76	28.91	49.32
8	22.68	34.25	43.06
12	28.90	27.40	43.68
16	28.63	26.29	45.12
20	33.76	22.40	43.82
24	36.64	19.54	43.81

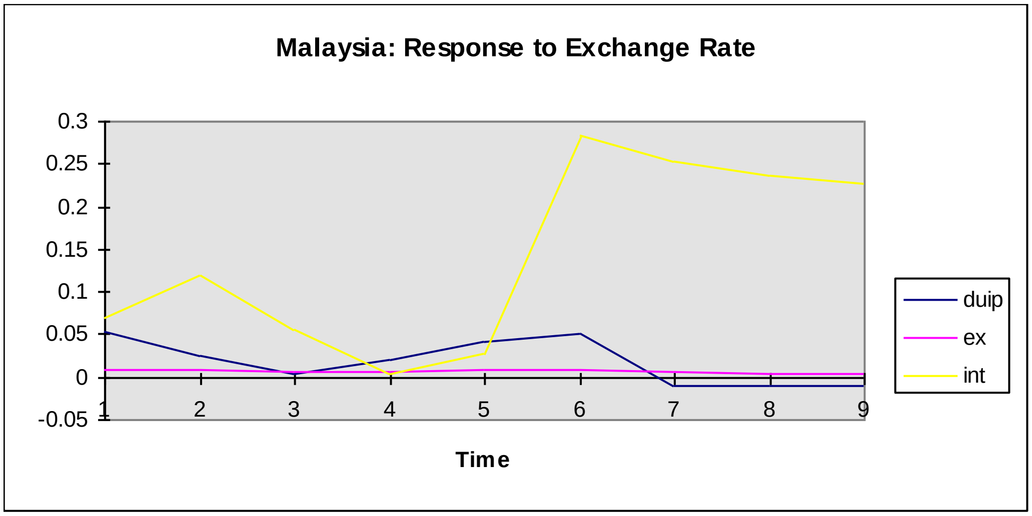
Note: Block causality test. Dependent variable appears first and Prob denotes significance probability of F statistic.
1) Interest rate: Int, Prob[(F=239.4)]=.00; Ex, Prob[(F= 1.16)]=.33; Var, Prob[(F=0.93)]=.48
2) Exchange rate: Int, Prob[(F=2.72)]=.01; Ex, Prob[(F= 62.0)]=.00; Var, Prob[(F=3.20)]=.00
3) VAR: Int, Prob[(F=8.03)]=.00; Ex, Prob[(F= 4.62)]=.00; Var, Prob[(F=8.07)]=.00

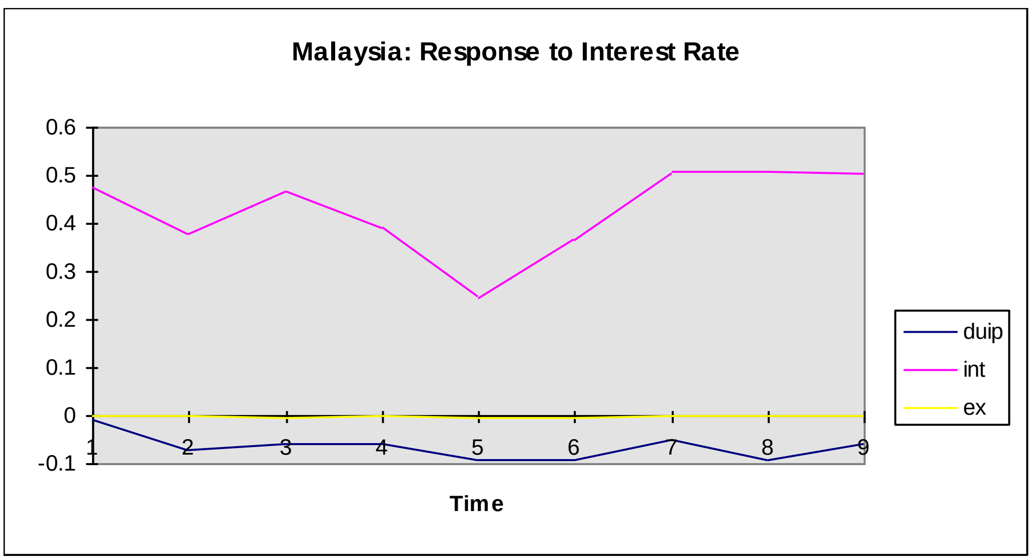
Block causality tests indicate that the interest rate causes the exchange rate and itself, the exchange rate causes the interest rate, and capital mobility causes the interest rate and itself. So, the ordering of capital mobility, interest rate and then exchange rate is used. Various other orderings were tried, but trends were comparable to those presented below.

Malaysia's impulse response function is shown in Figure 5-1. A one-standard-deviation shock to the exchange rate causes the deviation from UIP to increase (or capital mobility to decrease) in the short run (up to 6 months). However, a one-standard-deviation shock to the interest-rate differential causes the deviation from UIP to decrease (or capital mobility to increase).

Table 5 shows the variance decomposition for Malaysia. Because the impact of the interest-differential differential is larger than that of the exchange-rate shock, the combined impact has been an increase in Malaysia's capital mobility since August 1997. Figure 1 confirms this finding.

