A nesting GARCH Approach in Examining Volatility Spillovers between Stock and Foreign Exchange Markets in Asian Crisis

Volatility spillovers play an important role in international economic policy transmissions. An economic policy shock in some country might affect other economies. The spillover effect was obvious in the same region. Asian financial crisis apparently is a very good example fallen in this case. In July 1997, Thai currency was severely attacked by international speculators who were accused of the initiators of the crisis. Thai government was forced to abandon the fixed exchange rate system after struggling for foreign exchange market stability. The foreign exchange market shock in Thailand spread rapidly to other southern east countries, including Malaysia, Indonesia, and the Philippines. The shock even had spillovers to Singapore, Hong Kong, Taiwan, South Korea, and Japan. The Asian financial crisis was then received a great deal of attention.

During the Asian financial crisis, southern east countries suffered the most. The Indonesia currency depreciated against the US dollar almost eighty percent to a historical record low level. The foreign exchange market shock also had a market to market spillover to the stock market. Basically, the foreign exchange market and the stock market were interrelated in nature. A depreciation of foreign exchange simultaneously changes the performances of import and export industries and the capital inflows and outflows. The turbulence in foreign exchange market increases the uncertainty in the stock market. Investors have to adjust their portfolio to hedge the foreign exchange risk. High uncertainty drives many investors to stand aside line. On the other hand, governments face a policy debate concerning the foreign exchange and the stock markets. In order to stabilize the foreign exchange market, a government has to block out international speculators by a high borrowing rate of local currency that represents their short selling interest rate, or cost of speculation. This is why we find high short-term interest rate in these countries. However, this action apparently has a strong negative impact on stock market. Unexpected interest rate increases cause market downward. On the other hand, if a government choose to stabilize the stock market instead of the foreign exchange market, it lower borrowing rate of local currency. This policy encourages the stock market with the sacrifice of the foreign exchange market. A lower borrowing rate gives international speculators a good chance to borrow more local fund with cheaper cost. They rust to short sell local currency and long foreign exchange. The strong demand of foreign exchange again cause strong depreciation of local currency until in equilibrium the rate of return from currency operation is equal to the rate of return from borrowing.

Researchers blame the Asian financial crisis for several reasons. First of all is the mismatch of macroeconomic policy and foreign exchange policy. During the period of 1992 to 1995, Asian developing countries enjoyed an average of 9% economic growth rate which is much higher than that of the average of world's 3.2%. The high growth rate increases cost of capital and attracts capital inflows from western countries. The huge short-term capital inflow was a unstable factor in a capital market, especially in a developing country. We find high ratios of short-term capital over GNP in Indonesia, Thailand, Malaysia, and the Philippines. They also rely on foreign borrowings and adapt a fixed to dollar exchange rate policy. The fixed exchange rate system did increase the competition advantage in 1994 and 1995 when the dollar was low against the Japanese yen. However, during 1995 through 1997, dollar went strong against yen. The picture was different. These countries were no longer enjoyed competition advantage. The large deficits in current and capital account weakened the fixed foreign exchange system in these countries.

This paper discusses the volatility spillovers in two dimensions. The first dimension is in market to market. As we discussed, the foreign exchange market is interrelated with the stock market in nature. They were cross-related in essence. However, they have a policy conflict for governors. The governors of these two markets usually are not the same in most systems. Therefore, we have to close examine the relation of these two markets. How large is a foreign exchange policy shock to stock market? On the other hand, how extend is a stock market policy shock to foreign exchange market? These questions were important and shall be answered before we take actions in financial crisis.

The second dimension is in country to country. An economic shock in one country may cause a spillover to other countries, especially in the same region with intensive trade or capital flow relations. Volatility spillover is an important issue proposed by Schwert(1989). He analyzes the relations of stock volatility to real and nominal macroeconomic volatility, economic activities, etc. He finds that stock return volatility are related to the time-varying volatility of a variety of economic variables. It implies that a macroeconomic shock, such as a foreign exchange shock, affects stock market. Then, a shock in one country may cause a reaction in other markets. The spillover effects between capital markets were proposed by Hamao, Masulis and Ng(1990). Therefore, beside the market to market effect, the country to country effect was discussed in this study.

