

FINANCIAL CONTAGION IN THE EAST ASIAN CRISIS

- With Special Reference to the Republic of Korea -

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In this chapter, we analyze empirically the existence and extent of financial contagion in the East Asian crisis. We define financial contagion as a significant increase in correlation of financial variables after controlling fundamentals and common shocks, and we develop an autoregressive model to measure contagion. In particular, we attempt to exclude the common effects of the crisis in Southeast Asia on the East Asian NIE 4, and examine the existence of pure contagion among NIE 4. Our empirical results suggest that the Southeast Asian crisis did not directly trigger the crisis in Korea, but that its fallout to Taiwan played an important role in causing the Korean crisis. This result is consistent with the argument that the crisis in Korea was precipitated by foreign banks that after Taiwan was first affected by the Southeast Asian crisis in October 1997, drastically refused to roll over short-term loans to the Korean financial institutions, rather than portfolio investors.

1. INTRODUCTION

Over the last three years, there has been a growing body of literature on the East Asian crisis. A website created by Roubini, for example, lists more than 500 articles on the crisis. Despite the proliferation of studies on East Asian financial turmoil, the causes of the crisis still remain controversial. Radelet and Sachs (1998), Feldstein (1998), and Stiglitz (1999) argue that the primary source of the crisis was the sudden shifts in market expectations and confidence. According to these authors, foreign lenders and institutional investors were so alarmed by the Thai crisis, which broke out in July 1997, that they abruptly pull their investments out of the other countries in the region, causing the crisis to be contagious. Their withdrawal was in turn prompted by the belief that these countries suffered from the similar structural problems that

had invited a speculative attack in Thailand.

As opposed to this financial panic view, many others, including the IMF, pointed to structural weaknesses and policy distortions as the major causes of the crisis, although they acknowledged that the panic reaction also played a role (Corsetti *et al.*, 1998).

Among the East Asian crisis countries, Korea endured the most painful and unexpected financial turbulence. Over a two-month period, from October to December 1997, this new OECD member was reduced from being the world's 11th largest economy to an economy surviving on overnight loans from the international money markets.

Since the beginning of 1999, Korea has been able to engineer an impressive recovery from the crisis. The exchange rate has been stable between 1,100 and 1,200 won to a dollar, and the stock market has seen a sharp rebound. Furthermore, interest rates are now in the single digits. With the return of consumer confidence, there has been a surge in domestic demand. As a result of this surge and robust export growth, the economy grew more than 10 percent in 1999 in a striking contrast to the previous year's shrinkage of more than six percent. The current account recorded a sizeable surplus, and prices have been stable.

In view of the recent recovery, which is much faster than anticipated, many experts are now asking how a country with strong economic fundamentals like Korea could have become victim to a currency crisis in the first place. If succumbing to the crisis seemed unlikely, the turnaround of Korea has been even more surprising.

Despite Korea's structural weaknesses and policy distortion, the Korean experience raises the question of whether foreign investors should in part be held responsible for creating and deepening the crisis. There is the suspicion that too many foreign banks and institutional investors did not uphold due diligence in their lending to and investment in Korea.

What developments have made foreign investors so drastically change their expectations as to the future prospects of the Korean economy? It is often suggested that foreign investors were increasingly dismayed by and concerned about the structural weaknesses of the Korean economy that made Korea a highly risky place for portfolio investment and bank lending, and that at a certain point they were simply fed up and left. It is true that they have long known and complained about the lack of transparency in corporate management in Korea, always questioned the reliability of balance sheets and income statements of large corporations and banks, and warned about the risks involved in the cross-ownership and cross-debt guarantees between the affiliates of Korea's major conglomerates.¹

These problems, however, were not serious enough for them to contemplate a sudden withdrawal from Korea before the Southeast Asian currency crisis erupted. In fact, even well into the month of November, according to a survey by the Korea Development Institute,² many foreign investors were "optimistic" about the future of the Korean economy. Only two weeks later would they become so negative about it and leave all at once. This mass exodus caused a

bank run problem in which everyone divests from a country or a region at the same time, taking their money out of their investments almost regardless of whether those investments were good or bad.

The chain of events leading up to the crisis in November 1997 therefore shows that Korea has been adversely affected by the contagion of the Southeast Asian crisis and, in particular, that the stock market crash of Taiwan and Hong Kong sparked off the exodus of institutional investors out of Korea. Given the relatively strong economic fundamentals, would Korea not have come under speculative attack had proper measures been taken to contain the Southeast Asian crisis?

The exact causes of the crisis in East Asia will not be known anytime soon. However, the strong recovery underway in East Asia, in particular in Korea, in the past few months adds weight to the panic view. That is, the East Asian crisis should in a large measure be attributed to the panic reaction and herd behavior of foreign investors rather than a deterioration in fundamentals, and for this reason, the Thai crisis was much more contagious than otherwise.

The purpose of this chapter is to analyze empirically the existence and extent of crisis contagion in the eight East Asian countries. In particular, we will focus on the question of whether Korea would have come under speculative attack had proper measures been taken to contain the crisis in the ASEAN countries. We develop an autoregressive model and estimate it for the eight East Asian countries (ASEAN 4 plus NIE 4) to examine the existence and the process of contagion in these countries. In addition, we attempt to exclude the common effects of the crisis in ASEAN 4 on the East Asian NIE 4, and examine the existence of pure contagion among NIE 4. This chapter is organized as follows. Our empirical tests are explained in section 2, and an interpretation of the empirical results is given in section 3. Concluding remarks are in the final section.

2. EMPIRICAL EXAMINATION OF CONTAGION IN EAST ASIA

2.1 Definition of Contagion

Contagion in general refers to the spread of market disturbances from one country to the other, which is observed through movements in exchange rates, stock prices, and interest rates. Empirical examination of the evidence for contagion consists of four types of tests. The first estimates correlation coefficients of financial variables. According to this approach, a marked increase in correlations among markets of different countries is regarded as evidence of contagion (Calvo and Reinhart, 1996 and Frankel and Schmukler, 1996).

However, a high degree of correlation during the crisis period is not sufficient evidence of the presence of contagion. If the two markets are traditionally highly correlated, then one can naturally expect a change in one market in response to a sharp change in the other market. Thus, contagion can be identified only when correlations among markets increase during the crisis period. In this correlation approach, empirical evidence of contagion is stronger, if the increase is statistically significant (Baig and Goldfajn, 1998 and Forbes and Rigobon, 1998).