Figure 5-1: Malaysia: Impulse Response Function of Capital Mobility

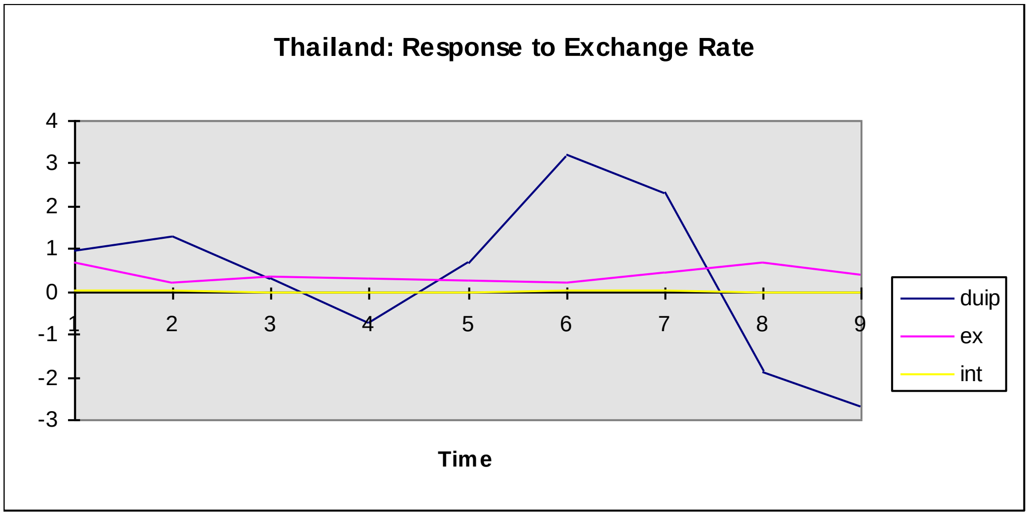




Thailand

An optimal lag length of five is chosen for the estimation. This is because a lag length of 5 is not a restriction on lag length 6, but a lag length of 4 is binding on a lag length of 5, i.e., the probability [Chi-squared (lag 6 vs lag 5)=12.28] is 0.1975 and the probability [Chi-squared (lag 5 vs lag 4)=23.46] is 0.005. The ordering of variables in the VAR model is based on the block causality test reported in the note of Table 6. Block causality tests show that the exchange rate causes the interest rate, capital mobility, and itself; the interest rate causes itself; and capital mobility (DUIP) causes the exchange rate, the interest rate, and itself. So, the ordering of exchange rate, capital mobility, and interest rate is used. Various other orderings were tried, but the results were not significantly different.

Figure 6-1: Thailand: Impulse Response Function of Capital Mobility



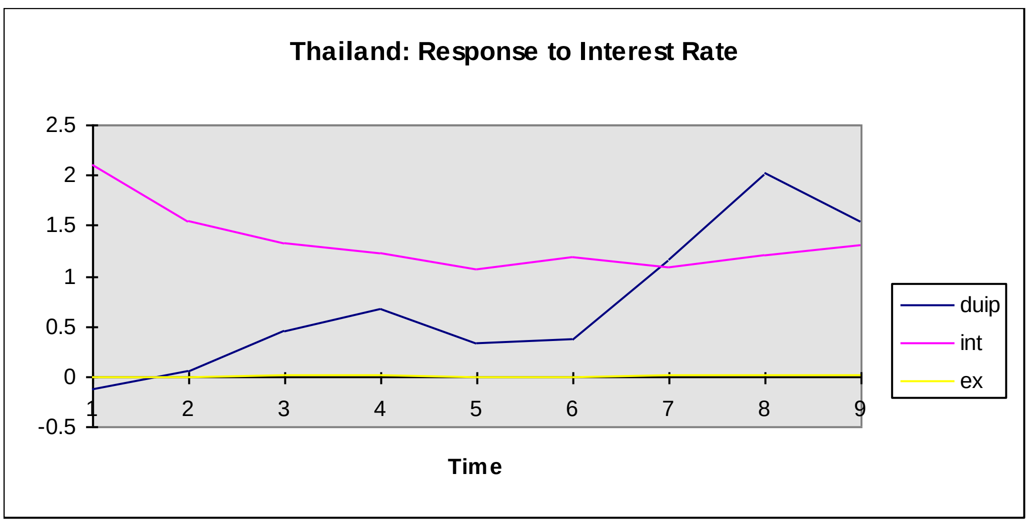


Figure 6-1 shows the impulse response function of Thailand for a one-standard-deviation shock of the foreign exchange rate on dynamic capital mobility measured by the deviation from uncovered interest parity. The exchange-rate shock decreases the dynamic capital mobility of Thailand in the short run (up to 3 months). The interest-rate differential has a very similar impact on Thailand's capital mobility.

Table 6 shows the variance decomposition of capital mobility and capital-market risk in Thailand. Because the exchange-rate effect has a dominating impact on the forecast error variance of the dynamic capital mobility, the combined effect from both the exchange-rate and interest-rate shocks was a decrease in Thailand's dynamic capital mobility. In fact, in the first four months of 1998 net capital outflows totaled U.S. $1.4 billion (Bangkok Bank, 1998).