The main purpose of this paper is to examine the volatility spillovers between foreign exchange and stock markets in Asian crisis countries, including Indonesia, Thailand, The Philippines, Malaysia, Singapore, Hong Kong, Taiwan, South Korea, and Japan. We employ the nesting GARCH family to model stock markets and investigate the spillovers between markets and countries. Furthermore, we compare the pre-crisis and post-crisis differences in market to market and country to country spillovers. Our study is organized as follows. Section II is a literature review. In section III, we describe the empirical methodology for detecting the market to market and country to country spillovers. We discuss data and empirical results in section IV. Finally, we summarize the major findings in section V.

II. Literature Review

Ajayi and Mougoue(1996) examine the short-term and long-term relations between stock prices and foreign exchange rates in the U.S., U.K., France, Germany, Holland, Japan and Italy during the period of 1985:4 and 1991:7. They use Kwiatkowski, Phillips, Schmidt, Shin (KPSS) and Augmented Dickey-Fuller (ADF) unit root testing and Engle and Granger error correction model. Their empirical findings show that both stock prices and foreign exchange rates are nonstationary and cointegrated. In their short-term relationship examination, they find that stock prices have a positive impact on next period exchange rate in all countries. They document that in bull market the stock prices move up to reflect economic booming which induce inflation in one country. The pressure of inflation pushes the depreciation of local currency in this country. At lease, people under the expectation of appreciation of foreign exchange rates. Furthermore, unexpected foreign exchange rate changes also have negative impacts on next period stock prices in all countries except the U.S. and France. The argued that depreciation of currency were induced by domestic production decreases or inflation in one country. Therefore, stock prices go down in this country. In examining the long-term relation, they find that stock price changes have significant positive effects on exchange rates in France, Japan and Italy. On the contrary, the effects were significant negative in Canada, Germany, Holland, U.K. and the U.S., They argue that in the bull market, international investors move their long-term capital in market and push down the exchange rate. They also document significant negative effects of exchange rate on stock prices in the U.S., U.K., Japan, Italy, France and Germany.

Adrangi(1992) examined the relationship between the foreign exchange and stock returns in the U.S., They employed the granger causality test to investigate the long-term relations of foreign exchange between the dollar, DM and Japanese Yen. They also compared the stock returns between the U.S., the German and the Japanese markets. Their empirical evidences rejected cointegration between stock returns and foreign exchanges, except that the relative of the U.S. and German stock returns cause the variation of foreign exchange.

Jorion(1991) examined the relation between foreign exchange risk and stock market returns of the U.S. under the framework of APT, which cover the and multifactors models. They documented different degree of impacts in different industries, for examples the chemical and mechanic industries carry a positive impact while the textile and department store industries carry a negative impact. Loudon(1993) reexamined the foreign exchange effects on Australian industries under the Jorion's framework. His empirical findings suggest that nine out of twenty three industries have a positive effect of foreign exchange on stock market.

Henry(1993) investigated Granger's causality relation between the foreign exchange rate and the stock returns of Hong Kong. He employed Dickey-Fuller unit root test first and found nonstationarity in these series. He also used bivariate ARIMA and Granger causality test to examine relations between variables. He found a negative feedback relation between foreign exchange and stock markets.

Smith(1992) used the optimizing intertemporal model to explain equity return is an important factor of foreign exchange variation. He chose government bond, monetary and equity securities as the investment assets and built a multiple regression of the pound sterling on the U.S. dollar based on quarterly data of the U.K., the U.S and the German 1974 through 1988. He documented a positive relation of equity and forex in the U.K., Smith(1992b) then used Augumented Dickly-Fuller cointegration test to investigate the relation between the DM and the Japanese Yen. He found a cintegration between the DM and the Yen. Furthermore, Japanese equity has a positive effect on the DM and the German equity has a negative impact on DM. On the other hand, Japanese Yen was negatively affected by equity and was positively affected by the U.S. equity market.

