Exchange Rate Regimes in East Asia After the Crisis: Implications from Intra-Daily Data

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The purpose of this paper is to investigate what affected the post-crisis exchange rates of five East Asian countries: Singapore, Thailand, Korea, Taiwan, and Malaysia. Based on intra-daily observations, we examine how and when these five East Asian currencies changed their correlations with the U.S. dollar and the Japanese yen. During the time zones when East Asian markets were closed, the East Asian currencies kept strong correlations with the U.S. dollar throughout the pos-crisis period. We, however, find structural breaks in the correlations during the time zones when East Asian markets were open. In the post-crisis period, the first structural break arose when Malaysia adopted the fixed exchange rate. The second structural break occurred when Indonesia and Thailand introduced inflation targeting. The structural breaks suggest strong monetary and real linkage among East Asian countries. After early 2000, the East Asian currencies increased correlations with the U.S. dollar and began reverting back to de facto pegs against the U.S. dollar in terms of their growth rates.

Keywords: Exchange rates, East Asia, Intra-daily data

JEL Classification: F31, F33, F36

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[**Seoul Journal of Economics** 2003, Vol. 16, No. 2]

I. Introduction

Since the onset of the Asian crisis, what characterizes the East Asian exchange rates has been a topic of considerable discussion. In the pre-crisis period, it was fairly evident that currencies of most East Asian economies maintained de facto pegs to the U.S. dollar. Among the East Asian economies, Hong Kong was the only East Asian economy that adopted the fixed exchange rate regime backed by a currency board arrangement. It was, however, well known that currencies in the other East Asian economies had maintained highly stable values against the U.S. dollar since the mid-1980s (see, for example, Frankel and Wei (1994), Goldberg and Klein (1997), and Ogawa (2001)).[1]

The de facto pegs to the U.S. dollar sometimes destabilized the real "effective" exchange rates of these currencies in the pre-crisis period. In particular, as the Japanese yen depreciated against the U.S. dollar from April 1995 to the summer of 1997, appreciation of the real "effective" exchange rates reduced the export competitiveness and increased current account deficits in the East Asian economies (see, for example, Corsetti, Pesenti, and Roubini (1999), and Ito, Ogawa, and Sasaki (1998)). Several economists have, thus, proposed the desirability of intermediate exchange rate regimes in East Asia that might stabilize their effective exchange rates (see, for example, Benassy-Quere (1999), Williamson (1999, 2000), Rajan (2002)). The bipolar or two-corner solution view of exchange rates, in contrast, states that intermediate policy regimes between hard pegs and floating are not sustainable (see, for example, Fischer (2001)).[2] The post-crisis experience in East Asia taught us that the road to the intermediate exchange rate regimes in the region would be pretty hard.[3]

[1]Takagi (1999) is an exceptional study that found some significant correlations between the East Asian currencies and the Japanese yen during this period.

[2]Fischer, however, argued that the proponents of the bipolar view have probably exaggerated their point. Frankel (1999) discussed that no single currency regime is right for all countries or at all times.

[3]Bayoumi, Eichengreen, and Mauro (2000, 2001) showed that on economic criteria, ASEAN appears less suited for a regional currency arrangement than Europe before the Maastricht Treaty, although the difference is not large.

TABLE 1

OFFICIAL EXCHANGE RATE REGIMES IN THE EAST ASIAN COUNTRIES

Country	Periods	Official Exchange Rate Regimes
Indonesia	November 1978-June 1997	Managed Floating
	July 1997-December 2000	Independently Floating
Korea	March 1980-October 1997	Managed Floating
	November 1997-December 2000	Independently Floating
Malaysia	January 1986-February 1990	Limited Floating
	March 1990-November 1992	Fixed
	December 1992-September 1998	Managed Floating
	September 1998-December 2000	Pegged Arrangement
The Philippines	January 1988-December 2000	Independently Floating
Thailand	January 1970-June 1997	Fixed
	July 1997-December 2000	Independently Floating

Source: International Financial Statistics (Various Issues).

In the post-crisis period, Hong Kong kept its currency board arrangement and the Chinese yuan virtually maintained its peg to the U.S. dollar. After experiencing some transitional regime, Malaysia started pegging to the U.S. dollar on September 1st 1998. In contrast, Thailand, Indonesia, and Korea as well as the Philippines and Taiwan have adopted managed float since the crisis (see Table 1). After going through steep devaluations and high volatility in 1997-8, their currencies have mostly stabilized over the past few years. Hernandez and Montiel (2001) have suggested that they are now allowed to float more at low frequencies than before 1997-8. Some other observers, however, have argued that the so-called floating exchange regimes of the countries are not really floating when we look at high-frequency day-to-day observations (Kawai and Akiyama 2000; McKinnon 2001; and McKinnon and Schnabl 2002). In particular, using a regression framework from Frankel and Wei (1994), they interpreted that the East Asian currencies were reverting back to de facto pegs against the U.S. dollar.[4]

[4]Calvo and Reinhart (2002) found that many emerging market countries that say they allow their exchange rate to float mostly do not.

The purpose of this paper is to investigate what affected the post-crisis exchange rates of five East Asian countries: Singapore, Thailand, Korea, Taiwan, and Malaysia. During the crisis, several East Asian countries shifted their exchange rate regimes from de facto U.S. Dollar pegs to managed float. In the following post-crisis period, the East Asian countries except for Malaysia had no institutional switch of exchange rate regimes. It is thus far from clear why the East Asian currencies reverted back to de facto pegs against the U.S. dollar in the late 1990s. Based on intra-daily observations, we examine how and when these five East Asian currencies changed their correlations with the U.S. dollar and the Japanese yen. During the time zones when East Asian (and European) markets were closed, we find that the East Asian currencies kept strong correlations with the U.S. dollar throughout the post-crisis period. We, however, find structural breaks in the correlations during the time zones when East Asian markets are open. In the post-crisis period, the first structural break arose when Malaysia adopted the fixed exchange rate on September 1st 1998. The second structural break occurred when Indonesia and Thailand adopted inflation targeting in early 2000.

During the time zones when East Asian markets were open, several East Asian currencies, particularly those of ASEAN, temporarily increased correlations with the Japanese yen in the post-crisis period. The increased correlations were conspicuous before September 1st 1998. However, after Malaysia adopted the fixed exchange rate, the East Asian currencies, particularly the Singapore dollar and the Thai baht, increased correlations with the U.S. dollar. After early 2000, most of the East Asian currencies increased correlations with the U.S. dollar and began reverting back to de facto pegs against the U.S. dollar even during the time zones when East Asian markets are open.

Korea started inflation targeting in September 1998. However, inflation targeting in Korea was not binding when Korean economy experienced unexpectedly dramatic recovery. It was early 2000 when inflation targeting became binding for Korean monetary policy. In contrast, inflation targeting was binding in Indonesia and Thailand soon after its introduction. It is therefore highly possible that there was a structural break of monetary policy in Indonesia, Thailand, and Korea in early 2000. Since the share of imports in consumption goods is large in these open economies, the structural

break of monetary policy might have affected their exchange rate policies. In particular, since the U.S. dollar has been dominant in invoice currencies in their imports (see, for example, Fukuda (1995)), the introduction of inflation targeting might have increased their incentives to stabilize their exchange rates against the U.S. dollar.

A noteworthy implication from our empirical results is that a regime switch in an East Asian country had an enormously large impact on the exchange rates of other East Asian countries that had no regime switch. This probably reflects the fact that economic linkage among East Asian countries is tight in monetary and real transactions. A regime switch in a country had a strong impact on its neighboring economies and that the affected economies had another impacts on their neighboring economies. Our empirical studies support this view and suggest that the exchange rate linkage was very important to see why the post-crisis East Asian countries had a tendency reverting back to de facto pegs against the U.S. dollar.

The paper proceeds as follows. Section II theoretically considers how exchange rates can be linked in East Asia. After explaining the method of estimations and the data in section III, section IV investigates how large impacts the regime switches in some East Asian country had on the post-crisis exchange regimes in East Asian countries. Sections V and VI provide formal tests to explore the existence of structural breaks. Section VII examines how volatility of exchange rates changed in the post-crisis period. After providing alternative interpretations in section VIII, section IX summarizes our main results and refers to their implications.

II. Linkages of the Exchange Rates in East Asia: An Example

In order to understand the interdependence of exchange rates in East Asian economies, this section theoretically considers an exchange rate that is determined by the weighted average of exchange rates of major trade partners. The Singapore dollar under a currency basket regime is a particular example for such an exchange rate. For analytical simplicity, we suppose that the Singapore dollar is determined by a basket of the U.S. dollar, the Japanese yen, and the Malaysia ringgit. All of the exchange rates

are denominated by a common numeraire currency such as the Swiss Franc. Denoting the nominal exchange rates of the U.S. dollar, the Japanese yen, the Singapore dollar, and the Malaysia ringgit by USD_t, JPY_t, SD_t, and MR_t respectively, the growth rate of Singapore dollar is written as

$$\Delta SD_t = a_1 \cdot \Delta USD_t + a_2 \cdot \Delta JPY_t + a_3 \cdot \Delta MR_t + \varepsilon_t, \tag{1}$$

where ΔE_t is the growth rate of an exchange rate E_t (E=*USD*, *JPY*, *SD*, and *MR*), and ε_t is a disturbance term.

If the growth rate of the Malaysia ringgit (ΔMR_t) is determined by

$$\Delta MR_t = b_1 \cdot \Delta USD_t + b_2 \cdot \Delta JPY_t + b_3 \cdot \Delta SD_t + \eta_t, \tag{2}$$

where η_t is a disturbance term, equations (1) and (2) lead to

$$\Delta SD_t = \frac{a_1 + a_3 \cdot b_1}{1 - a_3 \cdot b_3} \Delta USD_t + \frac{a_2 + a_3 \cdot b_2}{1 - a_3 \cdot b_3} \Delta JPY_t + \nu_t \tag{3}$$

$$\Delta MR_t = \frac{b_1 + a_1 \cdot b_3}{1 - a_3 \cdot b_3} \Delta USD_t + \frac{b_2 + a_2 \cdot b_3}{1 - a_3 \cdot b_3} \Delta JPY_t + \zeta_t \tag{4}$$

where $\nu_t \equiv (\varepsilon_t + a_3 \cdot \eta_t)/(1 - a_3 \cdot b_3)$ and $\zeta_t \equiv (b_3 \cdot \varepsilon_t + \eta_t)/(1 - a_3 \cdot b_3)$.

To the extent that ε_t and η_t are independent of ΔUSD_t and ΔJPY_t, equation (3) indicates that how the Singapore dollar is correlated with the U.S. dollar and with the Japanese yen depends not only the basket weights of the Singapore dollar in (1) but also on the basket weights of the Malaysia ringgit in (2). Thus, even if Singapore keeps its basket weights constant, the regime switch of the Malaysian exchange rate policy can have a significant impact on the Singapore dollar, particular when a_3 is large.

For example, suppose that the basket weights of the Singapore dollar are based on trade weights among five major trade partners. Then, noting that the Hong Kong dollar is fixed to the U.S. dollar, Singapore's trade weights in 1997 imply that $a_1 = 0.4131$, $a_2 = 0.2205$, and $a_3 = 0.2871$.[5] Therefore, when the weights of the

[5]The weights we use the following calculations are based on IMF, Direction of Trade Statistics, various issues.

TABLE 2

THEORETICAL WEIGHTS OF THE EXCHANGE RATES BASED ON TRADE WEIGHTS

(1) Theoretical weights before August 31, 1998

	Malaysia ringit	Singapore dollar
US dollar	0.443	0.540
Yen	0.376	0.328

(2) Theoretical weights after September 1, 1998
: The Case of the Singapore dollar

	case 1	case 2	case 3
US dollar	0.700	0.719	0.705
Yen	0.221	0.205	0.213

Notes: 1) The theoretical weights in (1) were calculated based on trade weights in 1997.
2) After September 1st 1998, the theoretical weights in cases 1, 2, and 3 were calculated based on the trade weights in 1997, 1998, and 1999 respectively.

Malaysia ringgit are also based on the trade weights among five major trade partners in 1997, that is, $b_1=0.2896$, $b_2=0.2830$, and $b_3=0.2833$, equations (3) and (4) lead to theoretical correlations in Table 1.[6] They indicate that both the Malaysia ringgit and the Singapore dollar have slightly larger correlation with the U.S. dollar than with the Japanese yen. The weights of the Japanese yen, however, amount to more than 0.3 in both currencies before Malaysia adopted the fixed exchange rate.

In contrast, when the Malaysia ringgit is fixed to the U.S. dollar, it holds that $\Delta MR_t=\Delta USD_t$, that is, $b_1=1$, and $b_2=b_3=0$. Substituting the trade weights in 1997, 1998, and 1999 into a_1, a_2, and a_3 respectively, we obtain Table 2. The table summarizes theoretical correlations of the Singapore dollar with the U.S. dollar and the Japanese yen after Malaysia adopted the fixed exchange rate.

Comparing the theoretical correlations in Table 2 with those in Table 1, the weight of the U.S. dollar rose from 0.54 to 0.7, while

[6]The values of a_1 and b_1 are calculated by the sum of the trade weights to the U.S.A and those to Hong Kong.

the weight of the Japanese yen declined from 0.328 to 0.2. This implies that the switch of the Malaysian exchange rate regime had significant impacts on the theoretical correlations of the Singapore dollar. It is noteworthy that these changes occurred even if Singapore did not switch its exchange rate regime. These changes are attributable to the high degree of interdependence between the Singapore dollar and the Malaysia ringgit.

III. The Estimation Method and Data

In order to investigate the determinants of exchange rates in the East Asian countries, we use the method of Frankel-Wei to estimate the weights of the U.S. dollar and the Japanese yen before and after the crisis. In this approach, an independent currency is chosen as an arbitrary numeraire for measuring the exchange variation. The goal here is to estimate the weight a currency assigns to another currency on a given frequency. Suppose that X_t^j is the exchange rate of an East Asian country j, where $j=$ Singapore, Malaysia, Thailand, Korea, and Taiwan. Suppose also that USD_t is the U.S. dollar and that JPY_t is the Japanese yen. The estimated model, where the local currency's value against the independent numeraire currency is regressed against the major world currencies, is then

$$\Delta X_t^j = \text{constant term} + a_1 \cdot \Delta USD_t + a_2 \cdot \Delta JPY_t, \tag{5}$$

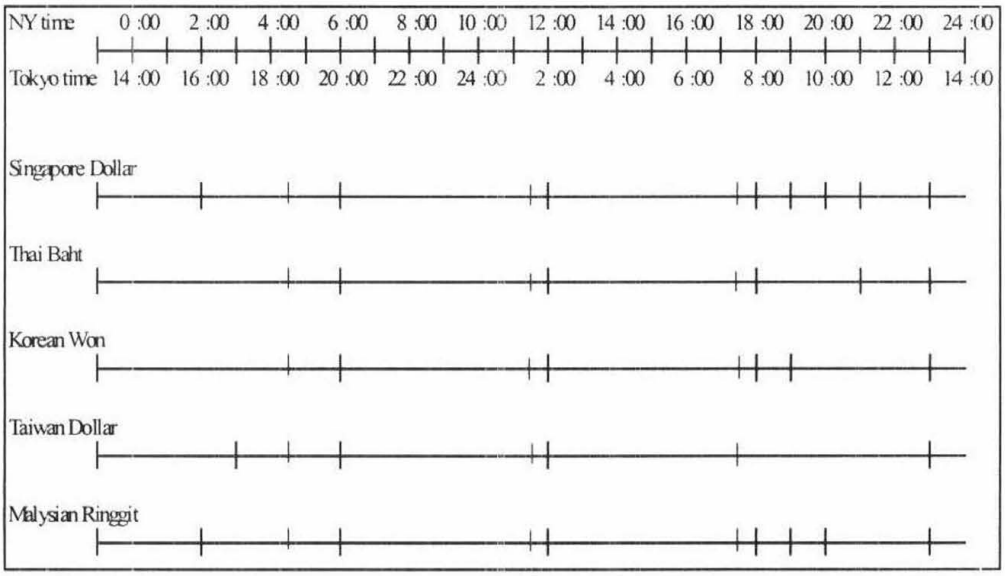
where ΔX_t^j is the growth rate of X_t^j. A heteroskedasticity and autocorrelation consistent covariance matrix is calculated by the method of Newey and West (1987). In several preliminary estimations, we included the Sterling pound in equation (5) as an additional explanatory variable. However, the estimated coefficients of the Sterling pound were not significantly positive in most cases and, if positive, were very small, without changing the other estimated coefficients.[7] We therefore use only ΔUSD_t and ΔJPY_t as explanatory variables in the following analysis.