Table 6: Thailand: Variance Decomposition

A. Dynamic Capital Mobility

Step	Interest Rate (Int)	Exchange Rate (Ex)	DUIP
1	1.18	66.68	32.12
4	11.10	52.85	36.04
8	16.93	61.06	22.00
12	11.35	65.81	22.83
16	4.08	75.32	20.58
20	3.46	81.04	15.49
24	5.17	80.20	14.62

Note: Block causality test. Dependent variable appears first and Prob denotes significance probability of F statistic.
1) Exchange rate: Int, Prob[(F=4.15)]=.00; Ex, Prob[(F= 74.04)]=.00; Duip, Prob[(F=3.97)]=.00
2) Interest rate: Int, Prob[(F=22.6)]=.00; Ex, Prob[(F=.39)]=.85; Duip, Prob[(F=0.55)]=.73
3) DUIP: Int, Prob[(F=3.01)]=.01; Ex, Prob[(F= 3.24)]=.01; Duip, Prob[(F=61.5)]=.00

B. Capital-Market Risk

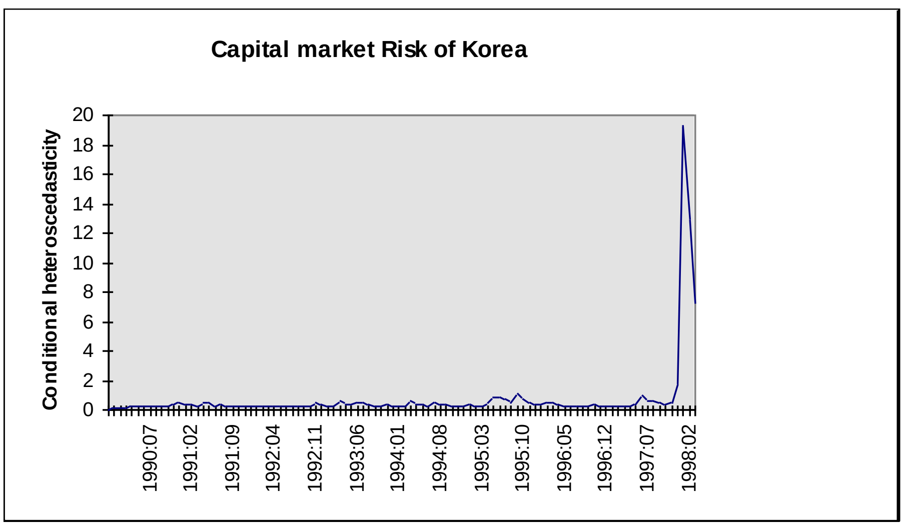
Step	Interest Rate (Int)	Exchange Rate (Ex)	Variance (Var)
1	9.51	0	90.48
4	40.48	1.60	57.91
8	56.32	2.43	41.24
12	63.43	1.85	34.72
16	68.29	1.38	30.32
20	71.51	1.05	27.43
24	73.83	0.81	25.35

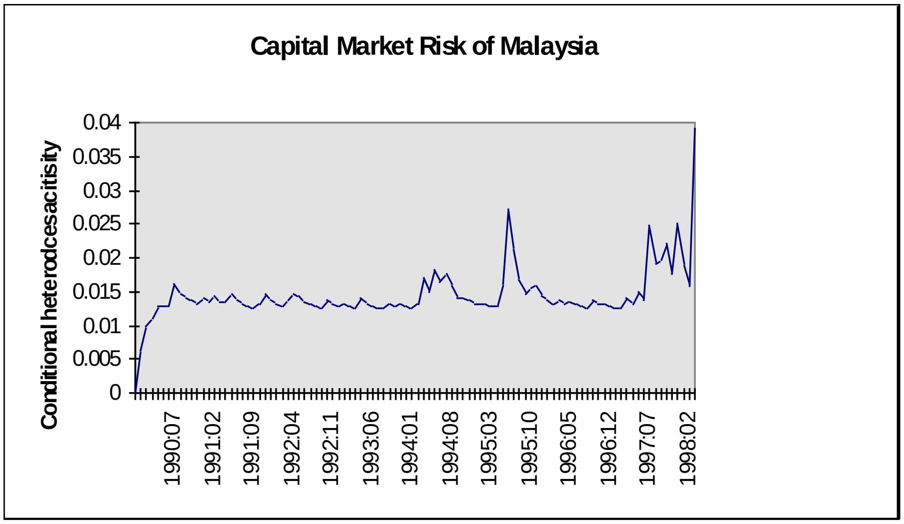
Note: Block causality test. Dependent variable appears first and Prob denotes significance probability of F statistic.
1) Interest rate: Int, Prob[(F=17.34)]=.00; Ex, Prob[(F= 0.36)]=.82; Var, Prob[(F=0.66)]=.61
2) Exchange rate: Int, Prob[(F=3.61)]=.00; Ex, Prob[(F=97.0)]=.00; Var, Prob[(F=3.20)]=.00
3) VAR: Int, Prob[(F=8.03)]=.00; Ex, Prob[(F= 4.62)]=.00; Var, Prob[(F=2.08)]=.00

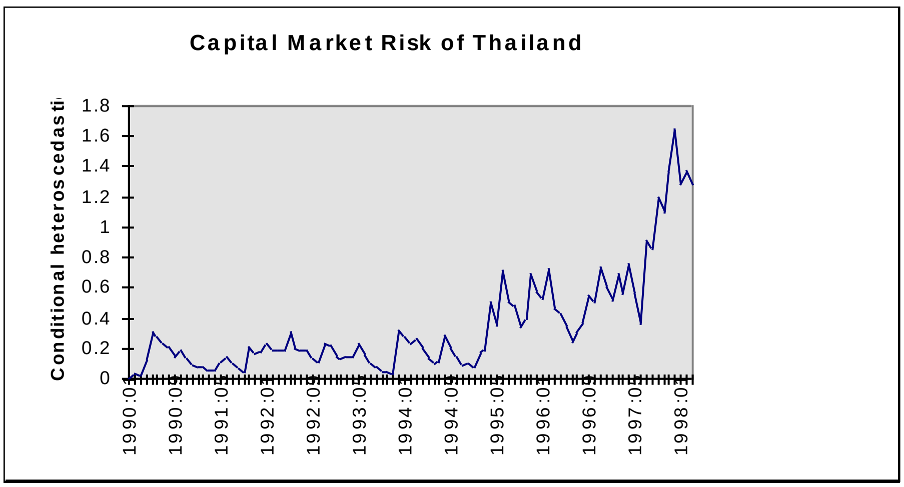
THE SHORT-RUN IMPACT OF INTEREST- AND EXCHANGE-RATE SHOCKS ON CAPITAL-MARKET RISK