III. Empirical Methodology

Volatility spillover between foreign exchange and stock markets in Asian financial crisis is the main focus of this study. We choose nine pacific basin countries suffered financial turmoil, including Thailand, Indonesia, Malaysia, the Philippines, Singapore, Hong Kong, Taiwan, Japan and South Korea. The data sample of daily stock index and spot foreign exchange rate was from AREMOS, Ministry of education, Taiwan, running from January 2, 1996 through October 31, 1998. The stock index and foreign exchange fluctuations of the nine countries during the crisis were presented in table 1.

From able 1, we find significant depreciation among countries, especially in Indonesia, South Korea and Thailand. The stock turmoil spread from Thailand, Korea, Singapore, the Philippines, Malaysia to Indonesia. Hong Kong, Japan, and Taiwan stock markets were among the least impacts. We observe that the foreign exchange turmoil occurred around July 1997 and the stock market turmoil happened during the period July through October 1997, Foreign exchange turmoil seems to be the leader in market transmission.

The spillover between foreign exchange and stock markets was obvious. We employ the nesting GARCH concept proposed by Hentschel(1995). Stock behavior in each country varies and can not be model by a standard mode is our prior belief. Therefore, we describe price behavior of each country of fitting a model in Hentschel's nest. The merit is that we may examine the unexpected shock from one country to another under a better filter which filter out the expected. The side benefit of this method is getting a better picture of shock pattern in each country. The Newton-Raphson algorithm was used in iterating maximum likelihood and likelihood ratio test was employed in model testing. The price behavior fitting results were shown in table 2.

Since the4 AVGRCH and TGARCH were among the choices, we employ them in investigating spillovers between markets. A mean spillover AVGARCHM model can be expressed as follows.

$$o_2 = \ll + \not\subset \mid_2^{NLO} + \mid_2$$
$$\mid_2 \left| \Omega_{2-N} \text{¼} k \text{ EMI} \mid_2 F \right.$$
$$\mid_2^{NLO} = \sim_M + \sim_N \times \left[\left| \mid_{2-N} + \text{¥} \right| + \sim_0 \left(\mid_{2-N} + \text{¥} \right) \right] + \ _N \times \mid_{2-N}^{NLO}$$

where R_t ß Daily index return at time t

f_{t-1} ß Daily variance of foreign exchange at time t

η_t ß Residual

μ, δ, α_0, α_1, α_2, γ, β_1 ß Parameters

A volatility spillover AVGARCHM be modeled as:

$$o_2 = \ll + \not\subset \mid_2^{NLO} + \mid_2$$
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$$\mid_2^{NLO} = \sim_M + \sim_N \times \left[\left| \mid_{2-N} + \text{¥} \right| + \sim_0 \left(\mid_{2-N} + \text{¥} \right) \right] + \ _N \times \mid_{2-N}^{NLO} + ^2 \times \text{¤}_{2-N}^{NLO}$$

where R_t ß Daily index return at time t

f_{t-1} ß Daily variance of foreign exchange at time t

η_t ß Residual

μ, δ, τ, α_0, α_1, α_2, γ, β_1 ß Parameters

In Singapore, Taiwan and Japan markets, a TGARCHM is a better fit. A mean spillover TGARCHM was stated as:

$$o_2 = \ll + \not\subset \mid_2^{NLO} + \mid_2$$
$$\mid_2 \left| \Omega_{2-N} \text{¼} k \text{ EMI} \mid_2 F \right.$$
$$\mid_2^{NLO} = \sim_M + \sim_N \times \left[\left| \mid_{2-N} \right| + \sim_0 \mid_{2-N} \right] + \ _N \times \mid_{2-N}^{NLO}$$

where R_t ß Daily index return at time t

f_{t-1} ß Daily variance of foreign exchange at time t

η_t ß Residual

μ, δ, α_0, α_1, α_2, β_1 ß Parameters

We model a volatility spillover model as follows.

