Contagion in South East Asia - Measuring Stock Market Co-Movements

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ABSTRACT[§]

This paper utilizes two different approaches to examine whether there is a contagion among South East Asian economies. According to the cross-market correlation analysis, there is a contagion between Thailand, Indonesia and Philippines and market co-movements which simply cannot be explained by the fundamental linkages between these economies. A contagion is also detected by the cointegration analysis. The long-run relationship among South East Asian countries and Japan significantly changed after July 1997. Both impulse response analysis and variance decomposition confirm the changes in market co-movements. The findings suggest that multinational investment managers may need to re-design their strategies for South East Asia consistent with Tang's advise [2001]. A quick move by IMF approving Philippines' request for an extension of its Extended Fund Facility (EFF), Chieng Mei initiative on foreign exchanged swapped and others proposed by Chaipravat and Bhanich Supapol [2000] under ASEAN commission and massive financial packages to Thailand and Indonesia are among justifiable measures supported by our empirical evidence.

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1 Introduction

The Dow Jones Industrial Average lost more than 7 percent of its value on October 28, 1997. It was preceded by a 5.8 percent plunge in the Hong Kong Stock Market following months of speculation and devaluation of South East Asian currencies. Many people believe that the downward spiral originated in the devaluation of Thai baht on July 2, 1997. The domino effect eventually reached South Korea and Japan. South Korea's currency, the won, lost the maximum daily trading limit, 10 percent of its value, on November 20, 1997. The demise of a powerful Japanese broker, Yamaichi Securities Co., on November 24, 1997, propelled the Asian currency and financial crises to another climax. Figure 1 shows the dramatic co-movements in Asian stock markets. This kind of phenomena, one turmoil propagates to another, has become a common scenario in the world financial markets. The question attracts the attention of practitioners, policy makers, and academics is how a seemingly country-specific event can evolve into a crisis in the entire region. Is there really a contagion? What is a contagion anyway?

Forbes and Rigobon (1999) distinguishes contagion from interdependence. They define contagion as a significant increase in the cross-market correlation during the period of turmoil. If an exogenous shock to one market has ripple effects and leads to a significant increase in market co-movements between this economy and others, then there is a contagion. However, if two markets are traditionally highly correlated and continue to be highly correlated after a shock to one market, there may not be any contagion, but only interdependence. Based upon this definition, a contagion implies that cross-market linkages are fundamentally changed after a shock to one market, while an interdependence implies no significant change in cross-market relationship before and after the shock to one market. Forbes and Rigobon (1999) finds little evidence of contagion in South East Asia and Latin America during crisis periods, but instead, they conclude that these economies are highly interdependent.

Another approach to define and to test the existence of a contagion is using vector autoregression (VAR) and the concept of cointegration. The cointegration approach allows us to estimate a long-run relationship among a group of economies. If this long-run relationship significantly changes after an exogenous shock to one economy, then a contagion does exist among these economies.

Testing the existence of contagion has many important implications. From practitioners' perspective, the existence of a contagion could change a multinational investment strategy. If there is no contagion after a negative shock to one country, the shock should remain as a country-specific

event. Theoretically the stock/financial markets between the country where the shock originated and the rest of the region should stay relatively uncorrelated. Then an internationally diversified investment strategy would reduce portfolio risks and increase expected returns. However, if a contagion actually occurs in a region, then the multinational investment strategy in the region has to be modified to take the possible contagion into account. Therefore, acquiring knowledge on the existence of a contagion in certain area becomes an important task for practitioners.

From academic researchers' perspective, the existence of a contagion can be used to explain why an economy moves from one equilibrium to another even the fundamentals in the economy remain the same. Many economic policies target at domestic stability. When there is no significant change in economic conditions in a country, policy makers in the country may take the current equilibrium for granted. If there is a contagion, policy makers have to preempt a crisis spreading to their country by changing their economic policy accordingly. Otherwise, the economy may move to another equilibrium which is not in favor by policy makers.

The other important reason to investigate the existence of a contagion is from the perspective of international institutions. If a negative shock to one economy can be transmitted to a second economy even the economic fundamentals and policies of the second economy are sound, then an international institution, such as the IMF, is justified to intervene in the second economy with massive financial packages.