Even a significant increase in correlations, however, may not prove the existence of contagion, as it may result from major economic shifts in industrial countries and commodity prices as well as changes in domestic economic fundamentals, risk perception and preferences. Bhattacharya *et al.* (1998), Valdes (1997), Arias *et al.* (1998), and Baig and Goldfajn (1998) argue that the correlation estimation must therefore control these variables to identify pure contagion.

Eichengreen *et al.* (1996) and Glick and Rose (1998) define contagion as a case where knowledge of a crisis elsewhere increases the probability of a crisis at home. One advantage of this definition is that it readily allows statistical tests of the existence of contagion. The second approach is based on this definition of contagion. This approach examines whether the likelihood of crisis is higher when there are crises in other countries, by estimating the probability of a crisis conditional on information of the occurrence of crisis elsewhere.

The third type of test estimates volatility among financial markets (Edwards, 1998 and Park and Song, 1998). This approach examines whether conditional variances of financial variables are related to each other among markets in different countries during the crisis period. Usually a GARCH type model is used in this approach. Finally, a fourth type of test examines whether foreign news affects financial variables at home (Kaminsky and Schmukler, 1999 and Ganapolsky and Schmukler, 1998).

There are several empirical studies on contagion of the East Asian crisis. Baig and Goldfajn (1998) show that the cross-countries correlation among currencies and sovereign spreads of Indonesia, Korea, Malaysia, the Philippines, and Thailand significantly increased during the crisis period (from July 1997 to May 1998) as compared to the non-crisis period. They also show that the correlation of residuals from regressions of changes in exchange rate rates, stock returns, and sovereign spreads on domestic fundamentals and common shocks were high and statistically significant during the crisis period. They, however, do not compare the correlation of residuals of the crisis period with that of the non-crisis period.

On the other hand, Forbes and Rigobon (1998) find that the turmoil of the Hong Kong stock market, which started on October 17, 1997 was not contagious to other East Asian countries. They show that the correlation coefficients of stock returns, after controlling the bias related to changes in market volatility, between Hong Kong and other East Asian countries

(Indonesia, Japan, Malaysia, the Philippines, Korea, Taiwan, and Thailand) did not increase significantly during the Hong Kong turmoil as compared to the tranquil period.

Investigating the effects of foreign news on domestic stock returns, Kaminsky and Schmukler (1999) present empirical evidence of contagion in the East Asian financial crisis. According to their results, U.S dollar denominated stock returns in crisis-affected East Asian countries, including Indonesia, Malaysia, the Philippines, Singapore and Thailand, were also significantly influenced by the news generated in other crisis countries in East Asia during the period from the beginning of July 1997 to the end of May 1998.

In this paper, we define financial contagion as a significant increase in correlation of financial prices such as the exchange rate, interest rates, and stock prices experienced by a group of countries, after controlling fundamentals and common shocks, following a crisis elsewhere. Put differently, contagion refers to an excessive comovement of financial variables of a given group of countries during a financial crisis.

We estimate the correlation coefficients of residuals from regression that controls fundamentals and common shocks as Baig and Goldfajn (1998) do. In addition, we also estimate for the non-crisis period, and examine whether there was a significant increase in correlation between the two periods. As a proxy for fundamentals, we use a domestic interest rate variable instead of domestic news, which may not properly reflect continuous changes in fundamentals.

2.2 The Model

In order to measure the existence and extent of contagion during the East Asian crisis period, this paper focuses on two financial markets--the foreign exchange and stock markets--and develops an autoregressive model to determine the exchange rate and stock return.

Our model consists of the following two equations:

$$\Delta S_t^j = c_0 + \sum_{i=1}^k \mathbf{a}_i \Delta S_{t-i}^j + \sum_{i=0}^l \mathbf{b}_i \Delta Yen_{t-i} + \sum_{i=0}^m \mathbf{g}_i i_{t-i}^j + \sum_{i=1}^n \mathbf{d}_i i_{t-i}^{us} + e_t^j \quad (1)$$

$$\Delta R_t^j = c_0 + \sum_{i=1}^k \mathbf{a}_i \Delta R_{t-i}^j + \sum_{i=0}^l \mathbf{b}_i (\Delta Yen_{t-i} - \Delta S_{t-i}^j) + \sum_{i=0}^m \mathbf{g}_i i_{t-i}^j + \sum_{i=1}^n \mathbf{d}_i R_{t-i}^{us} + e_t^j \quad (2)$$

S_t^j is log of the exchange rate of country j 's currency per U.S. dollar, and Yen_t is log of the yen-dollar exchange rate. i_t^j and i_t^{us} indicate short-term interest rates in country j and the U.S., respectively. We use the overnight call rate for i_t^j and the federal fund rate for i_t^{us} . R_t^j and R_t^{us} are stock returns in country j and the U.S. at time t measured by a stock price

index. Δ indicates the first order difference operator, and e_t^j is an error term. Country j is one of the eight East Asian countries. In our specification, we include only lagged values of R_t^{us} and i_t^{us} in equations (1) and (2), due to the time difference between East Asia and the U.S. In the case of Hong Kong, we use a variable measuring foreign exchange market pressure instead of changes in the foreign exchange rate since Hong Kong has maintained a currency board system.³ $(\Delta Yen_t - \Delta S_t^j)$ in equation (2) indicates changes in the yen-dollar exchange rate relative to changes in the exchange rate of the currency of country j .

Changes in the yen-dollar exchange rate and U.S. interest rate reflect common shocks, whereas changes in domestic economic fundamentals are assumed to be explained by changes in the domestic interest rate. We determine the order of lags on the basis of Schwarz Information Criterion and significance of variables.

Our empirical examination is divided into two stages. In the first stage, we examine the existence of crisis contagion among the eight East Asian countries, namely four ASEAN countries (ASEAN 4)--Indonesia, Malaysia, the Philippines, and Thailand--and four East Asian NIEs (NIE 4)--Hong Kong, Korea, Singapore, and Taiwan. The second stage analyses crisis contagion among NIE 4 after adjusting the impact of the crisis developments in the ASEAN 4 on these economies.