$$o_{2} = \ll + \text{¢}\,{}^{\text{NLO}}_{2} + {}_{2}$$

$${}_{2}\left|\Omega_{2-N} \text{¼}\, k\ \text{EMI}\ {}_{2}\right. \text{F}$$

$${}^{\text{NLO}}_{2} = \sim_{M} + \sim_{N} \times \left[\left|{}_{2-N}\right| + \sim_{0} {}_{2-N}\right] + \ {}_{N} \times {}^{\text{NLO}}_{2-N} + {}^{2} \times \text{¤}^{\text{NLO}}_{2-N}$$

where R_t ß Daily index return at time t

f_{t-1} ß Daily variance of foreign exchange at time t

η_t ß Residual

μ, δ, τ, α_0, α_1, α_2, β_1 ß Parameters

According to Hentschel's91995) argument, we shall consider every member in nesting GARCH family without prior information regarding to a market. We examine all of the seven members in nesting GARCH family, including GARCHM, GJRGARCHM, NARARCHM, TGARCHM, SGARCHM and AVGARCHM. Once we developed a best fit for each market, we then use the specific model to investigate the mean and volatility spillovers among foreign exchange and stock markets.

IV. Empirical Results

Spillover between foreign and stock markets in this study has been examined in two dimensions. We examine spillover between foreign exchange and stock markets in a country. It implies policy reaction between two markets, i.e. market to market spillover, in a closed economy. On the other hand, we extend regional spillovers among Asian countries. We investigate spillover between foreign exchange of another country and local stock market. We intend to find out the imported spillover effect. In the market to market effect, we emphasis on policy balancing to boom up stock market without sacrifice of a stable foreign exchange rate. In the imported spillover effect, we put emphasis on the local stock market reaction to an imported foreign exchange change. In order to capture different shock patterns in local stock markets, we employed concept of nesting GARCH to fit local stock market price behavior and use the empirical result, which were shown in table 3, as the patterned model in spillover investigation.

Table 3 shows the TGARCHM model was the common stock price behavior pattern in Asian countries. However, we find that South Korea stock returns follows AVGARCHM model and the best fit of Indonesia, Hong Kong and Japan markets is a SGARCHM model. We also document that all countries returns have a central point of zero except that of Korea stock returns. Most countries have a right rotated pattern which implies a large response to bad news and a small impact on good news. The empirical findings were consistence with findings of Black(1976), Christie(1982) and Schwert(1990), i.e. the volatility of stock returns was asymmetric. We also find that standard derivation is a better way than variance in describing stock price behavior, which is consistence with Taylor(1986), Schwert(1989) and Nelson and Foster(1994).

In order to examine spillover effect, we define spillover effects into mean spillover and volatility spillover. They are totally different in term of economic meaning. Mean spillover implies an investment fund flowing from one market to another. In conditional mean equation, we examine a first moment of first moment transmission effect. However, volatility spillover has a different implication in a sense that it is a second moment transmission. From economic point of view, volatility has a policy transmission effect, which mean that an economic policy in one market or country might transmit in long memory pattern to another market or country. Volatility spillover is a second moment to second moment transmission effect. Its persistence is stronger than that of a mean spillover.

We started from spillover between foreign exchange and stock in Thailand markets. From table 4, we find that the coefficients were negative and insignificant. It implies that spillovers between foreign exchange and stock markets are insignificant no matter what it is mean spillover or volatility spillover. We also note that information curve is right rotated before crisis in Thailand stock market while the curve moves to a symmetric pattern after the crisis. It means that Thai stock market responses to bad news rather than good news before the crisis. But after the crisis, market responses to both of good and bad news.

Indonesia market has the same effect when we examine spillover between foreign exchange and stock markets. We couldn't find a significant effect between foreign exchange and stock markets. However, in examining volatility spillover, we find a significant returns volatility spillover from foreign exchange to stock markets. It shows that the significant depreciation of Indonesia currency has a strong effect on its stock market. The information pattern before the crisis shows a slightly right rotated pattern, which means stock market had a larger response on bad news than on

good news in Indonesia market. However, the picture changed after the crisis. The information curve shows an extremely right rotated pattern, which implies only bad news has impact on market.