[7]The result is consistent with findings in previous literature that showed no significant impact of Mark or Euro in similar regressions.

TABLE 3

NEW YORK AND TOKYO TIMES IN WHICH OUR INTRA-DAILY DATA IS AVAILABLE

New York Time	Tokyo Time
18:00	8:00
19:00	9:00
20:00	10:00
21:00	11:00
23:00	13:00
2:00	16:00
3:00	17:00
4:30	18:30
6:00	20:00
11:30	1:30
12:00	2:00
17:30	7:30
18:00	8:00



The data of each currency's exchange rate is the intra-daily data. The data set was downloaded from Datastream. For missing data, we supplemented it with the data set in Bloomberg. Table 3 summarizes what time our intra-daily data is available in Tokyo time and in New York time. Depending on the availability, the span of each time zone varies from 0.5 to 6 hours. However, except for

the Taiwan dollar, we can classify the exchange rate movements of each business day into those when East Asian markets are open, those when European markets are open, and those when both East Asian and European markets are closed. The classification provides us with useful information because local news is usually revealed when the market is open.

As in the previous studies, the following analysis will use the Swiss Franc as a numeraire. The Swiss Franc has a desirable property as a numeraire because it is widely transacted in international markets but has little linkage with the East Asian currencies. However, the choice of the numeraire might be arbitrary. In particular, when there is an idiosyncratic shock on the Swiss Franc, the exchange rates denominated by the Swiss Franc would show spurious correlations in equation (5). The spurious correlations are likely when European markets are open because news on the Swiss Franc tends to be revealed during the time zone. They are, however, less likely when European markets are closed.

We estimate equation (5) for each time zone in four alternative sample periods: (i) from January 7th 1997 to June 15th 1997, (ii) from February 1st 1998 to the end of August 1998, (iii) from the September 2nd 1998 to December 29th 1999, and (iv) from January 4th 2000 to September 5th 2002. The period (i) is the pre-crisis period. We choose this period in order to see whether the previous results during the pre-crisis period are still confirmed by our intra-daily data. We break the post-crisis period into (ii), (iii), and (iv). In the post-crisis period, two structural breaks are assumed to arise when Malaysia introduced the fixed exchange rate regime and when some East Asian countries introduced inflation targeting effectively.

The first break is a natural choice because the Malaysian regime shift was the only drastic switch of the exchange rate regime in the post-crisis East Asian countries. Before shifting to the fixed exchange rate regime, Malaysia was under managed float after the crisis. In particular, since early 1998, the Malaysian government had explored a new economic policy, including the stabilization policy of real effective exchange rates of the ringgit.[8] The

[8]For example, the National Economic Action Council (NEAC), which was established by Prime Minister Mahathir in December 1997, announced the

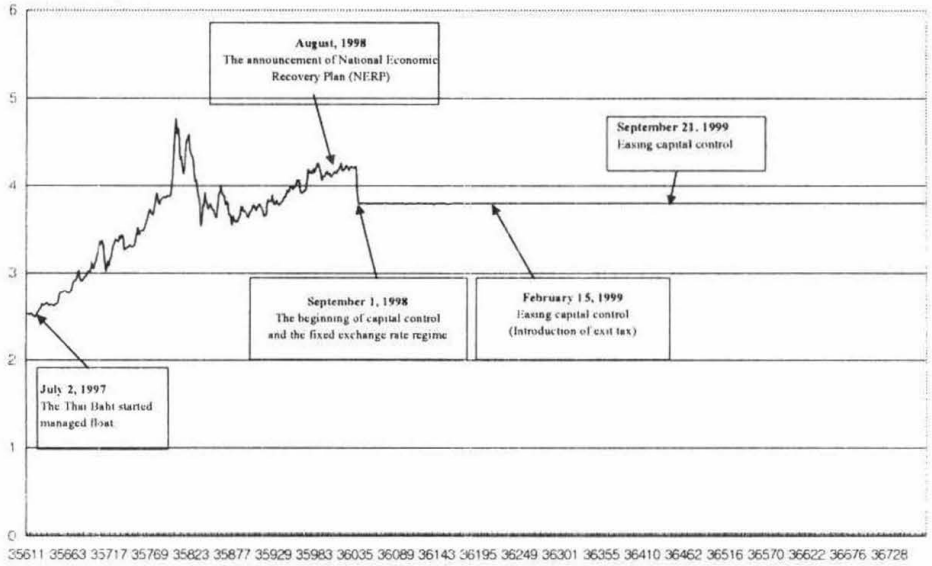


FIGURE 1
MOVEMENTS OF THE MALAYSIA RINGGIT AFTER THE CRISIS (RINGGIT/$)

introduction of the fixed exchange rate on September 1st 1998 was therefore a dramatic regime shift in Malaysia (see Figure 1). We start the estimation period of (ii) from the beginning of February 1998. This is because except for the Indonesian Rupiah, most of the East Asian countries almost stabilized the exchange rates after the end of January 1998.

The choice of the second structural break may be controversial. However, the regime shift in monetary policy can affect the exchange rate policy. In particular, when the share of imports in consumption goods is large, it is important to control exchange rates to achieve the inflation target. Among ASEAN countries, Indonesia announced inflation targeting at the beginning of 2000 and so did Thailand in May 2000. In the case of Korea, inflation targeting started in September 1998. However, inflation targeting in

National Economic Recovery Plan (NERP) in August 1998. The plan stressed the importance of stabilizing the real "effective" exchange rates and proposed the adoption of a trade weighted basket system as a desirable exchange rate regime. The plan was based on the idea that the de facto pegs to the U.S. dollar sometimes destabilized the real "effective" exchange rates.

Korea was not binding when Korean economy experienced unexpectedly dramatic recovery. It was early 2000 when inflation targeting became binding for Korean monetary policy. It is therefore highly possible that there was a structural break of monetary policy in Indonesia, Thailand, and Korea in early 2000.

In the following analysis, we investigate whether there were structural breaks in equation (5). In particular, we explore the existence of structural breaks not only in the country that had a regime shift in monetary policy but also in other countries that did not. The motivation is to see whether a regime switch in an East Asian country had a significant impact on the exchange rates of other East Asian countries that had no regime switch. If economic linkage among East Asian countries is tight in monetary and real transactions, a regime switch in a country would have a strong impact on its neighboring economies and that the affected economies would have another impact on their neighboring economies.

IV. The Estimation Results

A. From January 7th 1997 to June 15th 1997

We first estimated equation (5) for each available time zone in the sample period from January 7th 1997 to June 15th 1997. We made the estimations to see whether the previous results during the pre-crisis period are still confirmed by our intra-daily data. Table 4 summarizes the estimation results. Our estimations are different from previous studies not only in the data frequency but also in the sample period. The results, however, almost confirm previous ones that were estimated based on less frequency data such as daily, weakly, or monthly data.

In all countries, the estimated coefficient of the U.S. dollar was large and was close to one for almost all of the time zones. In contrast, the estimated coefficient of the Japanese yen was small for all of the time zones in all countries. In Thailand, Korea, and Taiwan, the coefficient of the Japanese yen was never significantly positive for any time zone. In Malaysia, it was not significantly positive except for a time zone. In the case of Singapore, it was significantly positive in several time zones. However, even in Singapore, the U.S. dollar had the dominant weight in the currency

TABLE 4

CORRELATIONS WITH THE U.S. DOLLAR AND THE JAPANESE YEN

: Pre-Asian Crisis

Sample period: January 4, 1997-Jun 15, 1997

① Singapore Dollar

NY time Tokyo time	(12:00-18:00) (2:00-8:00)	(18:00-19:00) (8:00-9:00)	(19:00-21:00) (9:00-11:00)	(21:00-23:00) (11:00-13:00)	(23:00-2:00) (13:00-16:00)	(2:00-4:30) (16:00-18:30)	(4:30-11:30) (18:30-1:30)	(11:30-12:00) (1:30-2:00)
Hours	6h	1h	2h	2h	3h	2.5h	7h	0.5h
Constant	0.000***	0.000	0.000***	0.000***	0.000	0.000	0.000	0.000***
US dollar	0.920***	0.970***	0.923***	0.852***	0.853***	0.662***	0.716***	0.977***
Japaness yen	0.035	0.068	0.108*	0.110***	0.069	0.227***	0.213***	-0.032
Adjusted R^2	0.949	0.891	0.688	0.748	0.786	0.735	0.893	0.973
D.W.	1.720	2.113	1.619	2.013	2.155	2.157	1.836	1.841

② Thai Baht

NY time Tokyo time	(12:00-18:00) (2:00-8:00)	(18:00-21:00) (8:00-11:00)	(21:00-4:30) (11:00-18:30)	(4:30-11:30) (18:30-1:30)	(11:30-12:00) (1:30-2:00)
Hours	6h	3h	7.5h	7h	0.5h
Constant	-0.001	-0.0002**	0.002*	0.001	-0.001
US dollar	1.156***	1.988*	1.382**	0.791***	0.003
Japaness yen	-0.102	-1.256	-0.568	-0.008	1.541
Adjusted R^2	0.637	0.106	0.103	0.182	0.125
D.W.	1.218	1.792	2.124	0.859	0.582

(Table Continued)

③ Korean Won

NY time Tokyo time	(12:00-18:00) (2:00-8:00)	(18:00-19:00) (8:00-9:00)	(19:00-4:30) (9:00-18:30)	(4:30-11:30) (18:30-1:30)	(11:30-12:00) (1:30-2:00)
Hours	6h	1h	9.5h	7h	0.5h
Constant	-0.002***	0.000	-0.007*	0.008*	0.003***
US dollar	0.902***	1.174***	0.741*	0.824*	1.007***
Japaness yen	0.030	0.083	0.238	-0.103	-0.157
Adjusted R^2	0.821	0.643	0.031	0.042	0.607
D.W.	2.011	1.672	0.127	0.148	1.937

④ Taiwan Dollar

NY time Tokyo time	(12:00-3:00) (2:00-17:00)	(2:00-4:30) (16:00-18:30)	(4:30-11:30) (18:30-1:30)	(11:30-12:00) (1:30-2:00)
Hours	13h	2.5h	7h	0.5h
Constant	0.000	0.000	0.000	0.001***
US dollar	0.840***	0.958***	0.925***	0.994***
Japaness yen	0.011	-0.020*	0.100	-0.021
Adjusted R^2	0.800	0.756	0.967	0.971
D.W.	1.935	2.042	1.952	1.983

(Table Continued)

⑤ Malaysian Ringgit

NY time Tokyo time	(12:00-18:00) (2:00-8:00)	(18:00-19:00) (8:00-9:00)	(19:00-23:00) (9:00-13:00)	(23:00-2:00) (13:00-16:00)	(2:00-4:30) (16:00-18:30)	(4:30-11:30) (18:30-1:30)	(11:30-12:00) (1:30-2:00)
Hours	6h	1h	4h	3h	2.5h	7h	0.5h
Constant	0.000	0.000	0.000	0.123***	0.000***	0.000	0.000***
US dollar	0.958***	1.176***	0.835***	0.135***	0.762***	0.770***	0.993***
Japaness yen	0.008	-0.028	-0.038	0.231	0.080	0.118	0.000
Adjusted R^2	0.961	0.774	0.540	0.170	0.678	0.900	0.986
D.W.	2.173	2.401	2.114	1.900	1.829	1.853	2.120

Note: ***, **, * indicate the significance at 1%, 5%, and 10% level, respectively.

basket of the Singapore dollar. In particular, the estimated coefficient of the U.S. dollar was much larger than the theoretical one that was calculated by the trade weights in Table 2. The results imply that the East Asian currencies were under *de facto* pegs against the U.S. dollar.

The adjusted R^2's of the estimated equations were large during most of the time zones in Singapore, Taiwan, and Malaysia. In contrast, in Korea, the adjusted R^2's were relatively large during the time zones between 11:30 and 19:00 in New York time (that is, 1:30-9:00 in Tokyo time) but were small during the other time zones. In Thailand, the adjusted R^2 was large during 12:00-18:00 in New York time (that is, 2:00-8:00 in Tokyo time) but it dropped down dramatically during the rest of the time zones. The results probably reflect the fact that the Thai baht and the Korean won had several modest devaluations in the first half of 1997 before experiencing devastating currency attacks.

B. From February 1st 1998 to the end of August 1998

We next estimated equation (5) for each available time zone in the post-crisis period before the Malaysian government shifted its exchange rate regime from managed float to the fix exchange rate. After the Thai crisis in July 1997, several East Asian countries experienced serious currency devaluations. During the crisis, the market values of the Malaysia ringgit, the Thai baht and the Korean won that moved to managed float had dropped to nearly half of the pre-crisis level until January 1998. It was after the end of January 1998 when these currencies were almost stabilized. We thus estimated equation (5) from February 1st 1998.

Table 5 summarizes the estimation results. Overall, compared with those in Table 4, the adjusted R^2's of the estimated equations in most of the time zones dropped down dramatically in all countries. This implies that the East Asian currencies increased their idiosyncratic flexibility after the crisis. The estimated coefficients, however, showed different characteristics depending on the time zones.

During the time zones when both East Asian and European markets were closed, most of the East Asian currencies kept strong correlations with the U.S. dollar. For example, the coefficients of the U.S. dollar in Singapore and in Malaysia exceeded one during

TABLE 5

CORRELATIONS WITH THE U.S. DOLLAR AND THE JAPANESE YEN
: Before Malaysia Pegged the Exchange Rate System

Sample period: February 1st, 1998-August 31, 1998

① Singapore Dollar

NY time Tokyo time	(12:00-17:30) (2:00-7:30)	(17:30-18:00) (7:30-8:00)	(18:00-19:00) (8:00-9:00)	(19:00-20:00) (9:00-10:00)	(20:00-21:00) (10:00-11:00)	(21:00-23:00) (11:00-13:00)	(23:00-2:00) (13:00-16:00)	(2:00-4:30) (16:00-18:30)	(4:30-6:00) (18:30-20:00)	(6:00-11:30) (20:00-1:30)	(11:30-12:00) (1:30-2:00)
Hours	5.5h	0.5h	1h	1h	1h	2h	3h	2.5h	1.5h	5.5h	0.5h
Constant	-0.0006**	-0.0001	0.0002	0.0004	-0.0009**	0.0004	-0.0018***	0.0025***	-0.0005***	0.0003	0.0003**
US dollar	1.0040***	1.5944***	1.1495***	0.2475	0.2289	0.0466	0.0304	-0.0043	0.1089**	0.1229**	0.0673**
Japaness yen	-0.1170	-0.1609	0.0797	0.6255	0.5741**	0.8012***	0.7084***	0.9493***	0.8029***	0.5918***	0.6201***
Adjusted R^2	0.2010	0.1131	0.2204	0.3404	0.4402	0.3612	0.2423	0.4257	0.7602	0.4554	0.3510
D.W.	2.2406	1.9483	1.5704	2.1359	1.8374	2.0088	2.0830	2.1541	1.9288	2.1193	1.9882

② Thai Baht

NY time Tokyo time	(12:00-17:30) (2:00-7:30)	(17:30-18:00) (7:30-8:00)	(18:00-21:00) (8:00-11:00)	(21:00-23:00) (11:00-13:00)	(23:00-4:30) (13:00-18:30)	(4:30-6:00) (18:30-20:00)	(6:00-11:30) (20:00-1:30)	(11:30-12:00) (1:30-2:00)
Hours	5.5h	0.5h	3h	2h	5.5h	1.5h	5.5h	0.5h
Constant	-0.0018***	-0.0006	-0.0040***	0.0031***	-0.0006	-0.0008*	0.0008	0.0018***
US dollar	1.5082***	0.4951	0.0935	0.2237*	0.1988**	0.1296*	0.1864**	0.1294*
Japaness yen	-0.2223	-0.1596	0.4133**	0.7839***	0.6653***	0.8127***	0.6754**	0.6281***
Adjusted R^2	0.1077	0.0029	0.0282	0.1045	0.1817	0.4509	0.1740	0.1882
D.W.	2.1704	2.0736	1.7296	1.8927	2.2179	1.9785	2.0212	1.7063