Using daily data, we estimate equations (1) and (2) for the eight countries and calculate residuals for the crisis period, which runs from July 2, 1997 to August 31, 1998. Residuals of equations (1) and (2) measure changes in the exchange rate and stock returns that are not explained by the independent and lagged dependent variables. During the crisis period, an unexpected development in country j or the spillover effect of the crisis in other countries on country j is reflected in the residuals. Consequently, if residuals of any pair of the sample countries are correlated, then it is highly likely that the crisis was contagious between the two countries. However, estimated residuals may show a significant degree of correlation even in a tranquil period due to common shocks which are not captured by equations (1) and (2). In order to isolate the effect of these common shocks, we also estimate equations (1) and (2) for the non-crisis period from January 2, 1995 to April 30, 1997, and then compare the two sets of equation whether there was any significant increase in correlation between a crisis and tranquil period.

It is found that the explanatory power of the two equations is, in general, acceptable in most cases, considering that dependent variables are expressed in terms of change except for Indonesia and Malaysia for equation (1) during the non-crisis period (see Table 1). For equation (2), the explanatory power is low for Korea, Taiwan, and Thailand during the non-crisis period.

To test the significance of changes in correlation, we use Anderson's z -test (1958). Null hypothesis and alternative hypothesis of the test are $H_0 : r_c^{ij} = r_{nc}^{ij}$ and $H_1 : r_c^{ij} > r_{nc}^{ij}$

where r_c^{ij} and r_{nc}^{ij} are correlation coefficients between country i and j during the crisis and non-crisis period, respectively.⁴

Our test results of equation (1), which are reported in Table 2, show that among ASEAN 4, correlation of residuals of the foreign exchange rates rose significantly during the crisis period, whereas among NIE 4 there occurred a significant increase in correlation between Taiwan on the one hand and Singapore, Hong Kong and Korea on the other. Between ASEAN 4 and NIE 4, only Singapore and Taiwan experienced a significant increase in correlation of residuals of the exchange rates with all of ASEAN 4 during the crisis period. A similar development can be found between Korea on the one hand and ASEAN 4, but the increase was not statistically significant.

As for the developments in stock markets, we observe that among ASEAN 4, the coefficient of correlation of residual of equation (1) for Thailand increased *vis-à-vis* Indonesia and the Philippines but not Malaysia. Between ASEAN 4 and NIE 4, stock prices of both Taiwan and Korea moved closely together with those of Indonesia, Malaysia, and Thailand (see Table 3).

The cases of Hong Kong and Singapore are somewhat surprising in that there was no evidence of significant comovement of its stock market together with those of ASEAN 4, except for the Philippines. This result, however, does not mean that stock markets of both Hong Kong and Singapore were insulated from market developments in ASEAN 4, whereas the markets of Korea and Taiwan were not. Instead, the weak significance of the increase in correlation of Hong Kong and Singapore with ASEAN 4 during the crisis period results from a traditionally close relation between the markets of the two groups of the countries during a normal period. That is, before the crisis, it is likely that the markets of ASEAN 4 were more closely integrated with those of Hong Kong and Singapore than Korea and Taiwan. Because of this market integration, the correlation coefficients may not have gone up during the crisis period as much as otherwise. Our results also indicate that among the NIE group, stock prices of Hong Kong, Taiwan, and Singapore moved closely together, but the Korean market reacted only to developments in the Singapore market.

As noted earlier, correlation coefficients of residuals among the sample countries are likely to be biased as a measure of contagion, because they cannot differentiate between changes in financial variables caused either by crisis developments or common shocks. For example, an increase in correlation between Taiwan and Korea may reflect crisis developments in ASEAN 4, which may have affected the financial markets of the two countries simultaneously.

In order to eliminate this bias and to test the existence of pure contagion among NIE 4 during the crisis, we estimate the following equation for these countries:

$$\hat{u}_t^j = \mathbf{a}_1 \hat{u}_t^I + \mathbf{a}_2 \hat{u}_t^M + \mathbf{a}_3 \hat{u}_t^P + \mathbf{a}_4 \hat{u}_t^T + e_t \quad (3)$$

where \hat{u}_t^j is the residual from equation (1) or (2) for country j which is one of NIE 4 and \hat{u}_t^I , \hat{u}_t^M , \hat{u}_t^P , and \hat{u}_t^T are residuals from equation (1) or (2) for Indonesia, Malaysia, the Philippines, and Thailand, respectively. Since these residuals of NIE 4 are adjusted for the crisis in ASEAN 4, their correlations may identify and gauge the extent of crisis contagion between any pair in the NIE group.

The test results of equation (3) are presented in Tables 4 and 5. Compared to the results in Tables 2 and 3, correlation coefficients of residuals among NIE 4 obtained from estimation of equation (3) are lower than those from equations (1) and (2) during the crisis period, suggesting that there existed common effects of the crisis in ASEAN 4 on NIE 4.

The results also indicate that financial turbulence was contagious among NIE 4 during the crisis, even after common effects from ASEAN 4 were controlled for. For example, in the case of the foreign exchange market, the coefficients of correlation of residuals for Taiwan with those of Hong Kong and Korea shot up during the crisis period as compared to tranquil periods. There was no measurable interaction between the foreign exchange markets of Taiwan on the one hand and those of Hong Kong and Korea during the periods preceding the crisis. However, during the crisis the correlation coefficient rose to 0.10 *vis-à-vis* Hong Kong from zero and 0.19 with Korea from 0.04. These changes were also statistically significant.

With regard to Singapore, Taiwan experienced a sharp increase in correlation during the crisis period in the first stage of estimation involving all eight East Asian countries. When ASEAN 4 are excluded in the second stage, the correlation coefficient between the two rose to a lesser degree, and its statistical significance disappeared, suggesting that the increase could be attributed to the common effect of the crisis in ASEAN 4 on the two countries.

Combining the results of estimation of contagion among the eight sample countries (first stage) and that of only NIE 4 (second stage), one could conclude that the crisis that broke out first in Thailand was contagious to NIE 4 as the crisis effect spilt over into the foreign exchange and stock markets of NIE 4. When the common effect of the crisis in ASEAN 4 on NIE 4, however, are controlled for, our results show that the effects of financial turbulence in Taiwan, which in turn was caused by the turmoil in ASEAN 4, were transmitted to the foreign exchange markets of both Hong Kong and Korea, further deepening the crisis in the two countries.