In examining mean spillover between foreign exchange and stock markets, we couldn't find a significant effect in Malaysia. However, foreign exchange had a significant positive effect on stock market in term of volatility spillover which implied a economic policy shock from foreign exchange to stock market. In Malaysia stock market, the information curve showed a right rotated pattern before the crisis while it shows a slightly right rotated pattern after the crisis.

The Philippines markets show different results in mean and volatility spillovers. Before the crisis, both mean and volatility spillovers from foreign exchange to stock market exhibits a negative effect. However, mean spillover showed a significant negative effect while volatility spillover didn't show a significant effect after the crisis. Its information curve showed a extremely right rotated pattern before the crisis and it showed a slightly right rotated one after the crisis.

In Singapore market, we couldn't find any significant impact from foreign exchange to stock market on matter what in mean or volatility spillovers. However, we find a different information curve pattern in this particular market. Before the crisis, Singapore market exhibited an extremely left rotated pattern which means stock returns in this market is no response to bad news. However, we find a totally different picture after the crisis that shows an extremely left rotated pattern. We conclude that the information curve changed dramatically during the crisis in Singapore market.

Hong Kong market shows a similar pattern to that of Singapore market in spillover between foreign exchange and stock markets. We couldn't find ant significant impact in mean or volatility spillover between foreign exchange and stock markets. However, the information pattern in Hong Kong is different from that of in Singapore market. Hong Kong market showed a symmetric information pattern before the crisis. However, the pattern was changed to an extremely right rotated one after the crisis.

We find a significant mean spillover from foreign exchange to stock market. However, the volatility spillover between markets was insignificant before the crisis. The mean and volatility spillovers between markets were negatively significant after the crisis. It implies that after the Asian crisis, Taiwan stock market take both impacts

from foreign exchange market fund and government policy. During the crisis, Taiwan government debated the issue of stabling foreign exchange market or stock market. Since they cannot stabilize both, they have to choose one policy and sacrifice another. This is so called policy dilemma. When they try to stabilize foreign exchange market, they raise borrowing rate on NT dollar to induce a high cost of short-selling NT dollar. It also prevent depreciation of NT dollar. However, the impact of raising short-term NT dollar borrowing rate simultaneously gives a downside impact on stock market.

The information curve in Taiwan market exhibited a right rotated pattern before the crisis and it exhibited an extremely right rotated pattern after the crisis. It implies a stronger response to bad news. Although Taiwan market has a high trading volume among top five in the world, it shows high volatility of stock returns. Information releasing channels work not so effective and investors overreact in Taiwan market.

We document some interesting findings in Japan market. Mean spillover from foreign exchange to stock market was significant positive and Volatility spillover between market was significant negative. Depreciation of Japanese Yen boom up stock market in Japan and foreign exchange policy apparently has a negative impact on Japanese stock market. Japanese information curve shows a consistence pattern before and after the crisis. It exhibits and extremely right rotated pattern which implies strong response to bad news.

Finally we examine spillovers between markets in south Korea. We couldn't find any significant mean or volatility spillover between foreign exchange and stock market. Korean information curve shows a slightly right rotated pattern which means a slightly strong response to bad news.

We summarize volatility and mean spillovers before and after the crisis in Asian countries in Table 4. From tabl3 4 we know that the Philippines, Taiwan and Japan have mean spillovers between foreign exchange and stock markets before the crisis. Malaysia, Indonesia and Japan have volatility spillovers between foreign exchange and stock markets before the crisis. However, after the crisis we find all countries has significant mean spillover except Indonesia. However, only Thailand, Indonesia, Malaysia and Taiwan have volatility spillovers. It implies that funding transfer between markets is getting close related between foreign exchange and stock markets after the crisis. The foreign exchange policy has a long memory impact on stock market in those countries suffered most in the crisis, such as Thailand, Indonesia and Malaysia. Taiwan market also counts on foreign exchange policy as a long term

impact. Actually, before the crisis most Asian countries adopted a fixed foreign exchange policy that induced bounded foreign investment flowing in. Those southeastern Asian countries raised interest rate in order to control inflation. This action again attracted more hot money flowing in to arbitrage foreign exchange profit without risk.