There are many theories in the literature to explain why a contagion occurs. One possible transmission mechanism is through the change in expectations which results in the existence of multiple equilibria. Obstfeld (1986) and Masson (1998) explain that currency crisis is a results of movement from a "good" equilibrium to a "bad" one that is triggered by changes in expectation. Mullainathan (1998) also suggests that investors only imperfectly recall past events. When a financial turmoil occurs in one country, investors in a second country rapidly recompute their priors (on variables such as debt default) and assign a higher probability to a bad state. Then the inevitable crisis in the second economy becomes a self-fulfilling prophesy. The resulting downward co-movements in price would occur because memories (instead of fundamentals) are correlated. The changes in investors' expectations can transmit a negative shock through a propagation mechanism that does not exist during stable periods.

The second possible contagion transmission is through the competitive exchange rate adjustment as suggested by Gerlach and Smets (1994). When one country, for certain reason, has a real

depreciation in its currency, its trade partner would lose its competitiveness and experience a trade deficit as well as loss in reserves. The second currency would then suffer speculative attack even the economic conditions in the second economy are still the same.

The third possible contagion transmission is through financial intermediaries. Goldfajn and Valdes (1995) and Valdes (1996) introduces the channel of propagating currency crisis by financial intermediaries because financial intermediaries offer relatively liquid assets to attract foreign investors in the first place. When there is a sudden devaluation of a currency, foreign investors would recompose their portfolio and sell assets in other countries. Financial intermediaries in these countries having difficulties to provide liquidity would face bank runs which would result in another currency crisis. A negative shock in one country could increase the degree of credit rationing and force investors to sell their holdings of assets in countries not affected by the initial crisis. Subsequently these countries would suffer currency crises too.

A final transmission mechanism is a political contagion. Drazen (1998) studies the European devaluations in 1992-3 and develops a model which assumes that central bank presidents are under political pressure to maintain fixed exchange rate of their respective countries. When one country decides to abandon its peg, this reduces the political costs to other countries of abandoning their respective pegs. The likelihood of these countries to switch exchange rate regimes increases. As a result, exchange rate crises may be bunched together, and once again, transmission of an initial shock occurs through a mechanism which does not exist before.

There are many empirical studies on contagion in various regions. Forbes and Rigobon (1999) uses adjusted cross-market correlation to examine contagion in Latin America and South East Asia. They conclude that economies in these regions are highly interdependent, but there is no contagion. Tan (1998) examines the nature and extent of contagion during Asian financial turmoil using a VAR model on stock markets and concludes that there is a contagion during Asian financial crisis. Valdes (1996) uses country credit ratings and secondary market debt prices to investigate whether fundamentals can account for cross country co-movements of credit worthiness. The answer is negative. However, Wolf (1996) uses stock returns and finds no significant evidence of a contagion in Latin America but a higher degree of contagion among Asian economies. Using conditional Capital Asset Pricing Model [CAPM], Tang (2001) finds the contagion and stock market integration are regional phenomenon – especially in Latin America and S.E. Asia due to international investment portfolio rebalancing.

To further examine the existence of contagion in Asia, this paper applies both correlation analysis and cointegrating regression with a broader database to investigate the stock market returns in Asian economies. This paper uses the same approach to calculate the adjusted cross-market correlation as Forbes and Rigobon (1999), but has the following different features. First, the time horizon for our data set is longer. We consider the period from 1990 - 2001. Second, we use Thailand as our numeraire (base country) and calculate the correlation between Thailand and other countries. Because the focus is on the devaluation of baht on July 2, 1997, we use that date to split our sample into two sub-periods and compare the correlation coefficient for these two periods. Lastly, we calculate the correlation coefficient for the daily stock return instead of two-day rolling average return which is employed by Forbes and Rigobon (1999), because all of the countries of our study are in the same/similar time zone and the market are open on the same date.

Different from Tan (1998), our paper includes Japan in the empirical analysis. Most of the South East Asian countries peg their currencies to the US dollar. The peg made their currencies appreciate against the Japanese yen during the 1990s when the yen depreciated against the US dollar. The appreciation in turn caused current account deficit and loss in reserves of these countries. Therefore, it is critical to examine the long-run relationship between Japan and the South East Asian countries. Again, we split our sample using July 2, 1997, and examine any significant change in the long-run relationship among the countries.

Prior to the devaluation of baht on July 2, 1997, it was first suffered a massive speculative attack on May 14-15, 1997 when speculators decided Thailand's slowing economy and political instability meant it was time to sell. Thailand and Singapore jointly intervened to defend the baht but the market did not respond well. On May 23, 1997, moves to save Finance One, Thailand's largest finance company, failed. On June 27, the Bank of Thailand suspended operations of 16 cash-strapped finance companies and ordered them to submit merger or consolidation plans. All these efforts to stabilize Thai economy did not work and the Bank of Thailand announced a managed float of the baht and called on the International Monetary Fund for "technical assistance" on July 2, 1997. The announcement effectively devalued the baht by about 15-20 percent. The baht ended at a record low of 28.80 to the dollar. This could be a trigger for the entire South East Asian currency crisis. We compare and analyze cross-market correlations in Asian stock markets from January 1, 1990 to July 1, 1997 and from July 2, 1997 to February 22, 2001 which is the most recent data available when the paper is completed.