Why was Taiwan so important in spreading the crisis that erupted in Thailand to Hong Kong and Korea? Our interpretation refers to the channel of contagion that focuses on economic similarities. Taiwan, Hong Kong, and Korea were fast growing economies. These East Asian “miracle” countries shared the export-oriented development strategy and were increasingly relying on the markets of ASEAN 4 for their export earnings. When foreign banks and institutional investors saw that such a stable country like Taiwan with strong

fundamentals was vulnerable to the crisis in Southeast Asia, they must have concluded that both Hong Kong and Korea would not be immune from the crisis. Realizing these possible consequences of the Southeast Asian crisis, they started attacking the foreign exchange markets of Hong Kong and Korea. Hong Kong was the first to be attacked; it was able to withstand the crisis, whereas Korea was not.

As for developments in the stock markets of NIE 4 during the crisis period, we observe a large increase in correlation between Hong Kong and Taiwan and between Hong Kong and Singapore even after the effects of the ASEAN crisis are controlled for. This result suggests that at least among the three countries the contagious effects were transmitted through the stock market. A similar development cannot be found between Korea on the one hand and the other NIEs, although Korea's stock market was also severely buffeted by the ASEAN crisis. This result is consistent with the argument that the crisis in Korea was precipitated by foreign banks that refused to roll over short-term loans and curtailed drastically inter-bank lending, rather than foreign equity investors.

2.3 Specification Adjustments

Our model consisting of equations (1) and (2) is defective as a framework for identifying and measuring contagion in two respects. One defect is that it cannot capture potential changes in the pattern of behavior of market participants during the crisis period. It is often argued that foreign lenders and portfolio investors exhibited herd behavior and also were prone to panic to the onset of the crisis. If this is true, then coefficients of independent variables of equations (1) and (2) could change once market participants perceive the possibility of crisis contagion.

Another criticism may be that the two equations determining the exchange rate and stock returns are not specified in a reduced form since in both equations the domestic short-term interest rate, which is an endogenous variable, enters as an independent variable. In our model, the interest rate variable is included as a proxy variable to capture changes in domestic fundamentals. However, since during the crisis period, domestic market interests rose markedly, residuals of equations (1) and (2) may not measure the extent of contagion properly, because the inclusion of i_t^j could alter the structure and the size of residuals of both equations during the crisis.

In order to remedy these weaknesses, the following two adjustments are made in our estimation. First, we estimate the two equations using only the data of the non-crisis periods before the onset of financial turmoil. We then use these equations to calculate the residuals of the crisis period. This adjustment attempts to show the difference in the magnitudes of residuals when the structure of the model is assumed to change as a result of the crisis and when it is not.

It should be noted that the foreign exchange markets of Indonesia, the Philippines, and Thailand experienced two different types of structural changes: one from the change in the exchange rate system from a strictly managed floating to a free floating system, and the other from the financial crisis. In our new estimation, however, we make an adjustment only for the structural changes originating in financial crisis. Accordingly, in calculating residuals of these three countries for the crisis period, we use the results from the estimation of equation (1) for the period from October 1, 1998 to June 30, 1999, when the three countries were on a free floating system without severe financial turbulences.

Our results of estimation adjusted for possible structural changes are shown in Tables 6 through 9. These results show that estimated values of coefficients of equations (1) and (2) for the crisis period are different from those for the non-crisis period. This can be seen from the fact that correlation coefficients with the adjustment for the crisis period are different from those without adjustment. For example, we can see from Tables 6 and 9 that correlation coefficients of residuals from equation (2) with adjustment are higher than those without adjustment in most of cases.⁵

The results of significance tests, however, are almost identical to those of the model without the adjustment.⁶ Our previous finding that financial turbulence was contagious among NIE 4 during the crisis period even after the common effects of crisis in ASEAN 4 on this region are considered is still valid. That is, the results of the new approach also suggest that there existed a contagion process between foreign exchange market of Taiwan on one hand and those of Korea and Hong Kong, as well as among the stock markets of Hong Kong, Singapore and Taiwan.

We also respecify the dependent variable of equation (2) in order to derive a reduced form equation by excluding the interest rate as an independent variable from the equation. For this purpose, we introduce a variable measuring foreign exchange market pressure as the dependent variable of equation (1). This variable is defined as a weighted sum of changes in both the exchange rate and interest rate where the relative weight is determined so as to equate the conditional variances of the two variables. In this new approach, we also estimate the model in terms of the non-crisis period data, and then use this structure to calculate the residuals of the crisis period. The results of this new approach are found in Tables 10 and 11.

This change lowers the values of correlation coefficients for the crisis period compared to the original specification. This implies that the foreign exchange market pressures in East Asian countries were less related than foreign exchange rates during the crisis.⁷ The results of significance tests, however, are almost identical to those of our earlier approaches. Particularly, in the case of NIE 4 analysis, the increase in the correlation coefficient between Taiwan and Korea during the crisis still remains significant. The increase in the correlation coefficient between Taiwan and Hong Kong, however, is no longer significant.

3. INTERPRETATION OF THE EMPIRICAL RESULTS

Developments in East Asian financial markets after the crisis touched off in Thailand in July 1997 suggest that the Thai crisis spread first to the neighboring ASEAN economies and then to NIE 4. Among the four more advanced economies in North East Asia, Singapore was the first to experience a serious fallout of the crisis in Southeast Asia, followed by Taiwan. The crisis then reached Hong Kong. The stock market plunge in Hong Kong during the third week of October 1997 brought about the dive in the Korean market and outflows of foreign equity investment in subsequent weeks.

According to our estimation of correlations of residuals of equation (1), the crisis in ASEAN 4 was not as contagious to Hong Kong and Korea as much as it could have under different circumstances. However, there is clear evidence that Taiwan's financial turbulence spread to both Hong Kong and Korea through the foreign exchange market. Therefore, a series of events that took place before Korea sought IMF emergency financing suggests that Taiwan was at the center of the East Asian contagion process in that only after Taiwan came under speculative attack, Hong Kong experienced, and then Korea succumbed to, a similar attack.

During the crisis, however, we observe somewhat different developments in the stock markets of the eight sample countries. It is clear that the stock markets of Taiwan, Hong Kong, and Singapore were closely linked to each other, and as a result of this linkage we find evidence that the crisis became contagious through the stock market. With the onset of the Southeast Asian crisis, the stock market collapse in ASEAN 4 spilt over into the markets of all of the NIEs, including Korea. Somewhat unexpectedly, however, we find that the stock market plunge in Taiwan, Hong Kong, and Singapore did not cause the sinking of the market in Korea, as much as it was expected.