In this study we also investigate imported policy effect which is the spillover from another country policy to local stock market. The empirical finding were exhibited in Table 5. From table 5 we find that all countries has a significant spillover effect from other country, especially after the crisis. It releases a strong implication that the Asian regional market is getting integrated after the crisis. The most important evidence is that from literature we knew that international capital markets were getting integrated after the October crash 1987. In Asian crisis we seem to find a similar pattern of regional capital market integration.

We also note that the four countries in Eastern Association, including Thailand, Indonesia, Malaysia and the Philippine didn't exhibit spillovers from other countries. However, after the crash the closed economic unit seems to suffer spillovers from other countries in this region. It also shows an integration of regional capital markets. We also document an important finding of spillovers in Japan market which is the leading capital market in Asian region. We couldn't find any spillovers from other regional countries in Japan, which is similar to the U.S. market in international markets. The conclusion is that leading market has a spillover effect on other countries while the reverse does not hold. Literature shows a spillover effect from U.S. market to other international market, but no markets have a significant impact on U.S. market. In Asian region, Japan has spillovers to other regional market while other regional markets do not have an impact on Japan market.

V. Summary

In this study we employ GARCH family to examine the information curve, spillover between foreign exchange and stock markets, spillover from other countries of Thailand, Indonesia, Malaysia, the Philippine, Hong Kong, Singapore, Taiwan, Japan and South Korea in Asian financial crisis. We document that all countries has asymmetric information pattern, except that of South Korea. On average, Asian countries have a right rotated pattern that implies a stronger response on bad news.

We find that spillover between foreign exchange and stock markets was getting more significant. It implies that funding and policy shock transmit frequently and are getting integrated between two markets. The spillovers between countries were getting stronger after the crisis that is consistence with recent literature findings of international capital market integration. Finally, Japanese market shows a leading market in Asian region and It has a strong spillover on other Asian markets while the reverse does not hold.

Table 1. Stock index and foreign exchange rate fluctuations

Country	Foreign exchange			Stock index		
	Jun. 97	Dec. 97	Floatation	June 97	Dec. 97	Fluctuation
Thailand	35.88	48.00	-46.1%	527.28	372.69	-29.3
Indonesia	2431.6	5100.0	-52.3%	724.55	401.71	-44.6
Malaysia	2.5245	3.8755	-34.9	1077.3	594.44	-44.8
Philippines	26.376	40.116	-34.3	2809.21	1869.23	-33.5
Singapore	1.4302	1.6768	-14.7	1987.95	1529.84	-23.0
Hong Kong	7.748	7.748	0.0	15196.74	10722.76	-29.4
Taiwan	27.846	32.638	-14.8	9030.28	8187.27	-9.3
Japan	114.3	129.92	-12.0	20604.96	15258.74	-25.9
South Korea	887.9	1695.0	-47.6	745.4	376.31	-49.5

Table 2. The best stock models in Asian countries

Country	Best Fitting Model	Likelihood value
Thailand	AVGARCHM	12989.49
Indonesia	AVGARCHM	588.23
Malaysia	AVGARCHM	1391.44
Philippines	AVGARCHM	10630.90
Singapore	TGARCHM	1367.57
Hong Kong	AVGARCHM	2152.72
Taiwan	TGARCHM	3533.27
Japan	TGARCHM	615.74
Korea	AVGARCHM	47584.96