In this section, we use the definition of capital-market risk used in Min (1998) and we connect the concept of dynamic capital mobility with capital-market risk as measured by conditional heteroscedasticity. Conditional heteroscedasticity has been used as a measurement of risk in various studies (see, e.g., Domowitz and Hakkio, 1985; Hassapis, 1995; and Malliaropulos, 1997). Both country and currency risk are often defined relative to an international reference country or currency, with the differential country risk of the others allowed to include actuarial compensation for losses expected from political instability, payments delays, and partial expropriation or default (see Furstenberg, 1998). The estimated capital-market risk for each of the four Asian crisis countries is presented in Figure 2.[7]

Figure 2: Capital-Market Risk of Indonesia and Korea



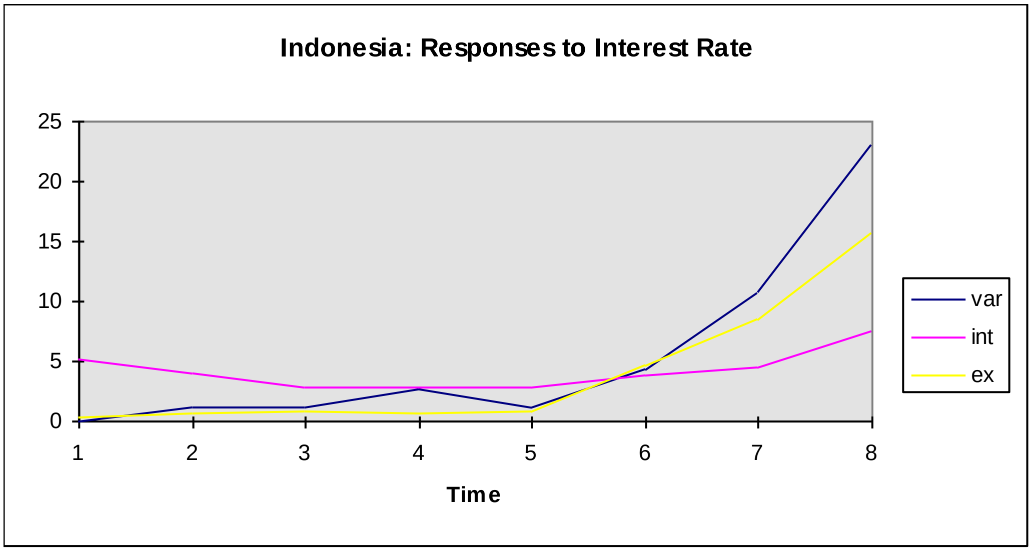




Indonesia

An optimal lag length of four periods is used for estimation. This is because a lag length of 4 is not a restriction on lag length 5, but a lag length of 3 is binding on a lag length of 4, i.e., probability [Chi-squared (lag 5 vs lag 4)=9.65] is 0.205 and the probability [Chi-squared (lag 5 vs lag 4)=143.8] is 0.000. The ordering of variables in the VAR model is based on the block causality test reported in the note at the bottom of Table 3. Block causality tests show that the interest rates causes the exchange rate and itself; the exchange rate causes the interest rate, capital-market risk, and itself; and capital-market risk causes the interest rate, the exchange rate, and itself. So the ordering of the interest rate, exchange rate, and capital- market risk is employed. Various other orderings were tried out, but the results were not substantially different.