One explanation for the initial effects of collapse of ASEAN 4 on NIE 4, including Korea, is that foreign investors, in particular institutional investors such as open-end emerging market fund manager may have had to sell off stocks issued by firms in other emerging market economies such as Korea and Taiwan after the Thai crisis in order to raise cash, as they would naturally expect to see a high frequency of redemption in the wake of the Thai crisis. Another interpretation is that the Thai crisis could well have induced foreign institutional investors to sell off their holdings in Hong Kong, Korea, and Taiwan in order to rebalance their portfolios.

However, the foreign investors' sell off was not serious enough to precipitate a financial crisis in Korea, largely because their holdings accounted for less than 15 percent of total capitalization of the Korean stock market at the time of crisis. Only when Taiwan became a target of speculative attack following the crisis in ASEAN 4 did foreign banks with a large

exposure to Korea began recalling their short and medium-term loans, reducing the availability of trade credit facilities and cutting off the lines of credit. This provoked a liquidity crisis in Korea's banking sector, which was in turn translated into a drainage of foreign exchange reserves. In the end, the drainage led to the collapse of the foreign exchange market.

What was so surprising about the crisis in Korea was that as late as in October 1997, no one including the IMF and the international credit agencies could have predicted that only two months later the economy would suffer such a severe financial distress in which the won fell by more than 50 percent against the U.S. dollar between November 19, 1997, when Korea decided to accept an IMF rescue plan and December 24, 1997, when the G-7 countries came out to pledge additional financing to avert Korea's debt default. During the same period, the stock price index (KOSPI) plummeted by 30 percent, and the short-term interest rate shot up to 40 percent per annum.

One month after Thailand came under speculative attack in July 1997, foreign investors began withdrawing their funds from the Korean stock market and out of the country, and by the fourth week of September, the stock price index fell by more than 100 points, from more than 800 before the Thai crisis. Until then Korean banks had access to international short-term money and also to the inter-bank loan market. During October, foreign portfolio investors moved out of the stock market in droves, and Korean banks found it increasingly difficult to secure new loans or to rollover the existing short-term loans. The total amount of short-term foreign liabilities at financial institutions stood at around US \$63 billion during the first nine months of the year. Within two months, the figure fell by US \$16 billion, because of foreign banks' refusal to renew short-term loans and trade related credit facilities (see Table 12).

Denied access at foreign banks, Korean financial institutions were forced to turn to the Bank of Korea for liquidity. In November alone, the Bank of Korea lost US \$15 billion of its reserves. Beginning of December, the central bank had usable reserves less than US \$8 billion (see Table 13).

Unable to control the situation, the Korean government decided to approach the IMF for assistance on November 21. Although the negotiation between the Korean government and the IMF was completed in a record time of 10 days by December 3 and secured a total of US\$ 21 billion for an emergency financing, the IMF package did little to allay fears and stabilize financial markets. The exchange rate of the Korean won continued to depreciate against the U.S. dollar, and the Bank of Korea was not able to build up its of usable reserves. The financial situation was unsustainable and in order to stop further hemorrhaging of the Korea economy, the IMF and G7 countries came up with a US \$10 billion emergency financing program, and finally, this package succeeded in turning the market confidence around.

Why did then the foreign investors, in particular international banks and institutional investors including hedge fund managers, panic and pull out their investments suddenly and all

at once? As explained before, they must have concluded that if Taiwan with such strong economic fundamentals could become a target of speculative attack, a country like Korea with somewhat weaker fundamentals would be the next.

They were also concerned about the possibility of competitive devaluation in East Asia. Most of the East Asian countries were locked in competition for a large export market share both within the region and in the U.S. and Europe. If Taiwan's exchange rate depreciates *vis-à-vis* the U.S. dollar, they reasoned that Korea would also have readjusted their exchange rate so as not to lose their export competitiveness as compared to that of Taiwan. This possibility of competitive devaluation could certainly have deepened the crisis and hastened the departure of foreign investors.

4. CONCLUDING REMARKS

While the extent and depth of the crisis in Korea should in part be attributed to structural weaknesses and policy distortions, foreign investors should largely be held responsible for deepening the crisis by overreacting to a deterioration in financial conditions of corporations and financial institutions. One could also ask whether Korea would have avoided the trauma had the channels of contagion of the crisis been blocked off through multilateral cooperation at the early stage of the crisis. The rapid recovery of the economy in the past few months suggests that it would have, and our empirical study, while limited in scope, supports this view.

A growing number of recent studies on contagion show that macroeconomic similarities, strong trade and financial linkages between countries are the causes of spreading a crisis in one country to others. Before the crisis broke out, East Asian NIEs did not share many macroeconomic similarities with ASEAN 4. They were not linked with the Southeast Asian countries in terms of capital account transactions. Although their exports to the region were growing, their linkage in trade with ASEAN 4 was not strong enough to serve as a major channel of contagion.⁸ This leads to the conclusion that financial panic and herd behavior were important causes of spreading the Thai crisis to NIE 4. The financial markets of NIE 4 suffered initially the fallout of the crisis in ASEAN 4. But the fallout effect could have been measurable had foreign institutional investors been less frightened about the ensuing financial instability in Taiwan. Once they saw the vulnerability of Taiwan to crisis, it appears that they concluded that Hong Kong and Korea were equally assailable.

Notes

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1. Banks and other financial institutions lent large sums of money to the conglomerates. When these are netted out, the cross-guarantees mean that in many cases, the loans to the chaebols are not backed by collateral or payment guarantees, giving rise to greater risks. Foreign investors had long been aware of this but thought nothing of it until just before the crisis.

2. See Korea Herald, November 18, 1997.

3. Eichengreen et al. (1996) measure foreign exchange market pressure by the weighted sum of changes in nominal exchange rate, interest rate and foreign exchange reserves. Since the daily data for foreign exchange reserves are not available, we define, in this paper, the foreign exchange market pressure of Hong Kong as a weighted sum of changes in the exchange rate and interest rate where the relative weight is determined so as to equate the conditional variances of the two variables.

4. Anderson's z-test statistics are defined as follows :

$$Z_0 = \frac{|Z_c - Z_{nc}|}{\sqrt{\frac{1}{(n_c - 3)} + \frac{1}{(n_{nc} - 3)}}$$

where $Z^p = \frac{1}{2} \log \frac{1+r_p^{\#}}{1-r_p^{\#}} (p = nc, c)$, and $\hat{r}_p^{\#}$ is estimated correlation coefficients. n_c and n_{nc} are the number of observations for crisis period and non-crisis period, respectively.