Table 3. The best model fitting results in Asian country

Country	Best fitting model	Type of information curve
Rate of return in Thailand stock	TGARCH-M	$f(h_t^{1/2}) = 0.127675(\lvert\eta_t\rvert - 0.119346\eta_t)$
Rate of return in Indonesia stock	SGARCH-M	$f(h_t^{1/2}) = 0.195551\times\lvert\eta_t\rvert$
Rate of return in Malaysia stock	TGARCH-M	$f(h_t^{1/2}) = 0.177243(\lvert\eta_t\rvert - 0.352468\eta_t)$
Rate of return in Philippines stock	TGARCH-M	$f(h_t^{1/2}) = 0.323889(\lvert\eta_t\rvert + 0.057685\eta_t)$
Rate of return in Singapore stock	TGARCH-M	$f(h_t^{1/2}) = 0.088458(\lvert\eta_t\rvert - 0.607126\eta_t)$
Rate of return in Hong Kong stock	SGARCH-M	$f(h_t^{1/2}) = 0.167054\times(\lvert\eta_t\rvert$
Rate of return in Taiwan stock	TGARCH-M	$f(h_t^{1/2}) = 0.172092(\lvert\eta_t\rvert - 0.545168\eta_t)$
Rate of return in Japan stock	SGARCH-M	$f(h_t^{1/2}) = 0.155315\times(\lvert\eta_t\rvert$
Rate of return in South Korea stock	AVGARCH-M	$f(h_t^{1/2}) = 0.058964\ [(\lvert\eta_t + 0.0.949392\rvert) - 0.058461(\eta_t + 0.949392)]$

Table 4. Spillovers between foreign exchange and stock markets in Asian countries

Sample Period	Period before the crisis		Period after the crisis	
Country	Mean spillover effect	Volatility Spillover effect	Mean Spillover effect	Volatility Spillover effect
Thailand	negative ß non-significant ß {	negative ß non-significant ß {	negative ß significant ß {	positive ß significant ß {
Indonesia	negative ß non-significant ß {	negative ß significant ß {	Positive ß non-significant ß {	positive ß significant ß {
Malaysia	Positive ß non-significant ß {	positive ß significant ß {	negative ß significant ß {	positive ß significant ß {
Philippines	negative ß significant ß {	negative ß significant ß {	negative ß significant ß {	Positive ß non-significant ß {
Singapore	negative ß non-significant ß {	negative ß non-significant ß {	negative ß significant ß {	Positive ß non-significant ß {
Hong Kong	negative ß non-significant ß {	Positive ß non-significant ß {	positive ß significant ß {	Positive ß non-significant ß {
Taiwan	negative ß significant ß {	negative ß non-significant ß {	negative ß significant ß {	negative ß significant ß {
Japan	positive ß significant ß {	negative ß significant ß {	negative ß significant ß {	negative ß non-significant ß {
South Korea	negative ß non-significant ß {	negative ß non-significant ß {	negative ß significant ß {	Positive ß non-significant ß {