(Table Continued)

③ Korean Won

NY time Tokyo time	(12:00-18:00) (2:00-8:00)	(18:00-19:00) (8:00-9:00)	(19:00-23:00) (9:00-13:00)	(23:00-4:30) (13:00-18:30)	(4:30-6:00) (18:30-20:00)	(6:00-11:30) (20:00-1:30)	(11:30-12:00) (1:30-2:00)
Hours	6h	1h	4h	5.5h	1.5h	5.5h	0.5h
Constant	-0.0021***	0.0007	-0.0010	-0.0006	0.0005	0.0005***	0.0014***
US dollar	1.0427***	0.8933***	0.6989**	0.5426**	0.7727**	0.4087***	0.1163***
Japaness yen	-0.0928	-0.1162	0.1093	0.5413**	0.7834	0.1366**	0.4122***
Adjusted R^2	0.2080	0.0385	0.0471	0.1540	0.1267	0.4334	0.1119
D.W.	1.9444	1.7493	2.0705	1.8463	1.6292	1.9476	1.8608

④ Taiwan Dollar

NY time Tokyo time	(12:00-17:30) (2:00-7:30)	(17:30-23:00) (7:30-13:00)	(23:00-3:00) (13:00-17:00)	(3:00-4:30) (17:00-18:30)	(4:30-6:00) (18:30-20:00)	(6:00-11:30) (20:00-1:30)	(11:30-12:00) (1:30-2:00)
Hours	5.5h	5.5h	4h	1.5h	1.5h	5.5h	0.5h
Constant	-0.0041***	0.0026***	0.0063***	-0.0044***	-0.0006***	0.0007**	0.0009***
US dollar	0.7504**	0.2204*	0.1711	0.3805***	0.1555***	0.3726***	0.1121
Japaness yen	-0.0391	0.5387***	0.4268	0.3258***	0.7387***	0.1256**	0.2937
Adjusted R^2	0.1045	0.1727	0.1389	0.4947	0.7136	0.3952	0.0490
D.W.	1.4150	1.8915	1.9690	1.9285	1.9276	1.7897	1.6578

(Table Continued)

⑤ Malaysian Ringgit

NY time Tokyo time	(12:00-17:30) (2:00-7:30)	(17:30-18:00) (7:30-8:00)	(18:00-19:00) (8:00-9:00)	(19:00-20:00) (9:00-10:00)	(20:00-23:00) (10:00-13:00)	(23:00-2:00) (13:00-16:00)	(2:00-4:30) (16:00-18:30)	(4:30-6:00) (18:30-20:00)	(6:00-11:30) (20:00-1:30)	(11:30-12:00) (1:30-2:00)
Hours	5.5h	0.5h	1h	1h	3h	3h	2.5h	1.5h	5.5h	0.5h
Constant	-0.001	0.001	-0.001	0.000	0.001	-0.025	0.003***	-0.002***	0.002	0.001***
US dollar	1.029***	2.203**	1.817**	0.999*	0.167	-0.016	0.093	-0.002	-0.014	0.037
Japaness yen	0.018	-0.401	0.209	0.498**	0.489***	0.603***	0.850***	0.855***	0.774***	0.686***
Adjusted R^2	0.055	0.028	0.087	0.144	0.160	0.139	0.174	0.399	0.206	0.133
D.W.	1.838	2.024	1.990	2.275	1.891	1.826	2.210	1.697	2.028	2.204

Note: ***, **, * indicate the significance at 1%, 5%, and 10% level, respectively.

12:00-17:30, 17:30-18:00, and 18:00-19:00 in New York time (that is, 2:00-7:30, 7:30-8:00, and 8:00-9:00 in Tokyo time). The coefficient of the U.S. dollar exceeded one in Thailand and was close to one in Taiwan during 12:00-17:30 in New York time. In Korea, the coefficient of the U.S. dollar exceeded one during 12:00-18:00 in New York time.

In contrast, when East Asian markets were open, the coefficients of the Japanese yen exceeded those of the U.S. dollar during several time zones. For example, the coefficients of the Japanese yen exceeded those of the U.S. dollar in the Singapore dollar and in the Malaysia ringgit during all of the time zone between 10:00am and 8:00pm in Tokyo time (that is, between 20:00pm and 6:00am in New York time).[9] The coefficients of the Japanese yen exceeded those of the U.S. dollar in the Thai baht during all of the time zone between 8:00am and 2:00am in Tokyo time and in the Taiwan dollar during 7:30-13:00 and 18:30-20:00 in Tokyo time. Even in the Korean won, the coefficients of the Japanese yen were almost equal to those of the U.S. dollar during 13:00-18:30 and 18:30-20:00 in Tokyo time. The results indicate that the East Asian currencies increased the correlations with the Japanese yen after the crisis during the time zones when East Asian markets were open.

The above results have two noteworthy implications. One is that the structural break occurred even in Singapore and Taiwan. Compared with the other countries, Singapore and Taiwan experienced relatively modest currency devaluation during the crisis. These countries therefore did not have an explicit shift of the exchange regime after the crisis. Our results, however, suggest that the regime switches in other East Asian countries had a large impact on their exchange rates that had no regime switch.

The other is that the structural break was observed mostly when East Asian markets were open. In general, news from the U.S. markets, which may cause the fluctuations of the U.S. dollar, tends to be revealed when the U.S. markets are open. To the extent that the exchange rates are flexible, the impacts of the news from the U.S. markets on the East Asian currencies would thus be reflected

[9]The coefficients of the Japanese yen also exceeded those of the U.S. dollar in the Singapore dollar during 9:00-10:00, 20:00-1:30 and 1:00-2:00 in Tokyo time and the Malaysia ringgit during 1:30-2:00.

in the coefficient of the U.S. dollar during the time zones when the U.S. markets are open. In contrast, news from Japanese markets, which may cause the fluctuations of the Japanese yen, tends to be revealed when the Japanese markets are open. Therefore, the impacts of the news from Japanese markets on the East Asian currencies would be reflected in the coefficient of the Japanese yen during the time zones when Japanese markets are open. Our empirical results support this view, suggesting that the East Asian currencies increased their flexibility after the crisis.

C. From the September 2nd 1998 to December 29th 1999

On September 1st 1998, the Malaysian government suddenly changed its exchange rate to the fixed exchange rate. It was the only drastic switch of the exchange rate regime that occurred in the post-crisis East Asian countries. In this sub-section, we make estimations after the Malaysian government shifted its exchange rate regime. Since $\alpha_1 = 1$ and $\alpha_2 = 0$ in Malaysia after September 1998, we estimated equation (5) for each available time zone in Singapore, Thailand, Korea, and Taiwan. The motivation of the estimation is to investigate how the dramatic regime shift in Malaysia affected the exchange rates of these East Asian countries that had no explicit regime switch.

Table 6 summarizes the estimation results. During the time zones when East Asian and European markets were closed, the East Asian currencies had strong correlations with the U.S. dollar. The results are more robust than those in Table 5. In all of the four currencies, the coefficient of the U.S. dollar was close to one during 12:00-17:30 in New York time (that is, 2:00-7:30 in Tokyo time). Except for Taiwan where the relevant time zones are not available, it was also close to one during 17:30-18:00, and 18:00-19:00 in New York time (that is, 7:30-8:00, and 8:00-9:00 in Tokyo time).[10] In the case of Korea, the latter result was in marked contrast with those in Table 4 where the coefficient was not statistically different from zero during the time zones between noon and 6pm in New York time. Compared with those in Table 4, the adjusted R^2's were still lower than those in the pre-crisis period in all countries. However, compared with those in Table 5, we can see

[10]In Thailand, the latter time zone is 18:00-21:00 in New York time because of missing data.

TABLE 6

CORRELATIONS WITH THE U.S. DOLLAR AND THE JAPANESE YEN
: After Malaysia Pegged the Exchange Rate System

Sample period: September 2nd, 1998-December 29, 1999

① Singapore Dollar

NY time Tokyo time	(17:30-18:00) (7:30-8:00)	(18:00-19:00) (8:00-9:00)	(19:00-20:00) (9:00-10:00)	(20:00-21:00) (10:00-11:00)	(21:00-23:00) (11:00-13:00)	(23:00-2:00) (13:00-16:00)	(2:00-4:30) (16:00-18:30)	(4:30-6:00) (18:30-20:00)	(6:00-11:30) (20:00-1:30)	(11:30-12:00) (1:30-2:00)	(12:00-17:30) (2:00-7:30)
Hours	0.5h	1h	1h	1h	2h	3h	2.5h	1.5h	5.5h	0.5h	5.5h
Constant	0.0000	0.0001	0.0003**	-0.0001	-0.0003***	-0.0005***	0.0006**	-0.0003**	-0.0003	0.0002*	-0.0002**
US dollar	0.8068***	0.8823***	0.7923***	0.6694***	0.1482***	0.2236***	0.4812***	0.4323***	0.3546**	0.1486***	0.8538***
Japaness yen	0.1957***	0.0291	0.0750*	0.1462***	0.2727***	0.2546***	0.1902***	0.2076***	0.2876***	0.3689***	0.1499***
R^2	0.5321	0.6139	0.6939	0.7092	0.3424	0.4085	0.6055	0.5905	0.5795	0.3486	0.8425
D.W.	1.8882	1.7633	1.9551	2.0153	2.1367	1.4989	1.5231	1.9021	2.1123	1.8759	1.8358

② Thai Baht

NY time Tokyo time	(17:30-18:00) (7:30-8:00)	(18:00-21:00) (8:00-11:00)	(21:00-23:00) (11:00-13:00)	(23:00-4:30) (13:00-18:30)	(4:30-6:00) (18:30-20:00)	(6:00-11:30) (20:00-1:30)	(11:30-12:00) (1:30-2:00)	(12:00-17:30) (2:00-7:30)
Hours	0.5h	3h	2h	5.5h	1.5h	5.5h	0.5h	5.5h
Constant	0.0004**	-0.0012***	0.0009***	0.0002	-0.0005	0.0001	0.0010***	-0.0010***
US dollar	1.0777***	0.8610***	0.1705***	0.4135***	0.4243***	0.3751***	0.1263***	0.9125***
Japaness yen	0.0737	0.2132**	0.3704***	0.1840***	0.1934***	0.2625***	0.4045***	0.0495
R^2	0.3572	0.1829	0.1374	0.3318	0.3551	0.3848	0.1880	0.5557
D.W.	1.7841	1.8479	1.7499	1.7745	1.7089	1.7804	1.8982	1.9743

(Table Continued)

③ Korean Won

NY time Tokyo time	(17:30-18:00) (7:30-8:00)	(18:00-19:00) (8:00-9:00)	(19:00-23:00) (9:00-13:00)	(23:00-4:30) (13:00-18:30)	(4:30-6:00) (18:30-20:00)	(6:00-11:30) (20:00-1:30)	(11:30-12:00) (1:30-2:00)	(12:00-17:30) (2:00-7:30)
Hours	0.5h	1h	4h	5.5h	1.5h	5.5h	0.5h	5.5h
Constant	0.0001	0.0007***	-0.0007**	0.0007	-0.0006*	-0.0004***	0.0010***	-0.0014***
US dollar	0.9806***	1.3011***	0.3146***	0.4496***	0.4149***	0.4369***	0.2116***	0.9626***
Japaness yen	0.0104	-0.0435	0.2375***	0.1330**	0.1617**	0.1643***	0.2573***	0.0424
R^2	0.1914	0.4955	0.1940	0.2710	0.1912	0.5254	0.2556	0.6106
D.W.	1.2167	1.3653	1.4789	1.6395	1.7099	2.0624	1.7493	1.3676

④ Taiwan Dollar

NY time Tokyo time	(17:30-23:00) (7:30-13:00)	(23:00-3:00) (13:00-17:00)	(3:00-4:30) (17:00-18:30)	(4:30-6:00) (18:30-20:00)	(6:00-11:30) (20:00-1:30)	(11:30-12:00) (1:30-2:00)	(12:00-17:30) (2:00-7:30)
Hours	5.5h	4h	1.5h	1.5h	5.5h	0.5h	5.5h
Constant	-0.0001	0.0048***	-0.0024***	-0.0002	-0.0003**	0.0017***	-0.0022***
US dollar	0.2424***	0.1393***	0.5301***	0.4202***	0.4266***	0.2082***	0.0170***
Japaness yen	0.2076***	0.2172**	0.1585***	0.1666***	0.1904***	0.3235***	0.0097
R^2	0.2827	0.2013	0.5776	0.4667	0.5542	0.2601	0.7325
D.W.	1.6529	1.9953	1.8363	1.9109	2.1014	1.7407	1.5690

Note: ***, **, * indicate the significance at 1%, 5%, and 10% level, respectively.

that the adjusted R^2's became larger after the regime shift in Malaysia. This implies that the East Asian currencies reduced their idiosyncratic flexibility after the regime shift.

During the time zones when East Asian markets were open, the coefficients of the Japanese yen were still statistically different from zero. In addition, the coefficient of the Japanese yen exceeded that of the U.S. dollar during some of the time zones. However, compared with those in Table 4, the number of such time zones declined dramatically. For example, if we focus on the time zone between 8:00am and 8:00pm in Tokyo time, the coefficient of the Japanese yen exceeded that of the U.S. dollar only in two of seven zones in Singapore, in one of four zones in Thailand and Taiwan, and in none of four zones in Korea.[11] Even when the yen's coefficient was larger, the difference between the coefficients of the Japanese yen and the U.S. dollar became much smaller than those in Table 5. The results indicate that even when East Asian markets were open, the East Asian currencies reduced the correlations with the Japanese yen and increased the correlations with the U.S. dollar after the regime shift in Malaysia. Compared with those in Table 5, the adjusted R^2's increased in most of the time zones in all countries. The increase in the adjusted R^2's were, however, not large.

The results have two interesting implications. One is that the structural break in Malaysia had a large impact on the exchange rates of other East Asian countries that had no regime switch. The changes were particularly conspicuous in Singapore and Thailand where economic linkage with Malaysia had been very tight. The other is that the structural break was observed when East Asian markets were open. To the extent that the exchange rates are flexible, the impacts of the news from Japanese markets on the East Asian currencies would be reflected in the coefficient of the Japanese yen during the time zones when Japanese markets were open. In the last sub-section, the increased coefficient of the Japanese yen thus implied the increased flexibility in the East Asian exchange rates after the crisis. However, since the coefficient of the Japanese yen declined after September 1998, the above empirical results suggest that the exchange rates became less

[11]Because of the data availability, the time zone in Taiwan starts from 7:30am in Tokyo time.

flexible after the regime shift in Malaysia.

D. From January 4th 2000 to September 5th 2002.

The introduction of inflation targeting is in principle a regime shift of domestic monetary policy. However, in a small open economy where the share of imports in consumption goods is large, it can have a strong impact on the exchange rate policy. This is because the import prices are a key determinant of targeted inflation in such an economy. In particular, when the U.S. dollar has been dominant in invoice currencies in their imports, the introduction of inflation targeting might have increased their incentives to stabilize their exchange rates against the U.S. dollar. For example, in the appendix of Inflation Report (July 2002), the Bank of Thailand showed a simulation result that 10% depreciation of the Thai baht against the U.S. dollar would cause about 0.9% increase of core inflation rate. It suggests that the exchange rate management is a critical factor to achieve the targeted inflation in Thailand.

Korea started inflation targeting in September 1998. However, inflation targeting in Korea was not binding when Korean economy experienced unexpectedly dramatic recovery. It was early 2000 when inflation targeting became binding for Korean monetary policy. In contrast, inflation targeting was binding in Indonesia and Thailand soon after its introduction. It is therefore highly possible that there was a structural break of monetary policy in Indonesia, Thailand, and Korea in early 2000. We thus estimated equation (5) from January 4th 2000.