5. Correlation coefficients of residuals of equation (2) with the adjustment are higher in 22 out of a total of 28 cases for the eight-country sample and 4 out of the six cases for the 4 NIE sample than without adjustment. In the case of equation (1), correlation coefficients are higher in about a half of the total cases.

6. This may stem from the low explanatory power of our model as can be seen Table 1. This implies that some of the important variables that explain stock returns and changes in exchange rates may be omitted from our model. The low explanatory power also implies that daily fluctuations of these variables are more closely related to expectation changes in market sentiments rather than fundamentals and common shocks.

7. Correlation coefficients are lower in 16 out of 28 cases for the eight-country sample compared to the original specification, while in the case of NIE 4, all correlation coefficients are lower.

8. Singapore is probably an exception. It had a strong direct trade linkage with Malaysia and Thailand before the crisis broke out .

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Table 1: Explanatory Power of the Model

Dep. Variables	Changes in Exchange Rate		Stock Returns	
Country \ Period	Non-Crisis	Crisis	Non-Crisis	Crisis
Indonesia	0.05	0.08	0.16	0.18
Malaysia	0.06	0.12	0.10	0.20
Philippines	0.14	0.14	0.11	0.21
Thailand	0.33	0.17	0.06	0.15
Hong Kong	0.10	0.09	0.23	0.24
Korea	0.13	0.32	0.04	0.18
Singapore	0.13	0.20	0.17	0.25
Taiwan	0.16	0.10	0.02	0.14

Note: Numbers indicate adjusted R^2 .

Table 2: Test of Contagion among Eight East Asian Countries () - Foreign Exchange Market

A. Non-Crisis Period

Countries	Indonesia	Malaysia	Philippines	Thailand	Hong Kong	Korea	Singapore	Taiwan
Indonesia	1.00							
Malaysia	0.09	1.00						
Philippines	0.02	-0.04	1.00					
Thailand	0.05	0.13	-0.01	1.00				
Hong Kong	0.06	0.03	0.11	0.11	1.00			
Korea	0.04	0.03	-0.05	0.04	0.03	1.00		
Singapore	0.03	0.35	-0.09	0.22	0.01	0.09	1.00	
Taiwan	0.01	-0.02	-0.02	-0.05	0.00	0.04	-0.02	1.00

B. Crisis Period

Countries	Indonesia	Malaysia	Philippines	Thailand	Hong Kong	Korea	Singapore	Taiwan
Indonesia	1.00							
Malaysia	0.44	1.00						
Philippines	0.20	0.26	1.00					
Thailand	0.40	0.51	0.37	1.00				
Hong Kong	-0.03	0.10	0.15	0.09	1.00			
Korea	0.08	0.07	0.02	0.04	0.08	1.00		
Singapore	0.41	0.64	0.27	0.51	0.09	-0.07	1.00	
Taiwan	0.18	0.25	0.13	0.33	0.14	0.19	0.23	1.00

C. Significance Test

Countries	Indonesia	Malaysia	Philippines	Thailand	Hong Kong	Korea	Singapore	Taiwan
Indonesia	-							
Malaysia	5.13*	-						
Philippines	2.35*	4.06*	-					
Thailand	5.00*	5.80*	5.14*	-				
Hong Kong	-1.21	1.01	0.63	-0.28	-			
Korea	0.61	0.61	0.83	0.04	0.65	-		
Singapore	5.48*	5.35*	4.88*	4.67*	1.10	-2.20	-	
Taiwan	2.29*	3.71*	1.93**	5.28*	1.91**	2.04**	3.40*	-

Notes: 1) Figures in Tables A and B indicate correlation coefficients, and those of Table C are z-statistics.
 2) * : Significant at 1% level, ** : Significant at 5% level.

Table 3: Test of Contagion among Eight East Asian Countries () - Stock Market

A. Non-Crisis Period

Countries	Indonesia	Malaysia	Philippines	Thailand	Hong Kong	Korea	Singapore	Taiwan
Indonesia	1.00							
Malaysia	0.34	1.00						
Philippines	0.36	0.33	1.00					
Thailand	0.21	0.32	0.19	1.00				
Hong Kong	0.26	0.32	0.18	0.23	1.00			
Korea	-0.01	-0.02	0.03	-0.03	0.05	1.00		
Singapore	0.40	0.57	0.28	0.37	0.42	0.02	1.00	
Taiwan	0.05	0.11	0.09	0.00	0.09	0.03	0.13	1.00

B. Crisis Period

Countries	Indonesia	Malaysia	Philippines	Thailand	Hong Kong	Korea	Singapore	Taiwan
Indonesia	1.00							
Malaysia	0.23	1.00						
Philippines	0.26	0.09	1.00					
Thailand	0.38	0.34	0.28	1.00				
Hong Kong	0.34	0.28	0.36	0.29	1.00			
Korea	0.04	0.19	0.08	0.23	0.03	1.00		
Singapore	0.43	0.40	0.40	0.44	0.59	0.13	1.00	
Taiwan	0.17	0.23	0.15	0.20	0.23	0.10	0.32	1.00

C. Significance Test

Countries	Indonesia	Malaysia	Philippines	Thailand	Hong Kong	Korea	Singapore	Taiwan
Indonesia	-							
Malaysia	-1.74	-						
Philippines	-1.51	-3.50	-					
Thailand	2.51*	0.41	1.36***	-				
Hong Kong	1.09	-0.64	2.63*	0.94	-			
Korea	0.81	2.99*	0.75	3.76*	-0.32	-		
Singapore	0.49	-3.90	1.72**	1.19	3.12*	1.50***	-	
Taiwan	1.73**	1.87**	0.83	3.00*	1.99**	0.94	2.91*	-

Notes: 1) Figures in Tables A and B indicate correlation coefficients, and those of Table C are z-statistics.

2) * : Significant at 1% level, ** : Significant at 5% level, *** : Significant at 10% level.