Vector autoregression and cointegrating regression are used to examine the long-run relationship and to test for co-movements among South East Asian stock markets. The dynamic impact of random disturbances on the stock market returns is also estimated. The impulse-response function is presented to trace the effect of a shock to the Thai market on other stock markets. At the same time, variance decomposition is used to explain how much variation in the Thai stock market is from other stock markets.

The paper is organized as follows. Section 2 introduces the correlation analysis and the cointegration approach. Section 3 describes the data set and presents the empirical results. Section 4 includes the concluding remarks.

2 Measuring and Testing Contagion

2.1 Cross-Market Correlation Analysis

The most common test for crisis-contingent theories is based on cross-market correlation coefficients. The correlation coefficient in returns between two markets is calculated for a stable period and for a turmoil period. A standard t-test is applied to test for any significant increase in this correlation coefficient after turmoil occurs. If the correlation coefficient increases significantly, this suggests that the transmission mechanism between the two markets increases after the shock and a contagion does exist. Most of the papers using this testing strategy reach a general conclusion that cross-market correlation coefficients usually increase significantly after a currency crisis.

However, as suggested by Forbes and Rigobon (1999), the simple correlation coefficient is conditional upon the variance in the numeraire. When the variance in the numeraire (such as the Thai market) increases, the estimated correlation coefficient between the numeraire and other markets increases too. This explains why the general findings in the literature are toward the acceptance of a contagion. Forbes and Rigobon (1999) proposes a simple adjustment factor to correct this bias. In order to compare our results with theirs, the same adjustment process is applied in this paper. The adjustment process is briefly described here. For details, please see Forbes and Rigobon (1999).

Let x and y be stochastic variables that represent stock market returns in two different markets. Assume that x is the numeraire and these returns are related as the following equation:

$$y_t = \alpha + \beta x_t + \varepsilon_t \tag{1}$$

where $E(\varepsilon_t) = 0$, $E(\varepsilon_t^2) < \infty$, and $E(x_t \varepsilon_t) = 0$. The simple correlation coefficient between y_t and

x_t is defined as

$$\rho = \frac{\sigma_{xy}}{\sigma_x \sigma_y} \tag{2}$$

The OLS estimates of equation (1) for β is $\frac{Cov(x,y)}{Var(x,y)} = \frac{\sigma_{xy}}{\sigma_{xx}}$, therefore equation (2) can be rewritten as

$$\rho = \frac{\sigma_{xy}}{\sigma_x \sigma_y} = \beta \frac{\sigma_x}{\sigma_y}. \tag{3}$$

Without losing generality, we can assume $|\beta| < 1$. According to equation (1), $\sigma_{yy} = \beta^2 \sigma_{xx} + \sigma_{\varepsilon\varepsilon}$. Since the variance of the error term ε is constant, a 1% increase in the variance of x (σ_{xx}) always results in a less than 1% increase in variance of y (σ_{yy}). Therefore the ratio of standard deviation, $\frac{\sigma_x}{\sigma_y}$, tends to increase during the turmoil. Consequently, the estimated correlation coefficient, ρ, would be larger than it should be during the turmoil. It means that the estimated correlation between x and y will increase when the variance of x increases, even if the actual correlation between x and y is the same. The standard correlation coefficient defined in equation (2) is conditional upon the variance of x. The simple correlation coefficient tends to over-estimate the actual correlation during the turmoil period. Forbes and Rigobon (1999) shows the relationship between the actual correlation and the unadjusted correlation as followings:

$$\rho_t^u = \rho_t \sqrt{\frac{1 + \delta_t}{1 + \delta_t \rho_t^2}} \tag{4}$$

where ρ_t^u is unadjusted correlation coefficient, ρ_t is the actual correlation coefficient, and δ_t is the relative increase in the variance of x:

$$\delta_t \equiv \frac{\sigma_{xx}^h}{\sigma_{xx}^l} - 1$$

where σ_{xx}^h is the variance of x during the turmoil period and σ_{xx}^l is the variance of x during the stable period of time. Solving equation (4) results in the unconditional correlation coefficient as

$$\rho_t = \frac{\rho_t^u}{\sqrt{1 + \delta_t [1 - (\rho_t^u)^2}}. \tag{5}$$

After the adjusted correlation coefficient in turmoil period between the numeraire and the other markets is calculated, a standard t-test is applied to test the hypothesis