Table 7 summarizes the estimation results. When East Asian markets were closed, the coefficient of the U.S. dollar was close to one during all of the time zones. In all of the four currencies, the coefficient of the U.S. dollar was greater than 0.8 during 6:00-19:00 in New York time (that is, 20:00-9:00 in Tokyo time). Except for Taiwan, it was greater than 0.9 during 12:00-18:00 in New York time (that is, 2:00-8:00 in Tokyo time). In contrast, the coefficient of the Japanese yen was less than 0.1 during 12:00-18:00 in New York time in all countries.

When East Asian markets were open (that is, during 8:00-20:00 in Tokyo time), the coefficient of the Japanese yen was never significantly positive in Taiwan, and lied between 0.1 and 0.2 in

TABLE 7

CORRELATIONS WITH THE U.S. DOLLAR AND THE JAPANESE YEN
: After the Introduction of Inflation-Targeting in Some East Asian Countries

Sample period: January 4, 2000-September 5, 2002

① Singapore Dollar

NY time Tokyo time	(17:30-18:00) (7:30-8:00)	(18:00-19:00) (8:00-9:00)	(19:00-20:00) (9:00-10:00)	(20:00-21:00) (10:00-11:00)	(21:00-23:00) (11:00-13:00)	(23:00-2:00) (13:00-16:00)	(2:00-4:30) (16:00-18:30)	(4:30-6:00) (18:30-20:00)	(6:00-11:30) (20:00-1:30)	(11:30-12:00) (1:30-2:00)	(12:00-17:30) (2:00-7:30)
Hours	0.5h	1h	1h	1h	2h	3h	2.5h	1.5h	5.5h	0.5h	5.5h
Constant	0.0000	-0.0001	0.0000	-0.0001	0.0002**	0.0000	-0.0001	0.0002**	0.0000	0.0002***	-0.0002***
US dollar	0.9807***	0.8659***	0.8860***	0.8373***	0.8293***	0.8159***	0.7719***	0.7848***	0.8255***	0.8747***	0.9238***
Japaness yen	0.0143	0.1227**	0.1158**	0.1118	0.1142**	0.2022**	0.1661***	0.1628***	0.1226***	0.1407***	0.0916***
R^2	0.7923	0.7464	0.3146	0.2874	0.3581	0.4108	0.8694	0.8961	0.9287	0.9245	0.9506
D.W.	1.7631	1.8729	1.9310	1.8848	1.9962	1.9157	1.8689	2.0103	1.9330	1.9609	1.9975

② Thai Baht

NY time Tokyo time	(17:30-18:00) (7:30-8:00)	(18:00-21:00) (8:00-11:00)	(21:00-23:00) (11:00-13:00)	(23:00-4:30) (13:00-18:30)	(4:30-6:00) (18:30-20:00)	(6:00-11:30) (20:00-1:30)	(11:30-12:00) (1:30-2:00)	(12:00-17:30) (2:00-7:30)
Hours	0.5h	3h	2h	5.5h	1.5h	5.5h	0.5h	5.5h
Constant	0.0000	-0.0013***	0.0011***	0.0002	0.0000	0.0001	0.0005***	-0.0005***
US dollar	09226***	0.7967***	0.7752***	0.8129***	0.8357***	0.8819***	0.8920***	0.9738***
Japaness yen	0.1044**	0.1896***	0.1467***	0.1533***	0.1305***	0.1074***	0.1100***	0.0545*
R^2	0.5571	0.3827	0.2494	0.7406	0.7679	0.9057	0.8923	0.9040
D.W.	1.9605	1.9578	1.6629	1.7008	1.9676	2.0525	2.0715	2.0171

(Table Continued)

③ Korean Won

NY time Tokyo time	(17:30-18:00) (7:30-8:00)	(18:00-19:00) (8:00-9:00)	(19:00-23:00) (9:00-13:00)	(23:00-4:30) (13:00-18:30)	(4:30-6:00) (18:30-20:00)	(6:00-11:30) (20:00-1:30)	(11:30-12:00) (1:30-2:00)	(12:00-17:30) (2:00-7:30)
Hours	0.5h	1h	4h	5.5h	1.5h	5.5h	0.5h	5.5h
Constant	-0.0002	0.0007***	-0.0007***	-0.0017***	0.0019***	0.0007***	0.0001	-0.0007***
US dollar	1.1967***	0.9495***	0.5427***	0.8206***	0.8239***	0.9847***	0.9333***	0.9686***
Japaness yen	-0.1380	0.1929	0.3515***	0.1210**	0.1352*	0.0042	0.0789**	-0.0098
R^2	0.2944	0.2552	0.1601	0.4567	0.3062	0.8592	0.6490	0.6086
D.W.	1.5930	1.7885	1.8171	1.3225	1.1561	1.5887	1.2196	1.1305

④ Taiwan Dollar

NY time Tokyo time	(17:30-23:00) (7:30-13:00)	(23:00-3:00) (13:00-17:00)	(3:00-4:30) (17:00-18:30)	(4:30-6:00) (18:30-20:00)	(6:00-11:30) (20:00-1:30)	(11:30-12:00) (1:30-2:00)	(12:00-17:30) (2:00-7:30)
Hours	5.5h	4h	1.5h	1.5h	5.5h	0.5h	5.5h
Constant	0.0002***	0.0019	-0.0010***	0.0008***	-0.0003***	0.0006***	-0.0007***
US dollar	0.8198***	0.6857***	0.9216***	0.9738***	0.9767***	0.9730***	1.0483***
Japaness yen	0.0570	0.1354	0.0378	0.0223	0.0070	-0.0818	-0.0857*
R^2	0.4687	0.6857	0.7601	0.7183	0.9119	0.4566	0.6155
D.W.	1.6203	1.9698	1.8167	1.8079	1.8285	1.4508	1.6583

Note: ***, **, * indicate the significance at 1%, 5%, and 10% level, respectively.

most of the time zones in other East Asian countries. In contrast, the coefficient of the U.S. dollar rose up to the range between 0.75 and 0.9 in most of the time zones in all countries. As a result, the coefficient of the Japanese yen never exceeded that of the U.S. dollar during any time zones and was less than one-fifth of that of the U.S. dollar during most of the time zones in all countries. The results indicate that even when East Asian markets were open, the East Asian currencies began reverting back to de facto pegs against the U.S. dollar after early 2000. It is noteworthy that the structural break of the exchange rates occurred in other East Asian countries that had no regime switch of monetary policy. This implies the existence of a strong linkage among the East Asian exchange rates.

To the extent that the exchange rates are flexible, the impacts of news from Japanese markets on the East Asian currencies would be reflected in the coefficient of the Japanese yen during the time zones when Japanese markets are open. The above results thus suggest that the flexibility on the East Asian exchange rates declined after early 2000. During most of the time zones, the adjusted R^2's were larger than those in Table 6 and were almost comparable to those in the pre-crisis period in all countries. However, the coefficient of the Japanese yen was significantly different from zero during most of the time zones in all countries except for Taiwan. The result is in marked contrast with that in the pre-crisis period where the Japanese yen had no significantly positive coefficient except in limited time zones in Singapore. This implies that de facto pegs against the U.S. dollar after early 2000 were accompanied by some degree of flexibility that did not exist in the pre-crisis period.

V. Tests of Structural Breaks: The Case of Coefficient Dummies

In the last section, we estimated equation (5) for each time zone in four alternative sample periods. The estimations were based on the assumption that the East Asian exchange rates had three structural breaks: when the crisis occurred, when Malaysia introduced the fixed exchange rate regime, and when some East Asian countries introduced inflation targeting effectively. The estimated coefficients suggested that the assumption was reasonable.

We have, however, provided no explicit test to support it. The purpose of the following two sections is to provide formal tests to explore whether the assumption was correct.

This section tests the existence of each structural break by using dummy variables. Given the dates of structural breaks, the tests would verify whether there were significant structural changes in the coefficients of the U.S. dollar and the Japanese yen for each time zone. By using the intra-daily data, we estimate the following equation:

$$\Delta X_t = \text{constant} + \beta_1 \cdot \Delta USD_t + \beta_2 \cdot \Delta JPY_t + \beta_{12} \cdot D_t \cdot \Delta USD_t + \beta_{22} \cdot D_t \cdot \Delta JPY_t, \quad (6)$$

where D_t is a dummy variable which takes one after the break but takes zero otherwise. We can conclude that there was a structural break in the coefficient of the U.S. dollar if the coefficient of $D_t \cdot \Delta USD_t$ is significantly different from zero. We can also see a structural break in the coefficient of the Japanese yen if the coefficient of $D_t \cdot \Delta JPY_t$ is significantly different from zero. We estimate equation (6) for three alternative sample periods: (a) from January 7th 1997 to August 31th 1998, (b) from February 1st 1998 to December 29th 1998, and (c) from September 2nd 1998 to September 5th 2002.

A. From January 7th 1997 to August 31th 1998

We first test whether the East Asian exchange rates had a structural break before and after the crisis. We test this by estimating equation (6) from January 7th 1997 to August 31th 1998. Since the period includes the turbulent period when several East Asian countries experienced serious currency devaluations, we excluded the period from July 2nd 1997 to January 31st 1998 from our sample period. In the estimation, the dummy variable D_t takes one from February 1st 1998 to August 31th 1998 but takes zero otherwise.

Table 8 summarizes the estimation results. In all countries, the coefficients of $D_t \cdot \Delta USD_t$ and $D_t \cdot \Delta JPY_t$ were significantly different from zero in several time zones. When the coefficient of $D_t \cdot \Delta USD_t$ was significantly different from zero, it always took a negative value. In contrast, if the coefficient of $D_t \cdot \Delta JPY_t$ was significantly

TABLE 8

STRUCTURAL STABILITY TEST AFTER THE CRISIS

Sample period: January 4, 1997-August 31, 1998 (excluding the period from July 2, 1997 until January 31, 1998)

① Singapore Dollar

NY time Tokyo time	(12:00-18:00) (2:00-8:00)	(18:00-19:00) (8:00-9:00)	(19:00-21:00) (9:00-11:00)	(21:00-23:00) (11:00-13:00)	(23:00-2:00) (13:00-16:00)	(2:00-4:30) (16:00-18:30)	(4:30-11:30) (18:30-1:30)	(11:30-12:00) (1:30-2:00)
Hours	6h	1h	2h	2h	3h	2.5h	7h	0.5h
Constant	0.000**	0.000	0.000**	0.000	-0.001***	0.001***	0.000	0.000***
US dollar (a)	0.928***	0.968***	0.911***	0.856***	0.675***	0.626***	0.711***	0.981***
Japaness yen (b)	0.029	0.061	0.127*	0.113***	0.158**	0.336***	0.224***	-0.033
Dummy variable								
US dollar (c)	-0.346***	0.184	-0.277	-0.808***	-0.617***	-0.624***	-0.535***	-0.913***
Japaness yen (d)	0.197***	0.020	0.212	0.687***	0.545***	0.611***	0.475***	0.648***
(a)+(c)	0.582***	1.152***	0.634***	0.048	0.059	0.003	0.176***	0.068***
(b)+(d)	0.226***	0.081	0.338***	0.801***	0.703***	0.947***	0.698***	0.616***
Adjusted R^2	0.489	0.328	0.234	0.389	0.268	0.449	0.699	0.639
D.W.	1.560	1.583	2.024	2.009	2.032	2.070	2.245	1.955

(Table Continued)

② Malaysian Ringgit

NY time Tokyo time	(12:00-18:00) (2:00-8:00)	(18:00-19:00) (8:00-9:00)	(19:00-23:00) (9:00-13:00)	(23:00-2:00) (13:00-16:00)	(2:00-4:30) (16:00-18:30)	(4:30-11:30) (18:30-1:30)	(11:30-12:00) (1:30-2:00)
Hours	6h	1h	4h	3h	2.5h	7h	0.5h
Constant	0.000**	-0.001	0.000*	-0.019	0.002***	0.000	0.001***
US dollar (a)	0.954***	1.152***	0.829***	-0.020	0.681***	0.773***	1.020***
Japaness yen (b)	0.013	-0.013	-0.037	0.350***	0.270**	0.116*	-0.001
Dummy variable							
US dollar (c)	-0.571	0.654	-0.657***	0.009	-0.598***	-0.646***	-0.985***
Japaness yen (d)	0.342	0.217	0.546***	0.261	0.587***	0.638***	0.676***
(a)+(c)	0.383	1.806**	0.172	-0.011	0.082	0.126	0.036
(b)+(d)	0.355	0.203	0.509***	0.611***	0.857***	0.755***	0.675***
Adjusted R^2	0.082	0.113	0.115	0.193	0.197	0.406	0.336
D.W.	1.978	1.986	2.162	2.044	2.291	1.940	2.116

③ Thai Baht

NY time Tokyo time	(12:00-18:00) (2:00-8:00)	(18:00-21:00) (8:00-11:00)	(21:00-4:30) (11:00-18:30)	(4:30-11:30) (18:30-1:30)	(11:30-12:00) (1:30-2:00)
Hours	6h	3h	7.5h	7h	0.5h
Constant	-0.002***	-0.004***	0.003***	0.002	-0.001
US dollar (a)	1.120***	2.052*	1.321**	0.851***	0.389
Japaness yen (b)	0.380	-1.486*	-0.542	-0.012	0.923
Dummy variable					
US dollar (c)	-0.424	-2.026*	-1.190**	-0.642**	-0.289
Japaness yen (d)	-0.328	1.834**	1.204	0.720**	-0.284
(a)+(c)	0.696***	0.026	0.132	0.209**	0.100
(b)+(d)	0.053	0.348*	0.662***	0.708***	0.639***
Adjusted R^2	0.198	0.069	0.089	0.122	0.021
D.W.	1.862	1.753	1.708	0.781	0.452

(Table Continued)

④ Korean Won

NY time Tokyo time	(12:00-18:00) (2:00-8:00)	(18:00-19:00) (8:00-9:00)	(19:00-4:30) (9:00-18:30)	(4:30-11:30) (18:30-1:30)	(11:30-12:00) (1:30-2:00)
Hours	6h	1h	9.5h	7h	0.5h
Constant	-0.002***	0.000	-0.005**	0.005**	0.002***
US dollar (a)	0.902***	1.178***	1.174***	0.776***	0.973***
Japaness yen (b)	0.036	0.066	0.332	0.223	-0.144
Dummy variable					
US dollar (c)	0.150	-0.155	-0.772***	-0.259	-0.852***
Japaness yen (d)	-0.128	-0.088	0.120	0.574	0.553***
(a)+(c)	0.052***	1.023***	0.402*	0.517**	0.122***
(b)+(d)	-0.092	-0.022	0.453**	0.597*	0.408***
Adjusted R^2	0.400	0.124	0.063	0.059	0.288
D.W.	1.920	1.837	0.841	0.943	1.769

⑤ Taiwan Dollar

NY time Tokyo time	(12:00-3:00) (2:00-17:00)	(3:00-4:30) (17:00-18:30)	(4:30-11:30) (18:30-1:30)	(11:30-12:00) (1:30-2:00)
Hours	13h	1.5h	7h	0.5h
Constant	0.001	-0.003***	0.000	0.001***
US dollar (a)	0.746***	0.628***	0.925***	0.999***
Japaness yen (b)	0.025	0.021	0.096	-0.019
Dummy variable				
US dollar (c)	-0.016	-0.134*	-0.536***	-0.884***
Japaness yen (d)	0.148**	0.199*	0.241	0.296
(a)+(c)	0.730***	0.494***	0.389***	0.115
(b)+(d)	0.173**	0.220**	0.336**	0.276
Adjusted R^2	0.363	0.512	0.644	0.265
D.W.	1.737	1.852	1.974	1.701

Notes: ***, **, * indicate the significance at 1%, 5%, and 10% level, respectively.
Dummy variables take 1 for the period from February 1st, 1998 until August 31, 1998, and 0 otherwise.

different from zero, it always took a positive value. The results imply that there was a significant structural break that decreased the coefficient of the U.S. dollar and increased the coefficient of the Japanese yen. The results of the formal tests are highly consistent with our findings in the last section.