Table 4 : Test of Contagion among East Asian NIE 4 () - Foreign Exchange Market

A. Non-Crisis Period

Countries	Hong Kong	Korea	Singapore	Taiwan
Hong Kong	1.00			
Korea	0.03	1.00		
Singapore	0.00	0.09	1.00	
Taiwan	0.00	0.04	-0.01	1.00

B. Crisis Period

Countries	Hong Kong	Korea	Singapore	Taiwan
Hong Kong	1.00			
Korea	0.09	1.00		
Singapore	0.04	-0.14	1.00	
Taiwan	0.10	0.19	0.01	1.00

C. Significance Test

Countries	Hong Kong	Korea	Singapore	Taiwan
Hong Kong	-			
Korea	0.07	-		
Singapore	0.55	-3.02	-	
Taiwan	1.36 ^{***}	2.03 ^{**}	0.23	-

Notes: 1) Figures in Tables A and B indicate correlation coefficients, and those of Table C are z-statistics.

2) ** : Significant at 5% level, *** : Significant at 10% level.

Table 5: Test of Contagion among East Asian NIE 4 () - Stock Market

A. Non-Crisis Period

Countries	Hong Kong	Korea	Singapore	Taiwan
Hong Kong	1.00			
Korea	0.07	1.00		
Singapore	0.28	0.04	1.00	
Taiwan	0.09	0.05	0.08	1.00

B. Crisis Period

Countries	Hong Kong	Korea	Singapore	Taiwan
Hong Kong	1.00			
Korea	-0.02	1.00		
Singapore	0.41	0.07	1.00	
Taiwan	0.10	0.08	0.19	1.00

C. Significance Test

Countries	Hong Kong	Korea	Singapore	Taiwan
Hong Kong	-			
Korea	-1.13	-		
Singapore	1.79**	0.36	-	
Taiwan	0.28	0.36	1.41***	-

Notes: 1) Figures in Tables A and B indicate correlation coefficients, and those of Table C are z-statistics.

2) ** : Significant at 5% level, *** : Significant at 10% level.

Table 6: Test of Contagion among Eight East Asian Countries () - Foreign Exchange Market

A. Crisis Period

Countries	Indonesia	Malaysia	Philippines	Thailand	Hong Kong	Korea	Singapore	Taiwan
Indonesia	1.00							
Malaysia	0.44	1.00						
Philippines	0.23	0.28	1.00					
Thailand	0.40	0.51	0.35	1.00				
Hong Kong	-0.01	0.10	0.14	0.06	1.00			
Korea	0.09	0.10	0.04	0.10	0.06	1.00		
Singapore	0.36	0.67	0.31	0.44	0.12	0.04	1.00	
Taiwan	0.15	0.25	0.19	0.28	0.17	0.14	0.26	1.00

B. Significance Test

Countries	Indonesia	Malaysia	Philippines	Thailand	Hong Kong	Korea	Singapore	Taiwan
Indonesia	-							
Malaysia	5.45*	-						
Philippines	2.92*	4.70*	-					
Thailand	5.18*	6.02*	5.16*	-				
Hong Kong	-1.05	1.11	0.46	-0.65	-			
Korea	0.80	1.31***	1.24	0.89	0.44	-		
Singapore	4.94*	6.34*	5.70*	3.61*	1.54***	-0.69	-	
Taiwan	2.00**	4.02*	2.88*	4.85*	2.40*	1.35***	4.06*	-

Notes: 1) Figures in Table A indicate correlation coefficients, and those of Table B are z-statistics.
 2) Correlation coefficients in the non-crisis period are the same as those in Table 2.
 3) * : Significant at 1% level, ** : Significant at 5% level, *** : Significant at 10% level.

Table 7: Test of Contagion among Eight East Asian Countries () - Stock Market

A. Crisis Period

Countries	Indonesia	Malaysia	Philippines	Thailand	Hong Kong	Korea	Singapore	Taiwan
Indonesia	1.00							
Malaysia	0.26	1.00						
Philippines	0.30	0.24	1.00					
Thailand	0.37	0.35	0.33	1.00				
Hong Kong	0.36	0.40	0.45	0.29	1.00			
Korea	0.05	0.23	0.14	0.25	0.07	1.00		
Singapore	0.48	0.47	0.52	0.43	0.70	0.13	1.00	
Taiwan	0.16	0.27	0.16	0.21	0.29	0.16	0.29	1.00

B. Significance Test

Countries	Indonesia	Malaysia	Philippines	Thailand	Hong Kong	Korea	Singapore	Taiwan
Indonesia	-							
Malaysia	-1.29	-						
Philippines	-0.88	-1.41	-					
Thailand	2.31*	0.56	1.85**	-				
Hong Kong	1.46***	0.88	3.97*	1.00	-			
Korea	0.89	3.32*	1.50***	3.77*	0.26	-		
Singapore	1.39***	-1.79	3.77*	1.01	5.59*	1.41***	-	
Taiwan	1.58***	2.22*	0.88	3.02*	2.79*	1.73**	2.34*	-

Notes: 1) Figures in Table A indicate correlation coefficients, and those of numbers in Table B are z-statistics.

2) Correlation coefficients in the non-crisis period are the same as those in Table 3.

3) *: Significant at 1% level, **: Significant at 5% level, ***: Significant at 10% level.

Table 8: Test of Contagion among East Asian NIE 4 () - Foreign Exchange Market

A. Crisis Period				
Countries	Hong Kong	Korea	Singapore	Taiwan
Hong Kong	1.00			
Korea	0.08	1.00		
Singapore	0.05	-0.07	1.00	
Taiwan	0.12	0.15	0.07	1.00

B. Significance Test				
Countries	Hong Kong	Korea	Singapore	Taiwan
Hong Kong	-			
Korea	0.06	-		
Singapore	0.66	-2.13	-	
Taiwan	1.65**	1.44***	1.19	-

Notes: 1) Figures in Table A indicate correlation coefficients, and those of Table B are z-statistics.

2) Correlation coefficients in the non-crisis period are the same as those in Table 4.

3) ** : Significant at 5% level, *** : Significant at 10% level.

Table 9: Test of Contagion among East Asian NIE 4 () - Stock Market

A. Crisis Period				
Countries	Hong Kong	Korea	Singapore	Taiwan
Hong Kong	1.00			
Korea	0.00	1.00		
Singapore	0.49	0.01	1.00	
Taiwan	0.19	0.12	0.15	1.00

B. Significance Test				
Countries	Hong Kong	Korea	Singapore	Taiwan
Hong Kong	-			
Korea	-0.97	-		
Singapore	3.30*	-3.39	-	
Taiwan	1.40***	0.86	0.91	-

Notes: 1) Figures in Table A indicate correlation coefficients, and those of Table B are z-statistics.