Figure 3-2: Indonesia: Impulse Response Function of Capital-Market Risk



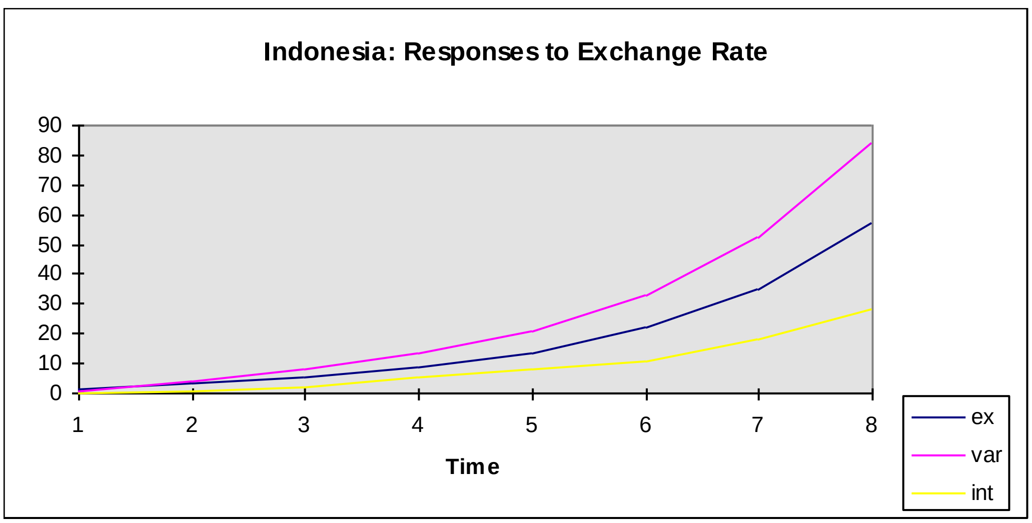


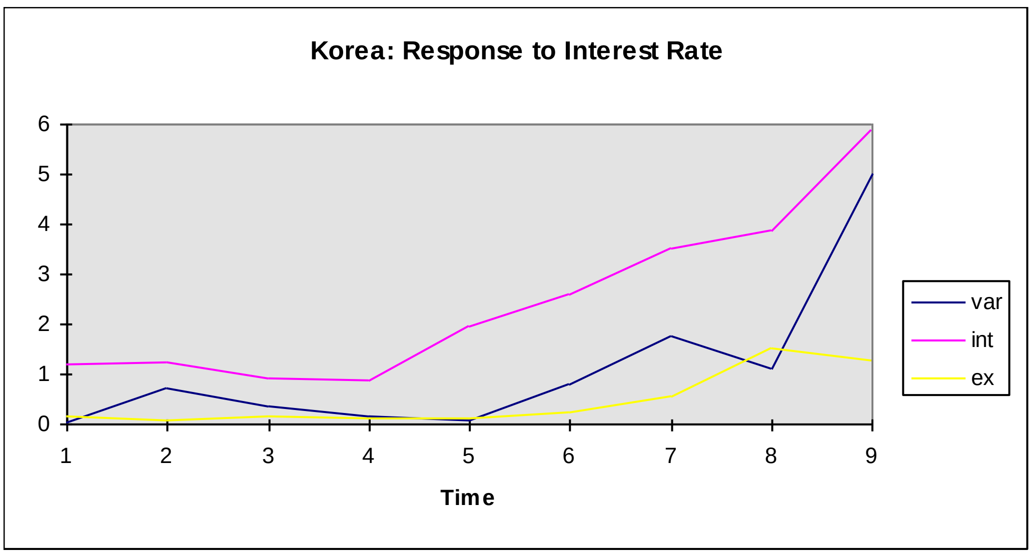
Figure 3-2 shows the impulse response function for Indonesia. A one-standard- deviation shock of the exchange rate (devaluation) increases capital-market risk measured by the conditional heteroscedasticity. We can see that a one-standard-deviation shock of the exchange rate increases capital-market risk in the short run (one to six months) by a small margin, whereas the exchange-rate impact is quite large in the long run (up to 24 months. If we look at the one-standard-deviation shock of the interest rate to capital- market risk, we can see that the response of capital-market risk (i.e., capital outflow) is increasing continuously throughout the period with little volatility in the short run. Consequently, an interest-rate shock destabilizes the capital market. From Figure 2 we can see that capital-market risk has increased two-fold after exchange rates became more flexible and interest rates increased.

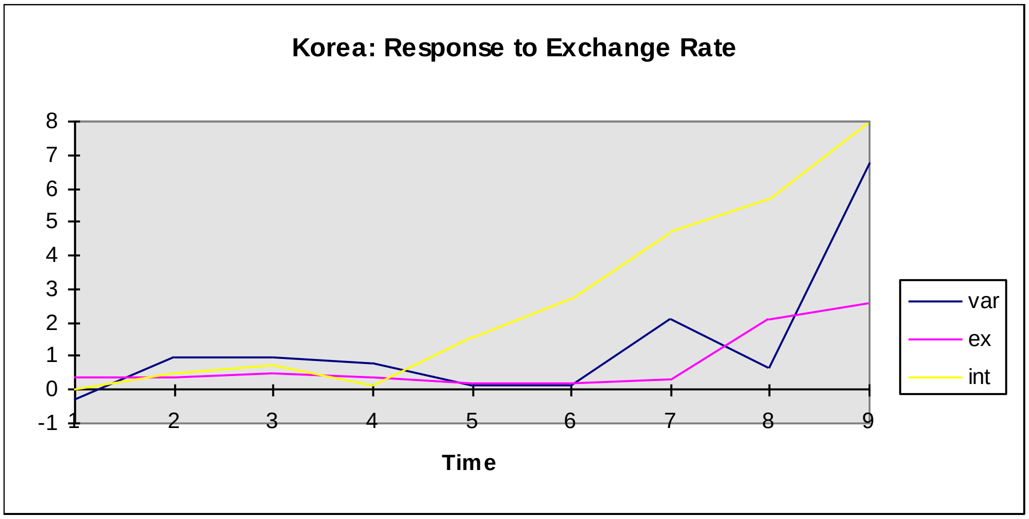
Table 3 shows the forecast error variance decomposition of capital-market risk. It is clear that exchange rates are playing the dominant role for the fluctuation of capital- market risk throughout the period of study. The policy implication of this finding is that, during the crisis the foreign-exchange market was in fundamental disequilibrium and the sudden floatation of exchange rates (see Table 2) increased the uncertainty in Indonesia's foreign-exchange market. The exchange-rate shock, from two months on, explains more than 80 percent of the forecast error variance of the capital-market risk. This accelerated the destabilizing impact of exchange-rate floatation in Indonesia. Figure 2 confirms this sharp increase in capital-market risk in Indonesia.