The absolute values of the coefficients of $D_t \cdot \Delta USD_t$ and $D_t \cdot \Delta JPY_t$ tended to be particularly large when East Asian markets were open. In Tokyo time, the coefficient of $D_t \cdot \Delta USD_t$ took large negative values during 11:00-18:30 in Singapore, 9:00-13:00 and 16:00-18:30 in Malaysia, 8:00-18:30 in Thailand, and 9:00-18:30 in Korea. Their absolute values were almost equal to those of the coefficient of ΔUSD_t during the same time zone, implying that the structural break cancelled out the positive impact of the U.S. dollar that was observed before the crisis. On the other hand, in Tokyo time, the coefficient of $D_t \cdot \Delta JPY_t$ took large positive values during 11:00-18:30 in Singapore, 9:00-13:00 and 16:00-18:30 in Malaysia, and 8:00-11:00 in Thailand. This indicates that the structural break caused a positive impact of the Japanese yen that was not observed before the crisis.

One exceptional time zone was 12:00-18:00 in New York time (that is, 2:00-8:00 in Tokyo time) when both East Asian and European markets were closed. During this time zone, the coefficients of $D_t \cdot \Delta USD_t$ and $D_t \cdot \Delta JPY_t$ were not significantly different from zero in Malaysia, Thailand, Korea, and Taiwan, suggesting no structural change in these countries. In Singapore, the coefficients of $D_t \cdot \Delta USD_t$ and $D_t \cdot \Delta JPY_t$ were significant. However, even in Singapore, their absolute values were relatively small. This supports our results that the structural break, if any, was very modest when both East Asian and European markets were closed.

B. From February 1st 1998 to December 29th 1998

We next test whether the East Asian exchange rates had a structural break when Malaysia introduced the fixed exchange rate regime. We test this by estimating equation (6) for the period from February 1st 1998 to December 29th 1998. In the estimation, the dummy variable D_t takes one from September 1st 1998 to December 29th 1998 but takes zero otherwise. The significance of the coefficients of $D_t \cdot \Delta USD_t$ and $D_t \cdot \Delta JPY_t$ verify whether there was a structural break when Malaysia introduced the fixed

exchange rate regime. Since the structural break in Malaysia was obvious, we estimated equation (6) for each available time zone in Singapore, Thailand, Korea, and Taiwan.

Table 9 summarizes the estimation results. In all countries, the coefficients of $D_t \cdot \Delta USD_t$ and $D_t \cdot \Delta JPY_t$ were significantly different from zero in various time zones. The signs of the estimates were, however, completely reversed. When the coefficient of $D_t \cdot \Delta USD_t$ was significantly different from zero, it tended to be positive. In contrast, if the coefficient of $D_t \cdot \Delta JPY_t$ was significantly different from zero, it tended to be negative. The significant coefficients were more conspicuous in Singapore and Thailand. The results imply that there was a significant structural break that increased the coefficient of the U.S. dollar and decreased the coefficient of the Japanese yen, particularly in Singapore and Thailand. The results are highly consistent with our findings in the last section.

The absolute values of the coefficients of $D_t \cdot \Delta USD_t$ and $D_t \cdot \Delta JPY_t$ tended to be particularly large when East Asian markets were open. In Tokyo time, the coefficient of $D_t \cdot \Delta USD_t$ took large positive values during 9:00-11:00 and 16:00-18:30 in Singapore and 8:00-11:00 in Thailand. The positive coefficient of ΔUSD_t implies that the total impact of the U.S. dollar became close to one in Singapore and Thailand after the structural break. On the other hand, in Tokyo time, the coefficient of $D_t \cdot \Delta JPY_t$ was significantly negative and its absolute value was large during 11:00-20:00 in Singapore and Thailand, and 7:30-13:00 and 18:30-20:00 in Taiwan. This indicates that a positive impact of the Japanese yen that was observed before the structural break almost disappeared during these time zones after the regime shift of Malaysia. Comparing the absolute values of the significant coefficients, those in Singapore and Thailand tended to be larger than those in Korea and Taiwan. This probably reflects the fact that Malaysia has had smaller linkages with Korea and Taiwan than with Singapore and Thailand.

In contrast, we could see no significant dummies during 12:00-17:30 in New York time (that is, 2:00-7:30 in Tokyo time) in Thailand and Taiwan. During similar time zones, the coefficient of $D_t \cdot \Delta USD_t$ was not significant in Singapore and neither was in Korea. The results suggest that the structural break, if any, was very modest when both East Asian and European markets were closed.

TABLE 9

STRUCTURAL STABILITY TEST AFTER MALAYSIA PEGGED THE EXCHANGE RATE

Sample period: February 1st, 1998-December 29, 1998

① Singapore Dollar

NY time Tokyo time	(12:00-17:30) (2:00-7:30)	(17:30-18:00) (7:30-8:00)	(18:00-19:00) (8:00-9:00)	(19:00-20:00) (9:00-10:00)	(20:00-21:00) (10:00-11:00)	(21:00-23:00) (11:00-13:00)	(23:00-2:00) (13:00-16:00)	(2:00-4:30) (16:00-18:30)	(4:30-6:00) (18:30-20:00)	(6:00-11:30) (20:00-1:30)	(11:30-12:00) (1:30-2:00)
Hours	5.5h	0.5h	1h	1h	1h	2h	3h	2.5h	1.5h	5.5h	0.5h
Constant	0.000**	0.000	0.000	0.000	0.000	0.000	-0.002***	0.002***	0.000***	0.000	0.000**
US dollar (a)	0.994***	1.640***	1.169***	0.205	0.167	0.041	0.036	-0.030	0.108**	0.126***	0.084***
Japaness yen (b)	-0.115	-0.142	0.079	0.639*	0.575**	0.810***	0.712***	0.950***	0.819***	0.619***	0.610***
Dummy variable											
US dollar (c)	-0.180	-0.981**	-0.512	0.880*	0.690***	0.121	0.182	0.433**	0.318*	0.290***	0.177**
Japaness yen (d)	0.333***	0.408*	0.020	-0.314	-0.139	-0.667***	-0.550***	-0.805***	-0.682***	-0.371**	-0.313*
(a)+(c)	0.814***	0.660***	0.657***	1.085***	0.858***	0.163**	0.218***	0.403**	0.426***	0.415***	0.261***
(b)+(d)	0.218***	0.265***	0.099**	0.325***	0.435**	0.143	0.162**	0.145	0.137	0.248***	0.297***
Adjusted R^2	0.420	0.139	0.223	0.371	0.433	0.352	0.250	0.390	0.668	0.507	0.313
D.W.	2.129	1.915	1.653	2.041	1.780	2.041	2.095	2.116	2.049	2.079	1.829

(Table Continued)

② Thai Baht

NY time Tokyo time	(12:00-17:30) (2:00-7:30)	(17:30-18:00) (7:30-8:00)	(18:00-21:00) (8:00-11:00)	(21:00-23:00) (11:00-13:00)	(23:00-4:30) (13:00-18:30)	(4:30-6:00) (18:30-20:00)	(6:00-11:30) (20:00-1:30)	(11:30-12:00) (1:30-2:00)
Hours	5.5h	0.5h	3h	2h	5.5h	1.5h	5.5h	0.5h
Constant	-0.002***	0.000	-0.003***	0.002***	-0.0005	0.000	0.001	0.002***
US dollar (a)	1.504***	0.468	0.092	0.224*	0.1992*	0.131*	0.189**	0.127**
Japaness yen (b)	-0.221	-0.171	0.398**	0.801***	0.6651***	-0.818***	0.682**	0.630***
Dummy variable								
US dollar (c)	-0.426	0.516	0.977***	-0.006	0.1702	0.278*	0.309***	0.145
Japaness yen (d)	0.250	0.255	-0.223	-0.550**	-0.6029***	-0.864***	-0.455	-0.300
(a)+(c)	1.077***	0.984***	1.069***	0.218***	0.3694***	0.409***	0.498***	0.272**
(b)+(d)	0.028	0.084	0.175***	0.251**	0.0622	-0.046	0.227***	0.329***
Adjusted R^2	0.214	0.018	0.063	0.107	0.1798	0.360	0.216	0.197
D.W.	2.155	2.070	1.698	1.851	2.1996	1.899	2.006	1.774

③ Korean Won

NY time Tokyo time	(12:00-18:00) (2:00-8:00)	(18:00-19:00) (8:00-9:00)	(19:00-23:00) (9:00-13:00)	(23:00-4:30) (13:00-18:30)	(4:30-6:00) (18:30-20:00)	(6:00-11:30) (20:00-1:30)	(11:30-12:00) (1:30-2:00)
Hours	6h	1h	4h	5.5h	1.5h	5.5h	0.5h
Constant	-0.002***	0.001**	-0.001	-0.0003	0.000	0.000*	0.001***
US dollar (a)	1.503***	0.886***	0.699**	0.5437**	0.770**	0.410***	0.117***
Japaness yen (b)	-0.093	-0.120	0.110	0.5408**	0.777	0.140***	0.412***
Dummy variable							
US dollar (c)	0.082	0.880	-0.472	-0.1477	-0.648	0.150**	0.252**
Japaness yen (d)	0.106	0.255	0.146	-0.6204**	-0.724	-0.139*	-0.234
(a)+(c)	1.153***	1.766**	0.227*	0.3960***	0.123	0.561***	0.368***
(b)+(d)	0.012	0.135**	0.256	-0.0796	0.052	0.001	0.178
Adjusted R^2	0.331	0.139	0.050	0.1516	0.116	0.472	0.164
D.W.	1.498	1.610	2.034	1.8391	1.648	1.954	1.903

(Table Continued)

④ Taiwan Dollar

NY time Tokyo time	(12:00-17:30) (2:00-7:30)	(17:30-23:00) (7:30-13:00)	(23:00-3:00) (13:00-17:00)	(2:00-4:30) (16:00-18:30)	(4:30-6:00) (18:30-20:00)	(6:00-11:30) (20:00-1:30)	(11:30-12:00) (1:30-2:00)
Hours	5.5h	5.5h	4h	1.5h	1.5h	5.5h	0.5h
Constant	-0.004***	0.002***	0.005***	-0.003***	0.000***	0.000	0.001***
US dollar (a)	0.714**	0.224*	0.238**	0.459***	0.156***	0.376***	0.115
Japaness yen (b)	-0.031	0.564***	0.355	0.257**	0.741***	0.132**	0.291
Dummy variable							
US dollar (c)	0.326	-0.015	-0.251**	-0.005	0.162	0.191**	0.177*
Japaness yen (d)	0.049	-0.458***	-0.292	-0.142	-1.030***	-0.095	-0.033
(a)+(c)	1.041***	0.209**	-0.013	0.454***	0.318***	0.567***	0.292***
(b)+(d)	0.018	0.105	0.063	0.115	-0.289	0.038	0.258**
Adjusted R^2	0.368	0.172	0.132	0.464	0.611	0.476	0.101
D.W.	1.389	1.763	1.965	1.980	2.001	1.793	1.686

Notes: ***, **, * indicate the significance at 1%, 5%, and 10% level, respectively.
Dummy variables take 1 for the period from September 1st, 1998 until December 29, 1998, and 0 otherwise.

C. From September 2nd 1998 to September 5th 2002

Finally, we test whether the East Asian exchange rates had a structural break when some East Asian countries introduced inflation targeting effectively. We test this by estimating equation (6) for the period from September 2nd 1998 to September 5th 2002. In the estimation, the dummy variable D_t takes one from January 4th 2000 to September 5th 2002 but takes zero otherwise. If the coefficients of $D_t \cdot \Delta USD_t$ and $D_t \cdot \Delta JPY_t$ are significantly different from zero, we can conclude that there was a structural break when some East Asian countries introduced inflation targeting effectively.

Table 10 summarizes the estimation results. In all countries, the coefficients of $D_t \cdot \Delta USD_t$ and $D_t \cdot \Delta JPY_t$ were significantly different from zero in several time zones. When the coefficient of $D_t \cdot \Delta USD_t$ was significantly different from zero, it tended to be positive. In contrast, if the coefficient of $D_t \cdot \Delta JPY_t$ was significantly different from zero, it tended to be negative. The significant coefficients were more conspicuous in those of $D_t \cdot \Delta USD_t$. The results imply that there was a significant structural break that increased the coefficient of the U.S. dollar and decreased the coefficient of the Japanese yen. The results are highly consistent with our findings in the last section.

The coefficients of $D_t \cdot \Delta USD_t$ tended to be particularly large when East Asian markets were open. In Tokyo time, it took large positive values during 11:00-16:00 in Singapore and 11:00-13:00 in Thailand. Even in Korea and Taiwan, it took significantly positive values during similar time zones. The positive coefficient of ΔUSD_t implies that the total impact of the U.S. dollar became close to one in the East Asian countries after the structural break.

In contrast, the negative coefficient of $D_t \cdot \Delta JPY_t$ was, if significant, moderate in its absolute value. In Korea and Taiwan, the coefficient of $D_t \cdot \Delta JPY_t$ took significantly a positive value in a time zone. This probably reflects the fact that a positive impact of the Japanese yen had almost disappeared before the structural break. In all countries, we could see no significant dummies during 12:00-17:30 in New York time (that is, 2:00-7:30 in Tokyo time) when both East Asian and European markets were closed. The results suggest that the structural break, if any, was negligible when both East Asian and European markets were closed.

TABLE 10

STRUCTURAL STABILITY TEST AFTER THE INTRODUCTION OF INFLATION TARGETING

Sample period: September 2nd, 1998-September 5, 2002

① Singapore Dollar

NY time Tokyo time	(17:30-18:00) (7:30-8:00)	(18:00-19:00) (8:00-9:00)	(19:00-20:00) (9:00-10:00)	(20:00-21:00) (10:00-11:00)	(21:00-23:00) (11:00-13:00)	(23:00-2:00) (13:00-16:00)	(2:00-4:30) (16:00-18:30)	(4:30-6:00) (18:30-20:00)	(6:00-11:30) (20:00-1:30)	(11:30-12:00) (1:30-2:00)	(12:00-17:30) (2:00-7:30)
Hours	0.5h	1h	1h	1h	2h	3h	2.5h	1.5h	5.5h	0.5h	5.5h
Constant	0.000	0.000	0.000	0.000	0.000***	0.000**	0.000	0.000	0.000	0.000***	0.000***
US dollar (a)	0.808***	0.882***	0.794***	0.482***	0.134***	0.231***	0.483***	-0.430***	0.353***	0.149***	0.855***
Japaness yen (b)	0.194***	0.030	0.083**	0.203***	0.377***	0.254***	0.184***	0.210***	0.293***	0.367***	0.148***
Dummy variable											
US dollar (c)	0.173*	-0.014	0.089	0.355**	0.689***	0.580***	0.286***	0.352***	0.472***	0.727***	0.069
Japaness yen (d)	-0.179***	0.091	0.033	-0.091	-0.260***	-0.055	-0.018	-0.048	-0.171***	-0.227***	-0.057
(a) + (c)	0.981***	0.868***	0.883***	0.837***	0.823***	0.811***	0.769***	0.781***	0.825***	0.876***	0.924***
(b) + (d)	0.014	0.121**	0.115**	0.112	0.117**	0.199**	0.166***	0.161***	0.122***	0.140***	0.091***
Adjusted R^2	0.680	0.680	0.498	0.402	0.417	0.407	0.781	0.794	0.811	0.769	0.912
D.W.	1.843	1.804	1.933	1.912	2.040	1.754	1.646	1.916	2.059	1.897	1.897

(Table Continued)