Table 5. Spillovers from other country of Asian stock market in the crisis

	R_t	Parameter	Floatation of exchange rate in the previous period ß ƒ$_{tJ1}$ ß {								
			Thailand	Indo-nesia	Malaysia	Philip-pines	Singa-pore	Hong Kong	Taiwan	South Korea	Japan
Period before the crisis(1996/01/02~1997/05/31)	Thailand	¨		-1.20800	-0.04118	1.67475	0.71439	-4.21425	0.06276	-0.16551	0.04574
		²		-0.48419	0.14653	-0.41946	-0.32578*	-1.14001	-0.23497	-0.00676	0.01284
	Indonesia	¨	0.85498		0.26483	-0.11547	0.59987	0.85498	0.06106	-0.14366	-0.14947
		²	-0.36826		0.44839*	-1.38695	-0.60868**	-0.96590	0.37584	-0.05561	-0.09361**
	Malaysia	¨	0.40202**	-1.03525		-0.13404	1.07604**	-0.46556	-0.55014	-0.10913	-0.05624
		²	0.41169*	-0.91972**		1.97006*	-0.06144	-0.71153	1.12568**	-0.05577	-0.23927**
	Philippines	¨	0.15389	-3.14137	0.31002		0.28525	-1.95951	-0.02799	0.51415*	0.04186
		²	-1.86441**	-5.08854**	-1.45809**		-1.12583**	-9.26926**	-0.48876	-0.14389	-0.46478**
	Singapore	¨	0.14621	-1.12964	0.13309	-1.48096		-3.84188	-0.08326	-0.14205	-0.06238
		²	-0.07075	0.14567	0.10353**	1.22951		-0.58914	-0.21224	0.01992	-0.09395
	Hong Kong	¨	-0.00301	-0.83509	0.60658	-0.98878	0.95103**		0.21718	-0.49561*	-0.26259*
		²	0.17345	2.34071	0.15635	2.43297**	0.19947		1.52363**	-0.25495**	-0.12555*
	Taiwan	¨	0.54842**	0.40279	0.14403	-2.42233	0.54419	0.98181		0.49721	0.02908
		²	0.32522**	-0.50579	-0.07459	1.39386*	0.26514*	1.13426		0.14626**	0.04067
	South Korea	¨	0.28374	-0.16845	-0.28635	-3.21002	-0.69607	3.30987	-0.74808		0.14047
		²	-0.22096	-1.02386	-0.46227*	2.22192	0.67223**	6.49575*	-0.13504		-0.13555
	Japan	¨	-0.21581	-1.31319	0.45087	-1.85931	0.15734	2.99431	-0.02303	-0.03331	
		²	-0.10599	-0.69061	0.04939	-0.47649	0.47445	2.41819	0.06239	-0.01015	
Period after the crisis(1996/01/02~1997/05/31)	Thailand	¨		-0.04213	-0.27318**	0.02617	-0.46829**	-4.82261	-0.91539**	-0.01625	-0.47041**
		²		0.03714	-0.07903	0.08854	-0.01285	3.19039	-0.21484	-0.02906	-0.31469**
	Indonesia	¨	-0.08498		-0.24768*	-0.00025	-0.27465	0.88495	-0.46516**	-0.00721	-0.05175
		²	0.03143**		0.08394**	0.02352	0.19335**	3.26648**	0.27694**	0.02678	-0.23742**
	Malaysia	¨	-0.21656**	-0.03246		-0.05259	-0.20839	3.32531	-0.95284**	-0.11418**	-0.35892*
		²	0.03886	0.04526**		-0.16437**	0.31148**	0.87089	0.10617	0.08487**	-0.24193**
	Philippines	¨	-0.04192	-0.12362**	-0.30427**		-0.61846**	-2.87657	-0.14816	0.00868	-0.20899
		²	0.03048	0.04281**	0.09376*		0.11178	2.67092	0.05356	0.05446	-0.25605**
	Singapore	¨	-0.06951	-0.11409**	-0.27551**	-0.03537		0.16353	-0.18485	0.01741	-0.17587
		²	0.00665	0.00581	0.01141	-0.02628		3.36192*	0.13841*	0.02101	-0.13335**
	Hong Kong	¨	-0.22875**	-0.06549	-0.37353**	0.00411	-0.68537**		-0.66298**	-0.03478	-0.10607
		²	0.05956*	0.01132	0.05903	0.03624	0.06725		0.06273	0.03706	-0.15439
	Taiwan	¨	-0.17455**	-0.06976**	-0.16061**	0.03954	-0.47062**	1.11902		-0.01236	-0.12693
		²	0.05507	0.01864	0.08164	-0.02429	-0.01218	3.57490		0.00248	-0.13778*
	South Korea	¨	0.04766	-0.03249	-0.13244	-0.03581	-0.22148	-7.49162**	0.06784		-0.29368*
		²	0.05818**	0.02165*	0.15213**	0.31057	0.21125**	3.08172*	0.38589**		-0.13805*
	Japan	¨	0.02193	0.01111	-0.05692	0.03322	0.05459	0.01062	-0.00451	-0.06663	
		²	0.00373	-0.00944	-0.00459	0.01404	0.00285	1.97600	0.08036	-0.01314	

1.Parameter ¨ refers to mean spillover effect, and parameter ² refers to volatility spillover effect .

2.Value in the table refers to estimators of parameters in the model.

3.* refers to t value reaching 5% significant level, and ** refers to t value reaching 1% significant level.

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