Korea

An optimal lag length of three periods is used for the estimation. Because a lag length of 3 is not a restriction on lag length 4, whereas a lag length of 2 is binding on a lag length of 3, i.e., the probability [Chi-squared (lag 4 vs lag 3)=15.41] is 0.08 and the probability [Chi-squared (lag 3 vs lag 2)=22.87] is 0.006. The ordering of variables in the VAR model is based on the block causality test reported in the note at the bottom of Table 4. Block causality tests show that the interest rate causes the exchange rate and itself; the exchange rate causes capital-market risk and itself; and capital-market risk causes the exchange rate and itself. So, the appropriate ordering is to have the interest rate followed by the exchange rate and capital-market risk. Different orderings were also tried, but the results were very similar.

Figure 4-2: Korea: Impulse Response Function of Capital-Market Risk





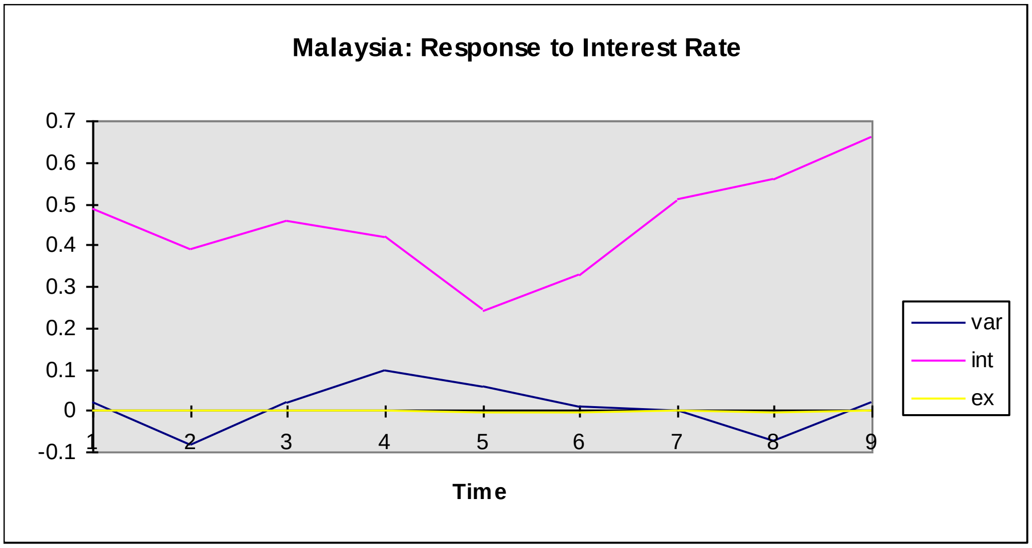
The impulse response of capital-market risk is shown in Figure 4-2. We can see that an exchange-rate shock has a positive impact on Korea's capital-market risk and its impact increases as time passes. An interest-rate shock has a similar effect on Korea's capital market; however, its six-month impact is contained within a one-standard deviation band.

Table 4 shows the variance decomposition for Korea. In the short and long runs an exchange-rate shock has about a 55 percent greater impact than an interest-rate shock on Korea's capital-market risk. This is shown in Figure 2.

Malaysia

An optimal lag length of seven periods is used for estimation. Since a lag length of 7 is not a restriction on lag length 8, but a lag length of 6 is binding on a lag length of 7, i.e., the probability [Chi-squared (lag 8 vs lag 7) =13.86] is 0.12 and the probability [Chi-squared (lag 7 vs lag 6)=24.14]= 0.004. The ordering of variables in the VAR model is based on the block causality test reported in the note of Table 5. Block causality tests show that the exchange rate causes the interest rate and itself; the interest rate causes itself; and capital- market risk causes the interest rate and itself. So, the ordering of capital-market risk, interest rate, and exchange rate is used. Different orderings were also used, but the results did not change substantially.

Figure 5-2: Malaysia: Impulse Response Function of Capital-Market Risk



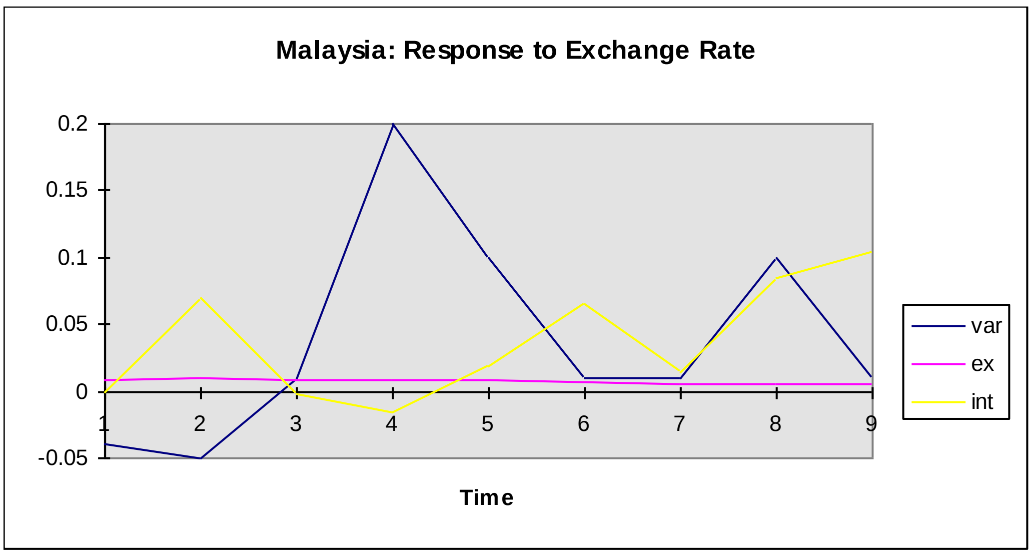


Figure 5-2 shows the impulse response function of Malaysia with a one-standard- deviation shock of the interest and exchange rates on capital-market risk. An exchange-rate shock increases the capital-market risk in the short run (up to 6 months). The interest-rate shock also increases the capital-market risk. Both shocks contributed to the increase of capital-market risk in the short run. Figure 2 confirms that Malaysia's capital-market risk increased over the period under study.