② Thai Baht

NY time Tokyo time	(17:30-18:00) (7:30-8:00)	(18:00-21:00) (8:00-11:00)	(21:00-23:00) (11:00-13:00)	(23:00-4:30) (13:00-18:30)	(4:30-6:00) (18:30-20:00)	(6:00-11:30) (20:00-1:30)	(11:30-12:00) (1:30-2:00)	(12:00-17:30) (2:00-7:30)
Hours	0.5h	3h	2h	5.5h	1.5h	5.5h	0.5h	5.5h
Constant	0.000*	-0.001***	0.001***	0.0003	0.000	0.000	0.001***	-0.001***
US dollar (a)	1.077***	0.858***	0.193***	0.4090***	0.419***	0.375**	0.122***	0.908***
Japaness yen (b)	0.060	0.147**	0.216*	0.1866***	0.206***	0.262**	0.394***	0.042
Dummy variable								
US dollar (c)	-0.151	-0.056	0.595***	0.4036***	0.413***	0.507***	0.781***	0.074
Japaness yen (d)	0.041	0.037	-0.073	-0.0332	-0.077	-0.155***	-0.290***	0.017
(a)+(c)	0.926***	0.803***	0.788***	0.8126***	0.832***	0.882***	0.903***	0.982***
(b)+(d)	0.101*	0.184***	0.140***	0.1534***	0.129***	0.107***	0.104***	0.059*
Adjusted R^2	0.455	0.275	0.170	0.5733	0.602	0.696	0.602	0.751
D.W.	1.850	1.877	1.746	1.7694	1.803	1.824	1.891	1.962

③ Korean Won

NY time Tokyo time	(17:30-18:00) (7:30-8:00)	(18:00-19:00) (8:00-9:00)	(19:00-23:00) (9:00-13:00)	(23:00-4:30) (13:00-18:30)	(4:30-6:00) (18:30-20:00)	(6:00-11:30) (20:00-1:30)	(11:30-12:00) (1:30-2:00)	(12:00-17:30) (2:00-7:30)
Hours	0.5h	1h	4h	5.5h	1.5h	5.5h	0.5h	5.5h
Constant	0.000	0.001***	-0.001***	-0.0009***	0.001***	0.000***	0.000***	-0.001***
US dollar (a)	0.963***	1.301***	0.313***	0.4350***	0.404***	0.435***	0.197***	0.948***
Japaness yen (b)	0.023	-0.044	0.236***	0.1190*	0.177**	0.184***	0.249***	0.048
Dummy variable								
US dollar (c)	0.237	-0.352*	0.230*	0.3750***	0.406***	0.548***	0.758***	0.031
Japaness yen (d)	-0.164	0.237**	0.115	0.0069	-0.047	-0.183***	-0.181***	-0.052
(a)+(c)	1.200***	0.949***	0.543***	0.8099***	0.810***	0.983***	0.955***	0.980***
(b)+(d)	-0.141	0.194*	0.352***	0.1260**	0.129*	0.001	0.068*	-0.004
Adjusted R^2	0.254	0.347	0.174	0.3758	0.259	0.745	0.535	0.610
D.W.	1.433	1.670	1.690	1.4185	1.306	1.765	1.377	1.201

(Table Continued)

④ Taiwan Dollar

NY time Tokyo time	(17:30-23:00) (7:30-13:00)	(23:00-3:00) (13:00-17:00)	(2:00-4:30) (16:00-18:30)	(4:30-6:00) (18:30-20:00)	(6:00-11:30) (20:00-1:30)	(11:30-12:00) (1:30-2:00)	(12:00-17:30) (2:00-7:30)
Hours	5.5h	4h	1.5h	1.5h	5.5h	0.5h	5.5h
Constant	0.000	0.003***	-0.002***	0.000***	0.000***	0.001***	-0.001***
US dollar (a)	0.242***	0.223***	0.577***	0.417***	0.427***	0.190***	0.990**
Japaness yen (b)	0.204***	0.001	0.130***	0.169***	0.191***	0.314***	0.012
Dummy variable							
US dollar (c)	0.576***	0.277***	0.289***	0.552***	0.550***	0.809***	0.081
Japaness yen (d)	-0.143**	0.266***	-0.049	-0.148**	-0.184***	-0.408***	-0.085
(a)+(c)	0.817***	0.500***	0.866***	0.968***	0.977***	0.999***	1.071***
(b)+(d)	0.062	0.268***	0.081***	0.020	0.007	-0.094	-0.073
Adjusted R^2	0.383	0.527	0.711	0.647	0.800	0.401	0.645
D.W.	1.693	1.911	1.812	1.814	2.018	1.471	1.519

Notes: ***, **, * indicate the significance at 1%, 5%, and 10% level, respectively.
Dummy variables take 1 for the period from January 4, 2000 until September 5, 2002, and 0 otherwise.

VI. Tests of Structural Breaks: The Case of Rolling Regressions

Until the last section, we have made estimations assuming that the dates of structural breaks were known. The dates were chosen based on those of regime switches in some East Asian countries. The choice, however, could be arbitrary particularly when inflation targeting was introduced. The purpose of this section is to make formal tests to explore when the exchange rates had structural breaks in Singapore, Thailand, Korea, and Taiwan in 1998 and in early 2000. By using the intra-daily data, we make rolling regressions of equation (6) and calculate series of t-values of the coefficients of $D_t \cdot \Delta USD_t$ and $D_t \cdot \Delta JPY_t$ in two alternative sample periods. In each sample period, the starting date was always fixed. We, however, changed the date of the structural break day by day. We fixed the ending day of each sample period by 51 days after the structural break.

The first sample period was chosen to find out when the East Asian exchange rates had a structural break in 1997. We start it from February 1st 1998 and change the date of the structural break from June 1st 1998 to October 15th 1998. We make the rolling regressions only for the time zones for which t-values of the coefficients of $D_t \cdot \Delta USD_t$ and $D_t \cdot \Delta JPY_t$ were significant at 10% level in Table 9. Figure 2 shows how the calculated t-values changed in our rolling regressions. The t-values vary depending on time zones and currencies. Their absolute values, however, tend to exceed two from mid-July to late September. This supports the view that the East Asian exchange rates had a structural break around September 1st 1998 when Malaysia introduced the fixed exchange rate regime.

The second sample period was chosen to find out when the East Asian exchange rates had a structural break in early 2000. We start it from September 2nd 1998 and change the date of the structural break from November 1st 1999 to June 30th 2000. We make the regressions only for the time zones for which t-values of the coefficients of $D_t \cdot \Delta USD_t$ and $D_t \cdot \Delta JPY_t$ were significant at 10% level in Table 10. Figure 3 shows how the calculated t-values changed in our rolling regressions. The t-values vary depending on time zones and currencies. Their absolute values, however, tended

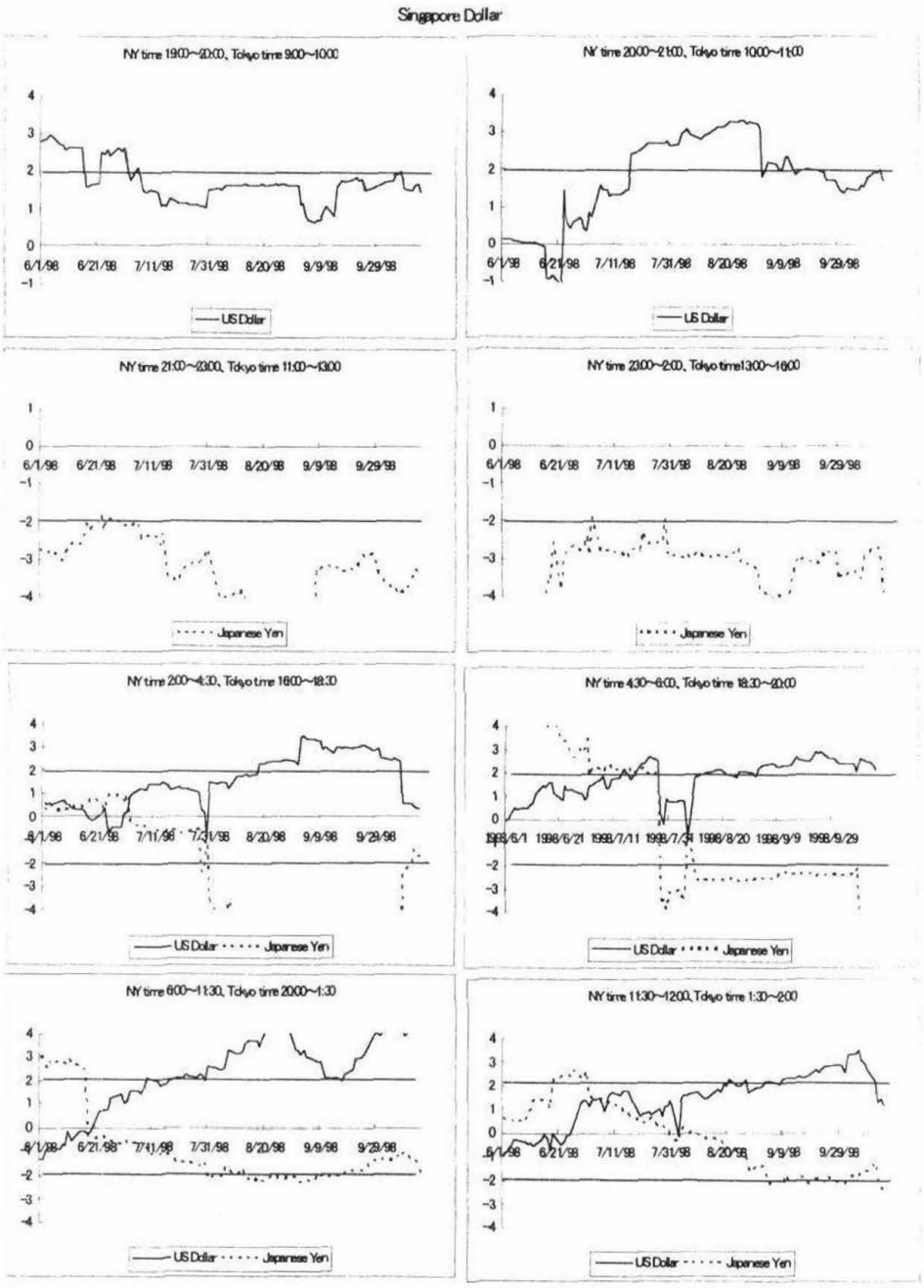


FIGURE 2-1

STRUCTURAL STABILITY TEST AROUND SEPTEMBER 1998:
THE CASE OF SINGAPORE
〈*t*-Values of Dummy Variables Estimated from the Rolling Regressions〉

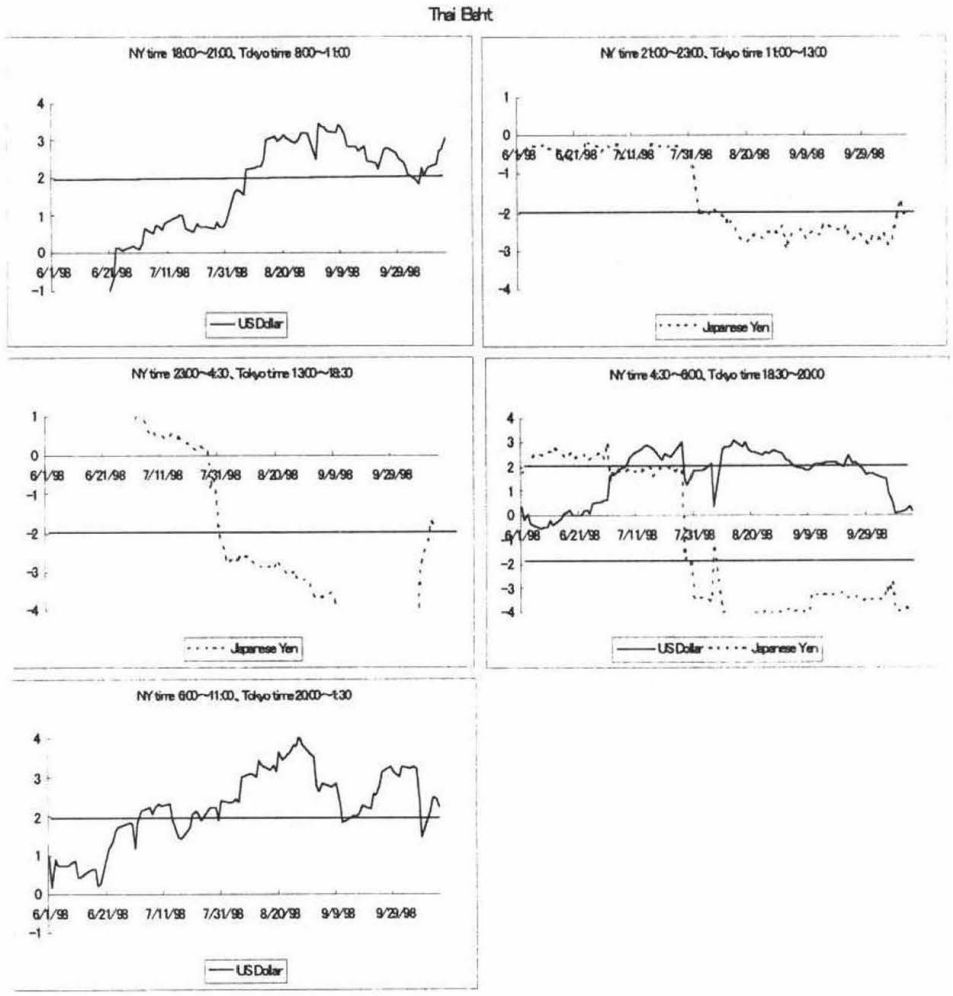


FIGURE 2-2

STRUCTURAL STABILITY TEST AROUND SEPTEMBER 1998:

THE CASE OF THAILAND

〈*t*-Values of Dummy Variables Estimated from the Rolling Regressions〉

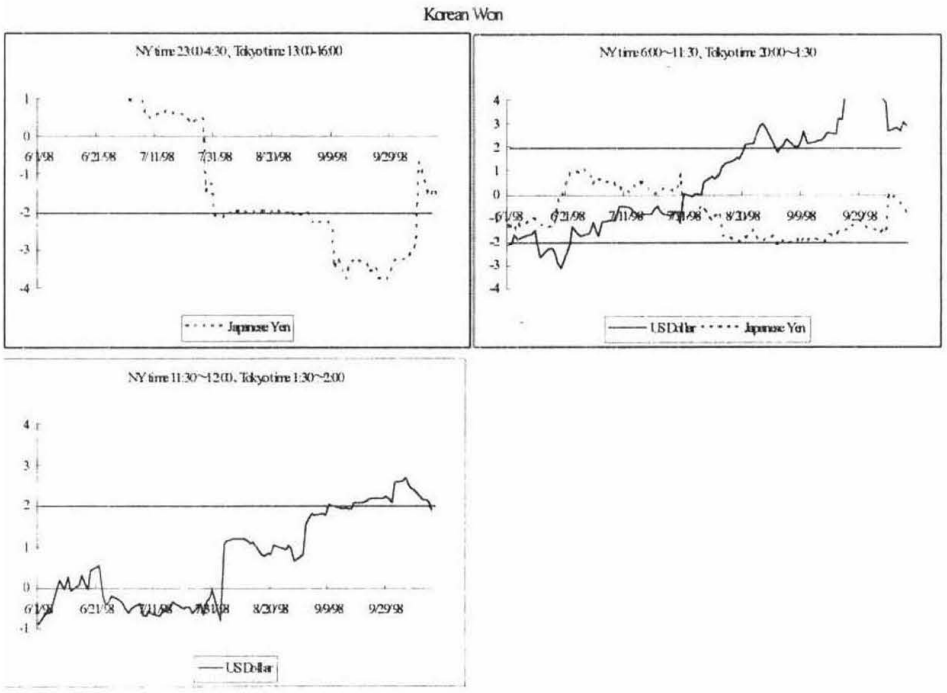


FIGURE 2-3

STRUCTURAL STABILITY TEST AROUND SEPTEMBER 1998:

THE CASE OF KOREA

〈*t*-Values of Dummy Variables Estimated from the Rolling Regressions〉

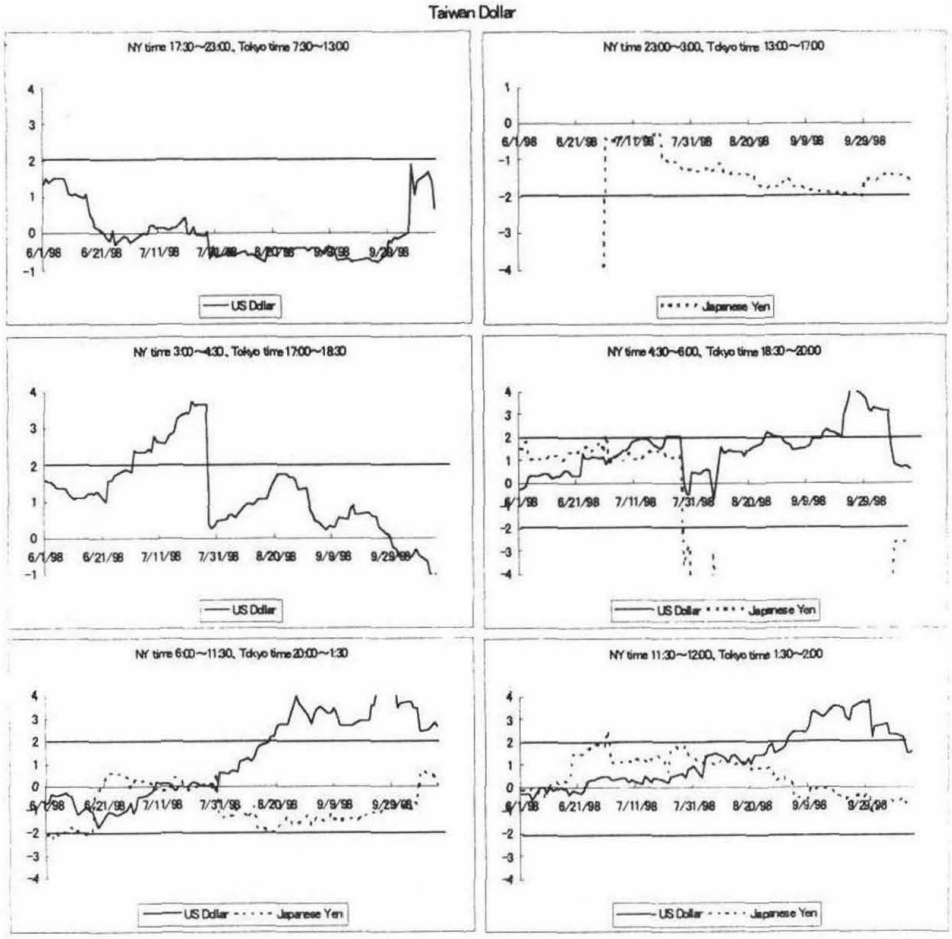


FIGURE 2-4

STRUCTURAL STABILITY TEST AROUND SEPTEMBER 1998:
THE CASE OF TAIWAN
〈*t*-Values of Dummy Variables Estimated from the Rolling Regressions〉

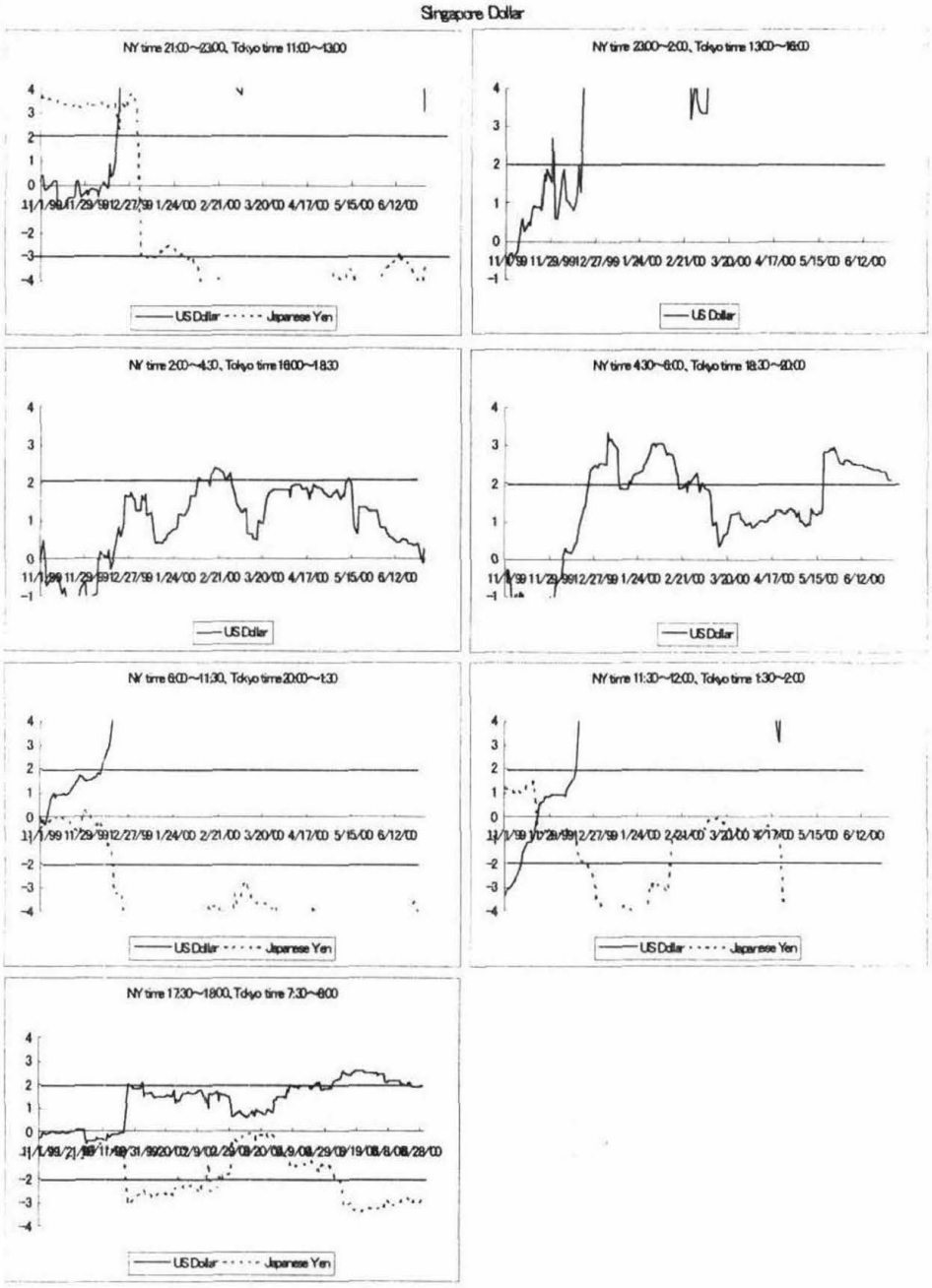


FIGURE 3-1

STRUCTURAL STABILITY TEST AROUND EARLY 2000:

THE CASE OF SINGAPORE

<*t*-Values of Dummy Variables Estimated from the Rolling Regressions>

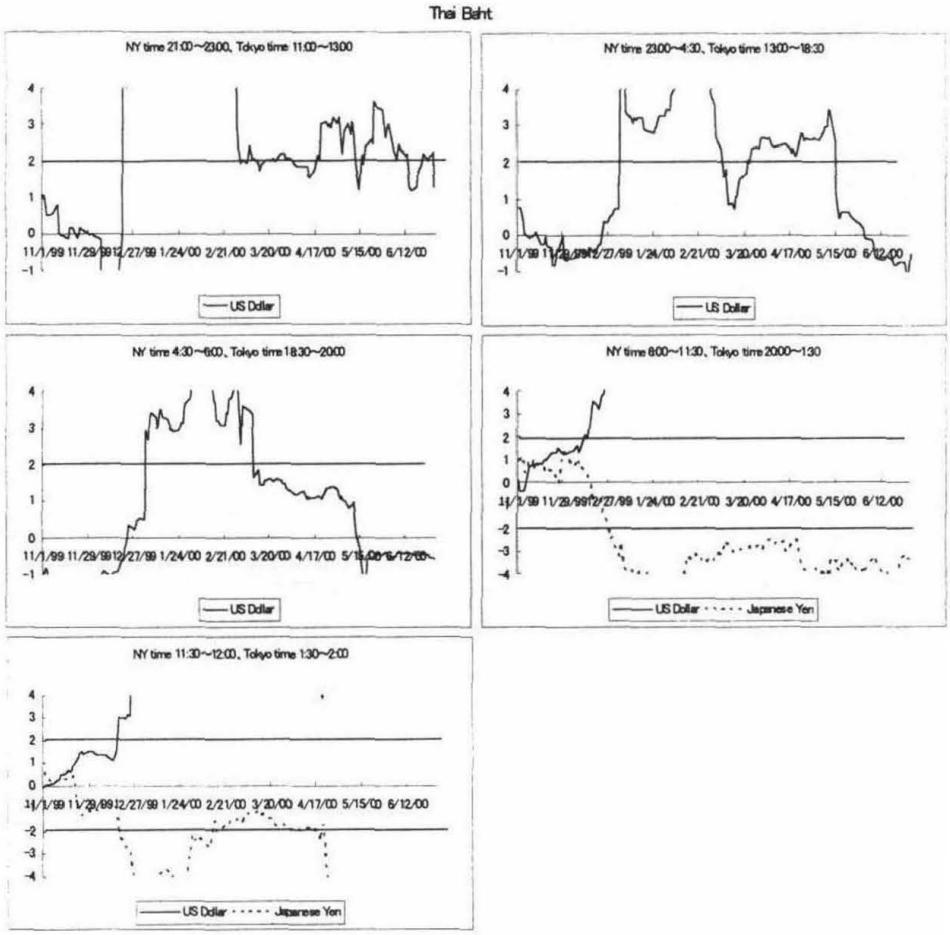


FIGURE 3-2

STRUCTURAL STABILITY TEST AROUND EARLY 2000:

THE CASE OF THAILAND

<*t*-Values of Dummy Variables Estimated from the Rolling Regressions>

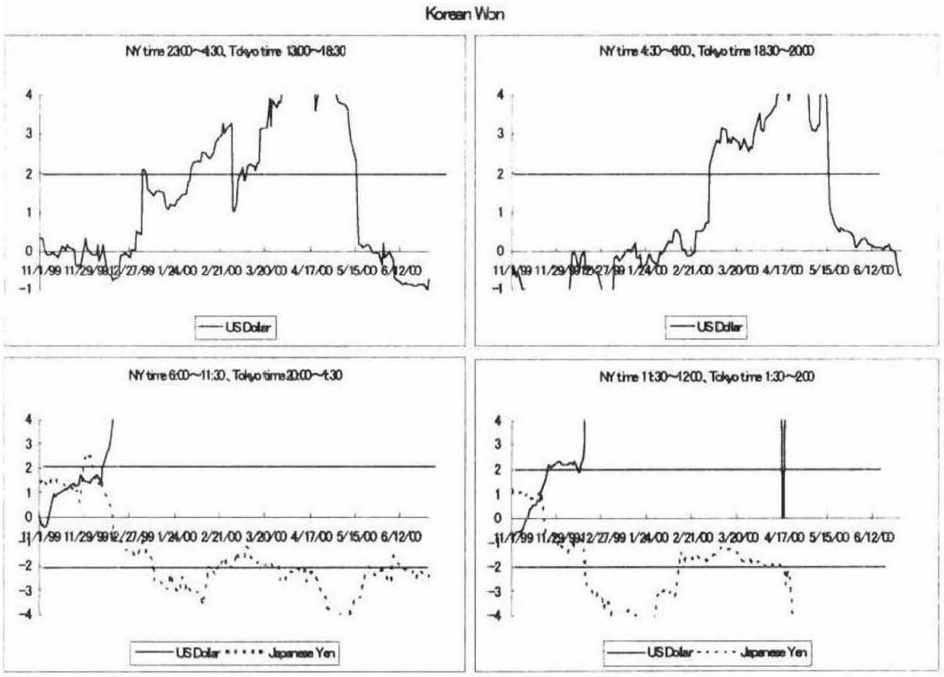


FIGURE 3-3

STRUCTURAL STABILITY TEST AROUND EARLY 2000:

THE CASE OF KOREA

<*t*-Values of Dummy Variables Estimated from the Rolling Regressions>

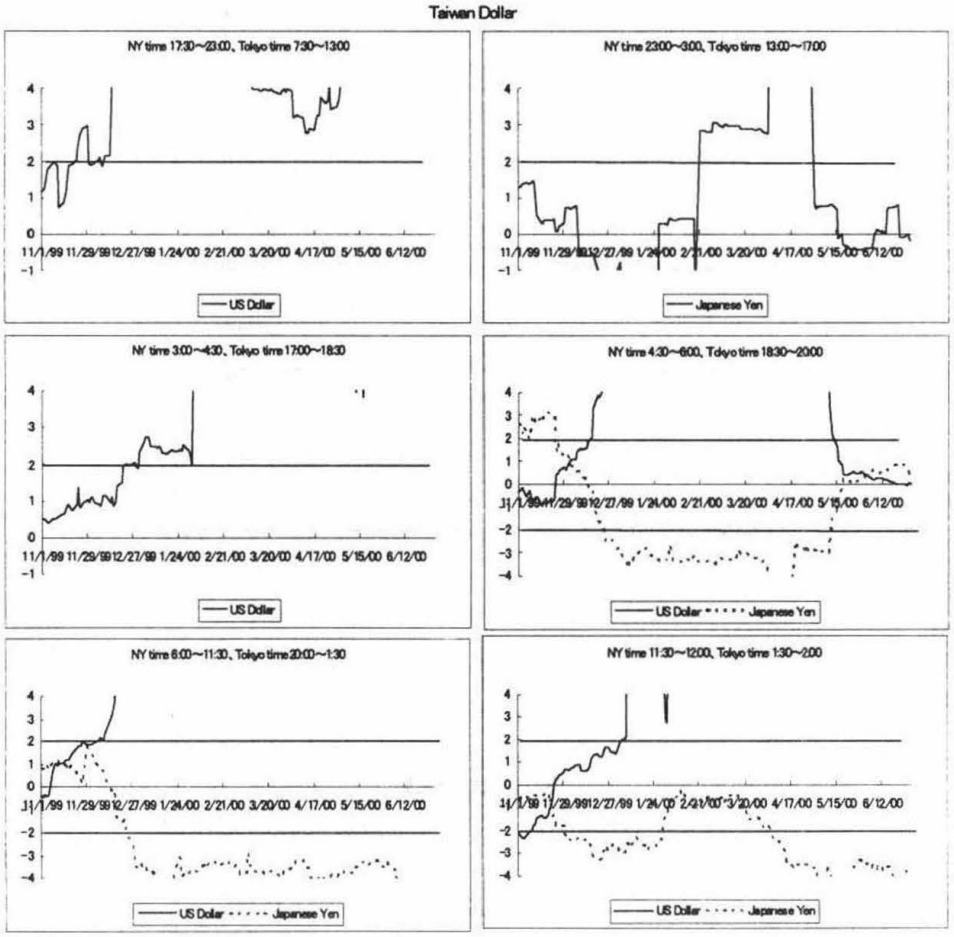


FIGURE 3-4

STRUCTURAL STABILITY TEST AROUND EARLY 2000:
THE CASE OF TAIWAN

<*t*-Values of Dummy Variables Estimated from the Rolling Regressions>

to exceed two from late December 1999 to early 2000. This supports the view that the East Asian exchange rates had a structural break around early 2000 when some East Asian countries introduced inflation targeting effectively.

VII. Comparison of Exchange Rate Volatility

Until the last sections, we have investigated how and when the East Asian currencies changed their correlations with the U.S. dollar and the Japanese yen. We first found that the Japanese yen temporarily increased the correlations with the East Asian currencies after the crisis. We, however, found that two structural breaks reduced the correlations with the Japanese yen and increased the correlations with the U.S. dollar in the East Asian currencies. As a result, in terms of the correlations, the East Asian currencies began reverting back to de facto pegs against the U.S. dollar after early 2000.

The high correlations with the U.S. dollar, however, do not necessarily mean that the East Asian currencies have de facto pegs against the U.S. dollar. During most of the time zones, the coefficient of the Japanese yen was significantly different from zero in most of the countries even after early 2000. This implies that de facto pegs against the U.S. dollar after early 2000 were accompanied by some degree of flexibility that did not exist in the pre-crisis period.