2) Correlation coefficients in the non-crisis period are the same as those in Table 5.

3) *** : Significant at 10% level.

Table 10: Test of Contagion among Eight East Asian Countries () - Foreign Exchange Market

A. Non-Crisis Period

Countries	Indonesia	Malaysia	Philippines	Thailand	Hong Kong	Korea	Singapore	Taiwan
Indonesia	1.00							
Malaysia	0.04	1.00						
Philippines	0.00	-0.03	1.00					
Thailand	0.01	0.06	-0.01	1.00				
Hong Kong	0.03	0.04	0.07	0.01	1.00			
Korea	0.04	0.02	0.03	0.07	0.08	1.00		
Singapore	0.06	0.14	0.01	0.03	0.08	0.10	1.00	
Taiwan	0.05	-0.02	-0.04	-0.05	-0.05	-0.02	-0.03	1.00

B. Crisis Period

Countries	Indonesia	Malaysia	Philippines	Thailand	Hong Kong	Korea	Singapore	Taiwan
Indonesia	1.00							
Malaysia	0.30	1.00						
Philippines	0.15	0.30	1.00					
Thailand	0.31	0.42	0.15	1.00				
Hong Kong	-0.06	0.13	0.14	0.06	1.00			
Korea	0.00	0.11	0.02	0.07	-0.02	1.00		
Singapore	0.16	0.52	0.18	0.23	0.06	0.13	1.00	
Taiwan	0.16	0.27	0.31	0.13	0.09	0.01	0.09	1.00

C. Significance Test

Countries	Indonesia	Malaysia	Philippines	Thailand	Hong Kong	Korea	Singapore	Taiwan
Indonesia	-							
Malaysia	3.66*	-						
Philippines	2.10*	4.84*	-					
Thailand	3.07*	5.39*	2.28*	-				
Hong Kong	-1.29	1.29***	1.06	0.66	-			
Korea	-0.51	1.24	-0.16	-0.06	-1.78	-		
Singapore	1.36***	3.94*	2.45*	2.88*	-0.31	0.41	-	
Taiwan	1.43***	6.20*	4.93*	2.60*	1.76**	0.80	1.64***	-

Notes: 1) Figures in Tables A and B indicate correlation coefficients, and those of Table C are z-statistics.

2) * : Significant at 1% level, ** : Significant at 5% level, *** : Significant at 10% level.

Table 11: Test of Contagion among East Asian NIE 4 () - Foreign Exchange Market

A. Non-crisis Period

Countries	Hong Kong	Korea	Singapore	Taiwan
Hong Kong	1.00			
Korea	0.08	1.00		
Singapore	0.08	0.12	1.00	
Taiwan	-0.04	-0.04	-0.03	1.00

B. Crisis Period

Countries	Hong Kong	Korea	Singapore	Taiwan
Hong Kong	1.00			
Korea	-0.01	1.00		
Singapore	0.02	0.01	1.00	
Taiwan	0.01	0.07	0.02	1.00

C. Significance Test

Countries	Hong Kong	Korea	Singapore	Taiwan
Hong Kong	-			
Korea	-1.18	-		
Singapore	-0.78	-1.67	-	
Taiwan	0.77	1.55***	0.50	-

Notes: 1) Figures in Tables A and B indicate correlation coefficients, and those of Table C are z-statistics.

2) *** : Significant at 10% level.

Table 12: Korea's Total External Liabilities

(end of period, bil. U.S. dollars)

Classifications	1995 ¹⁾	1996	1997			
			June	Sep.	Nov.	Dec.
Long-term Liabilities (A) ²⁾ (A/C, %)	33.1 (42.2)	57.5 (36.5)	60.7 (37.1)	66.6 (39.0)	72.9 (45.0)	86.0 (55.7)
I. Financial Institutions	-	41.5	43.4	47.6	53.2	50.3
1. Domestic Financial Institutions	-	38.3	39.7	43.8	49.4	46.3
Domestic	-	24.5	27.9	31.3	31.0	29.9
Offshore	-	8.5	9.6	9.6	9.6	9.2
Foreign Branches	-	5.3	2.2	2.9	8.8	7.3
2. Foreign Financial Institutions	-	3.2	3.7	3.8	3.8	4.0
Domestic Firms	-	13.6	15.1	16.9	17.6	17.6
Public	-	2.4	2.2	2.1	2.0	18.0
Short-term Liabilities (B) (B/C, %)	45.3 (57.8)	100.0 (63.5)	102.8 (62.9)	104.0 (61.0)	88.9 (55.0)	68.4 (44.3)
I. Financial Institutions	-	78.0	77.7	78.3	63.1	43.8
1. Domestic Financial Institutions	-	65.2	63.5	62.0	45.9	28.9
Domestic	-	26.2	28.5	23.6	18.7	11.7
Offshore	-	12.7	13.0	13.1	11.3	8.7
Foreign Branches	-	26.4	22.0	25.3	16.0	8.5
2. Foreign Financial Institutions	-	12.8	14.2	16.3	17.2	14.9
Domestic Firms	-	22.0	25.1	25.8	25.8	24.7
Total Liabilities (C) (%)	78.4 (100.0)	157.5 (100.0)	163.5 (100.0)	170.6 (100.0)	161.8 (100.0)	154.4 (100.0)

Notes: 1) The figures for 1995 represent external debts as defined by the World Bank.

2) Long-term liabilities are those with maturities longer than one year, while those of short-term liabilities are less than one year.

Source: The Korean Ministry of Finance and Economy.

Table 13: Foreign Reserves of the Bank of Korea

(end of period, bil. U.S. dollars)

Classifications	1996	1997						1998
		March	June	Sep.	Oct.	Nov.	Dec.	Jan.
Official Foreign Reserve (A)	33.2	29.2	33.3	30.4	30.5	24.4	20.4	23.5
Deposits at Overseas Branches (B)	3.8	8.0	8.0	8.0	8.0	16.9	11.3	11.0
Other (C)	—	—	—	—	0.2	0.2	0.2	0.2
Usable Reserves (A-B-C)	29.4	21.1	25.3	22.4	22.3	7.3	8.9	12.4

Notes: Official foreign reserve holdings are based on the IMF definition. Deposits at overseas branches are those deposits made by the Bank of Korea at overseas branches of Korean commercial banks.

Source: The Bank of Korea.