Table 5 shows the variance decomposition of Malaysia's capital-market risk. The exchange rate has a dominating impact on capital-market risk up to eight months, thereafter the interest-rate shock dominates. Since both shocks affect the capital-market risk in the same way, capital-market risk increases in the short run as indicated in Figure 2.

Thailand

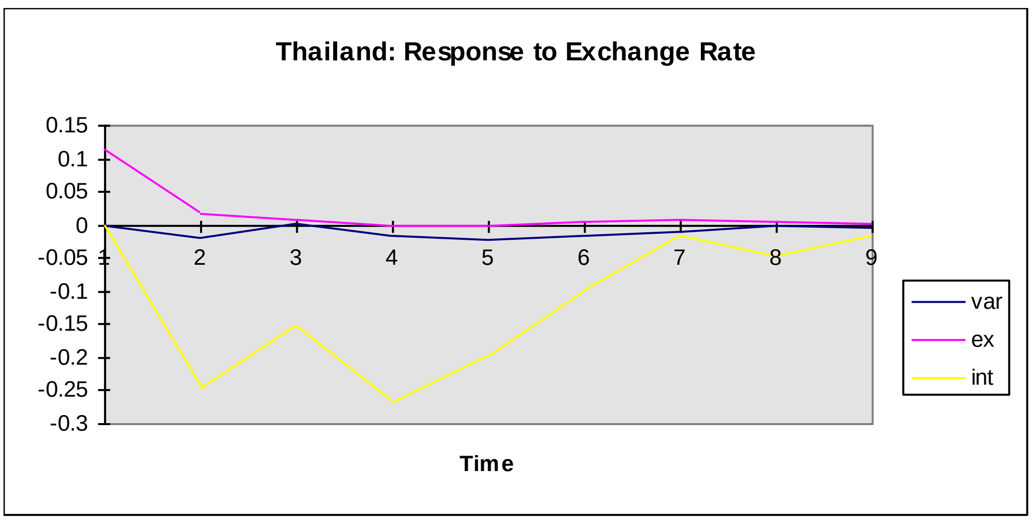
An optimal lag length of one is used for estimation. Since a lag length of 1 is not a restriction on lag length 2, but a lag length of 0 is binding on a lag length of 1, i.e., the probability [Chi-squared (lag 2 vs lag 1)=15.7] is 0.073 and the probability [Chi-squared (lag 1 vs lag 0)=1460.6] is 0.000. The ordering of variables in the VAR model is based on the block causality test reported in the note at the bottom of Table 6. Block causality tests show that the interest rate causes itself; the exchange rate causes itself; whereas capital-market risk causes the interest rate and itself. So, the ordering of capital-market risk, interest rate, and exchange rate is used. Different orderings were tried out, but the results were very similar to those presented below.

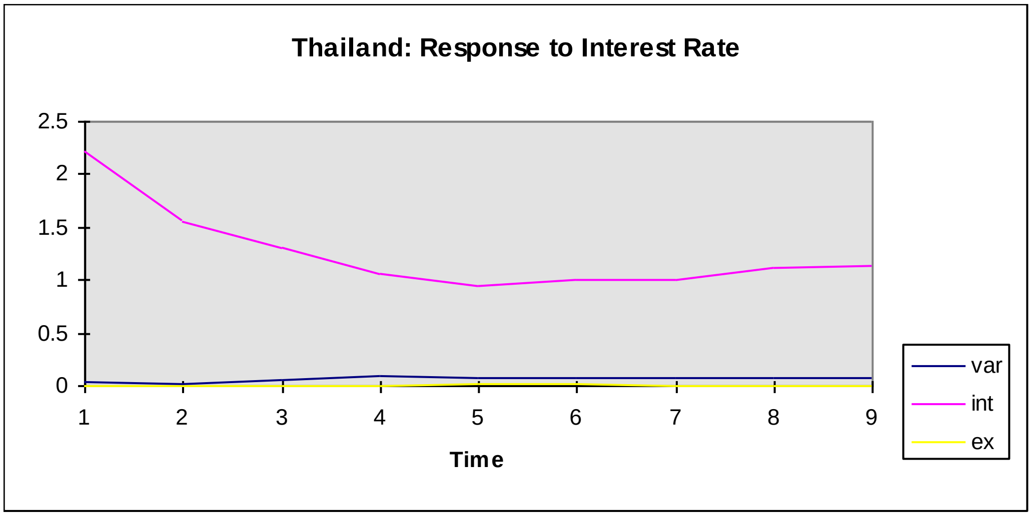
From the three-variable vector-autoregression model, the impulse response of capital-market risk to a one-standard-deviation exchange-rate shock is plotted in Figure 6-2.