The purpose of this section is to explore how the structural breaks changed volatility of exchange rates in the post-crisis period. By using the daily data (the data at 11:30am in New York in each business day), we calculate variation coefficients for the logged level of each East Asian exchange rate against the U.S. dollar through dividing its standard deviation by its mean. We also calculate the standard deviations and ranges for the daily growth rate of each East Asian exchange rate against the U.S. dollar. We compare the calculated variation coefficients as well as the standard deviations and the ranges among five sample periods: (i) from January 7th 1997 to June 15th 1997, (ii) from July 2nd 1997 to January 31st 1998, (iii) from February 1st 1998 to the end of August 1998, (iv) from the September 2nd 1998 to December 29th 1999, and (v) from January 4th 2000 to September 5th 2002. The period (i) is the pre-crisis period. We choose this period as a benchmark period. The period (ii) is the post-crisis period when many East Asian currencies experienced dramatic depreciations. In periods (iii), (iv), and (v), the East Asian currencies were relatively stabilized. We divide these period by two structural breaks that arose when

Malaysia introduced the fixed exchange rate regime and when some East Asian countries introduced inflation targeting effectively. We calculate the ratios of the variation coefficients in each sub-sample period to those in the pre-crisis period. If the ratios are greater than one, we may conclude that the exchange rates became more flexible against the U.S. dollar than those in the pre-crisis period.

Table 11 reports means, standard deviations, and variation coefficients of the logged level of each East Asian exchange rate against the U.S. dollar for each sub-sample period. It also reports the ratios of the variation coefficients in each sub-sample period to those in the pre-crisis period. When we compare the variation coefficients of each exchange rate, we can easily see that the variation coefficients increased in all of the East Asian currencies after the crisis. The most dramatic increases occurred in the period (ii) when many East Asian currencies experienced dramatic depreciations. The variation coefficients declined after the exchange rates were stabilized, particularly after September 1998. However, except for Malaysia, the ratios were still greater than two even after early 2000. This implies that the levels of the East Asian exchange rates against the U.S. dollar were more flexible even after 2000 than those in the pre-crisis period.

Table 12 summarized volatility of the daily growth rate of each East Asian exchange rate for each sub-sample period. When we compare the variation coefficients of each exchange rate, we can see that the variation coefficients increased in all of the East Asian currencies in the period (ii). This obviously reflects the fact that the East Asian currencies experienced dramatic depreciations. The variation coefficients, however, declined steadily after September 1998. In particular, except for Taiwan, the ratios became lower than one after early 2000. This implies that the growth rates of the East Asian exchange rates against the U.S. dollar after 2000 had a stability that was comparable to those in the pre-crisis period.

TABLE 11

VOLATILITY OF DAILY LOGARITHMIC EXCHANGE RATES AGAINST THE U.S. DOLLAR

① Taiwan Dollar

	(a)1997.1.7-1997.6.15	(b)1997.7.2-1998.1.31	(c)1998.2.1-1998.8.31	(d)1998.9.2-1999.12.29	(e)2000.1.5-2002.9.5
Observations	115	154	151	346	698
Mean (α)	27.61027	30.41252	33.63100	32.48628	32.99810
Standard Deviation (β)	0.14761	2.19412	0.86809	0.74824	1.62919
Variation Coefficient ((β)/(α))	0.00535	0.07215	0.02581	0.02303	0.04937
Ratio of Variation Coefficient (*)		13.49471	4.82814	4.30819	9.23504

② Singapore Dollar

	(a)1997.1.7-1997.6.15	(b)1997.7.2-1998.1.31	(c)1998.2.1-1998.8.31	(d)1998.9.2-1999.12.29	(e)2000.1.5-2002.9.5
Observations	115	154	151	346	698
Mean (α)	1.42827	1.57380	1.66677	1.68720	1.76894
Standard Deviation (β)	0.01336	0.09667	0.05574	0.03132	0.04711
Variation Coefficient ((β)/(α))	0.00935	0.06143	0.03344	0.01857	0.02663
Ratio of Variation Coefficient (*)		6.56633	3.57502	1.98464	2.84673

(Table Continued)

③ Malaysian Ringgit

	(a)1997.1.7-1997.6.15	(b)1997.7.2-1998.1.31	(c)1998.2.1-1998.8.31	(d)1998.9.2-1999.12.29	(e)2000.1.5-2002.9.5
Observations	115	154	151	346	698
Mean (α)	2.49401	3.32496	3.92322	3.80094	3.79997
Standard Deviation (β)	0.01456	0.60177	0.20104	0.01672	0.00300
Variation Coefficient ((β)/(α))	0.00585	0.18099	0.05124	0.00440	0.00079
Ratio of Variation Coefficient (*)		31.00183	8.77787	0.75373	0.13512

④ Korean Won

	(a)1997.1.7-1997.6.15	(b)1997.7.2-1998.1.31	(c)1998.2.1-1998.8.31	(d)1998.9.2-1999.12.29	(e)2000.1.5-2002.9.5
Observations	115	154	151	346	698
Mean (α)	872.28918	1114.13485	1411.04897	1218.52738	1222.00391
Standard Deviation (β)	19.45144	325.85641	111.11731	63.61473	79.53863
Variation Coefficient ((β)/(α))	0.02230	0.29247	0.07875	0.05221	0.06509
Ratio of Variation Coefficient (*)		13.11587	3.53141	2.34116	2.91887

(Table Continued)

⑤ Thai Baht

	(a)1997.1.7-1997.6.15	(b)1997.7.2-1998.1.31	(c)1998.2.1-1998.8.31	(d)1998.9.2-1999.12.29	(e)2000.1.5-2002.9.5
Observations	115	154	151	346	698
Mean (α)	25.74256	38.82225	41.53185	37.83687	42.48220
Standard Deviation (β)	0.51792	7.32354	2.50036	1.29093	2.44786
Variation Coefficient ((β)/(α))	0.02012	0.18864	0.06020	0.03412	0.05762
Ratio of Variation Coefficient (*)		9.37620	2.99232	1.69580	2.89396

⑥ Japanese Yen

	(a)1997.1.7-1997.6.15	(b)1997.7.2-1998.1.31	(c)1998.2.1-1998.8.31	(d)1998.9.2-1999.12.29	(e)2000.1.5-2002.9.5
Observations	115	154	151	346	698
Mean (α)	121.01932	122.81633	135.41444	116.15569	117.71373
Standard Deviation (β)	4.16006	5.49671	6.55690	8.27495	8.79628
Variation Coefficient ((β)/(α))	0.03438	0.04476	0.04842	0.07124	0.07473
Ratio of Variation Coefficient (*)		1.30197	1.40860	2.07243	2.17384

Note: (*) They are relative variation coefficients against the value of the pre-crisis period indicated in column (a).

TABLE 12

VOLATILITY OF DAILY CHANGE OF FOREIGN EXCHANGE AGAINST THE U.S. DOLLAR

① Taiwan Dollar

	(a)1997.1.7-1997.6.15	(b)1997.7.2-1998.1.31	(c)1998.2.1-1998.8.31	(d)1998.9.2-1999.12.29	(e)2000.1.5-2002.9.5
Observations	115	154	151	346	697
Mean	0.00013	0.00121	0.00014	-0.00028	0.00016
Standard Deviation	0.00163	0.00992	0.00766	0.00657	0.00426
Ratio of Standard Deviation (*)		6.08451	4.69731	4.02759	2.61535
Maximum	0.00909	0.05925	0.02482	0.02749	0.05238
Minimum	-0.00928	-0.05838	-0.02005	-0.02829	-0.05392
Range	0.01838	0.11763	0.04487	0.05578	0.10631
Ratio of Range (**)		6.40126	2.44155	3.03565	5.78504

② Singapore Dollar

	(a)1997.1.7-1997.6.15	(b)1997.7.2-1998.1.31	(c)1998.2.1-1998.8.31	(d)1998.9.2-1999.12.29	(e)2000.1.5-2002.9.5
Observations	115	154	151	346	697
Mean	0.00013	0.00121	0.00016	-0.00008	0.00008
Standard Deviation	0.00264	0.00660	0.00972	0.00652	0.00274
Ratio of Standard Deviation (*)		2.49818	3.68172	2.46661	1.03815
Maximum	0.01161	0.02277	0.03062	0.02229	0.01432
Minimum	-0.01140	-0.02532	-0.03452	-0.01876	-0.01320
Range	0.02301	0.04810	0.06513	0.04105	0.02753
Ratio of Range (**)		2.08988	2.83024	1.78382	1.19615

(Table Continued)

③ Malaysian Ringgit

	(a)1997.1.7-1997.6.15	(b)1997.7.2-1998.1.31	(c)1998.2.1-1998.8.31	(d)1998.9.2-1999.12.29	(e)2000.1.5-2002.9.5
Observations	115	154	151	346	697
Mean	0.00003	0.00331	-0.00036	-0.00012	0.00000
Standard Deviation	0.00283	0.01865	0.01671	0.00607	0.00106
Ratio of Standard Deviation (*)		6.58092	5.89624	2.14127	0.37549
Maximum	0.01221	0.06519	0.05623	0.01473	0.01267
Minimum	-0.01235	-0.06513	-0.06192	-0.03831	-0.01313
Range	0.02456	0.13031	0.11815	0.05304	0.02579
Ratio of Range (**)		5.30570	4.81033	2.15940	1.05011

④ Korean Won

	(a)1997.1.7-1997.6.15	(b)1997.7.2-1998.1.31	(c)1998.2.1-1998.8.31	(d)1998.9.2-1999.12.29	(e)2000.1.5-2002.9.5
Observations	115	154	151	346	697
Mean	-0.00007	0.00370	-0.00137	-0.00040	0.00009
Standard Deviation	0.00687	0.04160	0.02404	0.00927	0.00609
Ratio of Standard Deviation (*)		6.05644	3.50096	1.35031	0.88736
Maximum	0.02093	0.15943	0.12352	0.03415	0.03287
Minimum	-0.02650	-0.17148	-0.08148	-0.02572	-0.02704
Range	0.04743	0.33091	0.20500	0.05986	0.05991
Ratio of Range (**)		6.97694	4.32221	1.26217	1.26313

(Table Continued)

⑤ Thai Baht

	(a)1997.1.7-1997.6.15	(b)1997.7.2-1998.1.31	(c)1998.2.1-1998.8.31	(d)1998.9.2-1999.12.29	(e)2000.1.5-2002.9.5
Observations	115	154	151	346	697
Mean	-0.00047	0.00476	-0.00172	-0.00021	0.00019
Standard Deviation	0.00791	0.02164	0.01760	0.00796	0.00419
Ratio of Standard Deviation (*)		2.73506	2.22371	1.00545	0.52918
Maximum	0.03689	0.15906	0.05434	0.02842	0.02914
Minimum	-0.04386	-0.05303	-0.06836	-0.03036	-0.02703
Range	0.08075	0.21210	0.12270	0.05878	0.05617
Ratio of Range (**)		2.62647	1.51939	0.72794	0.69559

⑥ Japanese Yen

	(a)1997.1.7-1997.6.15	(b)1997.7.2-1998.1.31	(c)1998.2.1-1998.8.31	(d)1998.9.2-1999.12.29	(e)2000.1.5-2002.9.5
Observations	115	154	151	346	697
Mean	-0.00014	0.00066	0.00078	-0.000858	0.00020
Standard Deviation	0.00861	0.00870	0.01052	0.01321	0.00632
Ratio of Standard Deviation (*)		1.01003	1.22205	1.53423	0.73419
Maximum	0.02788	0.02038	0.02455	0.05567	0.02129
Minimum	-0.03232	-0.04347	-0.03592	-0.07485	-0.02416
Range	0.06020	0.06385	0.06048	0.13052	0.04545
Ratio of Range (**)		1.06063	1.00457	2.16807	0.75494

Notes: (*) They are relative variation coefficients against the value of the pre-crisis period indicated in column (a).
(**) They are relative range against the value of the pre-crisis period indicated in column (a).

VIII. Alternative Interpretations

Until the last sections, we have demonstrated that the East Asian currencies had changed their correlations with the U.S. dollar and the Japanese yen in September 1998 and in early 2000. We interpreted that the structural breaks arose when Malaysia introduced the fixed exchange rate regime and when some East Asian countries introduced inflation targeting effectively. However, several other interpretations may be possible.

One interpretation is that a change of macroeconomic correlation altered the correlations of East Asian exchange rates with the U.S. dollar and the Japanese yen. Throughout the late 1990s, the U.S. economy was booming, while the Japanese economy experienced a long stagnation. Since East Asian countries had shown a sharp recovery after the middle of 1998, macroeconomic fundamentals had a strong positive correlation with those of Japan in the first half of 1998 but with those of the United States after the latter half of 1998. To the extent that macroeconomic fundamentals affect exchange rates, this may provide a partial explanation on sources of the structural change in September 1998.

However, since the change of macroeconomic correlation was gradual, it cannot explain a drastic structural change that we observed in the previous sections, particularly that in early 2000. More importantly, the feature of the structural change was different in different time zones. It is hard to explain the feature in terms of macroeconomic correlations.

The other interpretation is that a structural change of the Japanese yen/U.S. dollar exchange rate changed the correlations of the East Asian exchange rates. The Japanese yen/U.S. dollar exchange rate had series of structural breaks during the past decade. Figure 4 draws movements of the yen/dollar exchange rates from January 1994 to December 2001. It shows that the yen steadily depreciated against the U.S. dollar and that the rate of depreciation was accelerated after November 1997. The trend of the depreciation had continued until the end of July 1998. However, after August 1998, the yen, in turn, started appreciating against the U.S. dollar and that the appreciation had continued until the end of December 1999. This indicates that if the East Asian currencies had asymmetric responses to appreciation and deprecia-

tion of the yen/dollar exchange rates, they could have had different correlations with the U.S. dollar and the Japanese yen before and after September 1998.

The yen/dollar exchange rates, however, had a tendency to depreciate after early 2000. If the asymmetric responses to the yen/dollar exchange rates were important, the estimated correlations would have been reversed and became similar to those before September 1998 in the post-crisis period. We, however, found that the estimated correlations never returned to those before September 1998. Instead, the East Asian currencies increased correlations with the U.S. dollar after early 2000. The yen/dollar exchange rates are thus not satisfactory in explaining why large structural changes were observed in early 2000.

IX. Concluding remarks

In this paper, we investigated the determinants of the post-crisis exchange rates of five East Asian countries: Singapore, Thailand, Korea, Taiwan, and Malaysia. Based on intra-daily observations, we examined how and when these five East Asian currencies changed their correlations with the U.S. dollar and the Japanese yen. During the time zones when East Asian and European markets were closed, the East Asian currencies kept strong correlations with the U.S. dollar throughout the pos-crisis period. We, however, found two structural breaks in the post-crisis correlations during the time zones when East Asian markets were open. The first structural break arose when Malaysia adopted the fixed exchange rate. The second structural break occurred when Indonesia and Thailand introduced inflation targeting. The structural breaks suggest strong monetary linkages among East Asian countries. After early 2000, the East Asian currencies began reverting back to de facto pegs against the U.S. dollar.

A noteworthy implication from our empirical results was that a regime switch in an East Asian country had an enormously large impact on the exchange rates of other East Asian countries that had no regime switch. This probably reflects the fact that economic linkage among East Asian countries is tight in monetary and real transactions. During the past decade, intra-regional trade among East Asian countries increased dramatically. The increased intra-

regional capital mobility intensified the linkage of financial markets in East Asia. As a result, a regime switch in a country came to have a strong impact on its neighboring economies and that the affected economies came to have another impacts on their neighboring economies in East Asia. Our empirical studies supported this view and suggest that the exchange rate linkage was very important to see why the post-crisis East Asian countries had a tendency reverting back to de facto pegs against the U.S. dollar.

In the present period, several East Asian economies adopt different types of exchange rate regimes; Hong Kong kept its currency board arrangement and the Chinese yuan virtually maintained its peg to the U.S. dollar. After experiencing some transitional regime, Malaysia started pegging to the U.S. dollar on September 1st 1998. In contrast, Thailand, Indonesia, and Korea as well as the Philippines and Taiwan have adopted managed float since the crisis. The so-called floating exchange regimes of these countries are, however, not really floating. The de facto pegs to the U.S. dollar may destabilize the real "effective" exchange rates of these currencies. To avoid another crisis in East Asia, it is an urgent issue to reconsider what is the desirable exchange rate regime in East Asian from a view of regional cooperation.

(*Received 29 October 2003; Revised 13 January 2004*)

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