In the short run (up to 8 months) an exchange-rate shock has a small, negative impact on the capital-market risk of Thailand. However, when we consider a one-standard-deviation band for the impulse response line, we can conclude that the effect of a one-standard-deviation exchange-rate shock on capital-market risk is uncertain. Figure 6-2 also indicates that a one-standard-deviation interest-rate shock increases capital-market risk by a small magnitude.

Table 6 shows the variance decomposition of the capital-market risk for Thailand. An interest-rate shock has a dominating impact on the capital-market risk. Therefore, capital-market risk in Thailand has increased. Figure 2 confirms this result.

Figure 6-2: Thailand: Impulse Response Function of Capital-Market Risk





POLICY IMPLICATIONS AND CONCLUDING REMARKS

This study has investigated the short-run impact of the Asian crisis countries' policy response (increases in interest rates and exchange-rate flexibility) in the presence of very *thin* foreign-exchange markets on their capital-market risk and dynamic capital mobility. A summary table, Table 7, indicates that in response to a one-standard-deviation shock to interest and exchange rates, dynamic capital mobility has decreased in all countries studied. In addition, capital-market risk has increased in each of the crisis countries.

In sum, we can conclude that the short-run interest-rate increases and exchange-rate floatations were not successful in keeping foreign investors' capital in the crisis countries where foreign-exchange markets are very *thin* even compared with Mexico. This may have been because recent experience also indicates that a large depreciation may actually cause capital outflows as it creates the fear that the local currency may soon no longer be convertible into dollars or Western European money (Global Investing News, 1998).

According to Table 7, Indonesia, Korea, Malaysia, and Thailand experienced increased capital-market risk and decreased capital mobility. An implication of this study is that foreign investors' behavior -- their (self-fulfilling) expectations and their "herding"[8] -- had a much greater effect on the foreign-exchange market than did the crisis countries' policy response of interest-rate increases and exchange-rate flexibility. This is partially attributable to the thinness of foreign exchange markets. Consequently, capital outflows could not be stopped in the short-run, the period under study.

The Asian crisis countries' policy responses of tight money and increased exchange-rate flexibility may not be effective in controlling capital outflows if there is a fundamental disequilibrium in the foreign-exchange market in the crisis countries.[9] It is interesting to note that much of the skepticism and nervousness of foreign investors that led to massive capital outflows has been attributed to the disclosure of information about these countries' economies, business practices, and corporate structures (especially the weakness of financial sectors). However, much of this information about structure and business practices was available before the crisis broke out and was largely ignored.[10] What led to this information suddenly becoming a catalyst for capital flight?

It is hoped that future research on the herding behavior of investors during the Asian crisis will explain the circumstances under which known information is suddenly acted upon.[11] This will help to clarify how financial crises in emerging economies are transmitted and allow for regulations to be designed that could more directly counter the destabilizing herding behavior of financial investors.

Table 7: Impact Of Interest- And Exchange-Rate Shocks On Capital Market

Country	Capital-Market Risk	Capital Mobility
Indonesia	+ [1)]	- [2)]
Thailand	+	-
Malaysia	+	-
Korea	+	-

Note: 1) Increased, 2) Decreased

ACKOWLEDGEMENTS

An earlier version of this paper was prepared when the first author was an economist at the World Bank. We are grateful to Gerard Caprio, Robert Cull, Patrick Honohan, Aart Kraay, Jacques Loubert, and other seminar participants at the World Bank for their valuable comments but all remaining errors are our own.

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ENDNOTES

1. This "second kind of openness" refers to Asia's financial system being protected from outside competition.
2. See *The Economist* (1998b) for some of the practical difficulties and dangerous side effects of capital controls. See Krugman (1998) for his suggestions as to effective ways to control capital flight. See the IMF (1998c) for a good discussion of many capital mobility issues, including the IMF's role in the capital-account liberalization process.
3. It should be pointed out that the crisis would have been much greater had the Fund not intervened and provided much-needed liquidity. See Fischer (1998) for a discussion of some of the lessons that have been learned from this crisis.
4. The equation for DUIP, equation 6, also includes an expectational error for the future spot rate. We are indebted to A. Kraay for this point.
5. See Min et al (2003) for the identification and detailed estimation process.
6. The monthly trend of foreign investments in Korea during 1998 is given below in millions of U.S. dollars. The figures in parentheses denote the percentage rate of decrease compared to 1997 (Ministry of Finance and Economy, 1998).
7. January $130 (-85.1 percent); February $199 (-45.2 percent); March $243 (-72.6 percent); and April $567 (-63.8 percent).See Min (1998) for the details.

8. The provision of improved data and information on emerging economies to institutional investors would, in principle, help encourage sounder and more informed investor behavior and reduce the likelihood of subsequent large "corrections" from earlier excesses (IMF, 1998d).
9. Of course, other factors may have also interfered with the short-term success of these policies. These include the external economic environment and the fact that perhaps borrowing countries did not act quickly enough. See Fischer (1998) for more information.
10. Admittedly some information came to light that previously was not known (e.g., the bad debts of many banks that previously hadn't been disclosed, the borrowing of South Korea's private sector, or the reserves of Thai banks). However, much information was known far in advance of the crisis and yet investors chose -- until the crisis -- to ignore it. This previously ignored information included lax banking regulations, weak management, corruption, and "cronyism," the habit of lending to connected firms regardless of the risk. See *The Economist* (1998a)
11. As Richard Cooper points out, however rational this herd behavior might be, it is also myopic and does not necessarily optimize the use of real capital. See the IMF (1998c).