$$H_0 : \rho_t^h > \rho_t^l$$

$$H_1 : \rho_t^h \leq \rho_t^l$$

where ρ_t^h indicated the adjusted correlation for the turmoil period and ρ_t^l is the adjusted correlation for the stable period (it should be the same as unadjusted correlation for the stable period). The t statistic is defined as

$$t = \frac{\rho_t^h - \rho_t^l}{\sigma^h + \sigma^l}. \tag{6}$$

2.2 Vector Autoregression (VAR) and Cointegrating Relationship

Assume all stock returns in the region are endogenous variables in data generating process, and every endogenous variable in the system is intertemporally a function of the lagged values of all the endogenous variables in the system. The VAR of order p is expressed as

$$y_t = A_1 y_{t-1} + A_2 y_{t-2} + ... + A_p y_{t-p} + B x_t + \varepsilon_t \tag{7}$$

where is y_t a k vector of endogenous variables, x_t is a d vector of exogenous variables, $A_1, A_2, ..., A_p$ and B are matrices of coefficients to be estimated, and ε_t is a vector of innovations that may be contemporaneously correlated with each other but are uncorrelated with their own lagged values and uncorrelated with all of the right-hand side variables. Re-writing the VAR as

$$\Delta y_t = \Pi y_{t-1} + \sum_{i=1}^{p-1} \Gamma_i \Delta y_{t-1} + B x_t + \varepsilon_t \tag{8}$$

where $\Pi = \sum_{i=1}^{p} A_i - I_r$, $\Gamma_i = -\sum_{j=i+1}^{p} A_j$. Granger's representation theorem asserts that if the coefficient matrix Π has reduced rank $r < k$, then there exist $k \times r$ matrices α and β each with rank r such that $\Pi = \alpha\beta'$ and $\beta' y_t$ is stationary. r is the number of cointegrating relations (the cointegrating rank) and each column of β is the cointegrating vector. The elements of α are known as the adjustment parameters in the vector error correction model. Johansen's method is to estimate the Π matrix in an unrestricted form, then test whether one can reject the restriction implied by the reduced rank of Π. The Johansen's test is a joint test for the deterministic and stochastic cointegration restrictions. When there is no cointegrating relation accepted, it may be because of either the deterministic or the stochastic restriction is violated.

An unrestricted VAR is estimated and tested for the cointegrating relationship. Following the estimation are impulse response analysis and variance decomposition. An impulse response function traces the effect of a one standard deviation shock to one endogenous variable on current and future values of the variables in the VAR. By contrast, variance decomposition decomposes variation in an endogenous variable into the component shocks to the endogenous variables in the VAR. The

variance decomposition gives information about the relative importance of each endogenous variable on explaining the variation of one particular variable. The long-run relationship among stock returns in South East Asia during stable period and turmoil period are estimated and compared. If there is a significant change in the long-run relationship, a further examination on both impulse response function and variance decomposition will be made to dissect the cause of the shift in the long-run relationship.

3 Empirical Studies

3.1 The Data and Sample

We use daily stock market indices reported by Datastream to calculate stock market returns. The countries included in this studies are Hong Kong, Indonesia, Japan, Malaysia, Philippines, Singapore, South Korea, Taiwan, and Thailand. Our sample starts from January 1, 1990 to February 22, 2001. We perform each analysis using market returns measured in US dollars which allows us to compare our results with previous empirical work on testing contagion. Different from the two-day rolling average return employed by Forbes and Rigobon (1999), we calculate the daily return directly from the indices since all the countries are in the same/similar time zone. As discussed in the Introduction section, we use Thailand as our numeraire (base country) to investigate the potential turmoil propagation mechanism by the devaluation of baht. We also use July 2, 1997 to split the entire sample period into two sub-periods. One is from January 1, 1990 to July 1, 1997; and the other is from July 2, 1997 to February 22, 2001.

3.2 Cross-Market Correlation

Figure 1 shows the nine stock indices in US dollar after the devaluation of Thai baht on July 2, 1997. The dramatic co-movements among these stock markets are apparent in the figure. The co-movements indicate these markets are highly correlated with each other after July 2, 1997. Still, it is not clear this phenomena is from a contagion caused by the financial distress in Thailand or just the existing fundamental linkage among these markets. We then calculate the correlation coefficients between Thailand and other economies for two different periods - 1/1/1990 - 7/1/1997 and 7/2/1997 - 2/22/2001. The results are presented in Table 1. The unadjusted correlation coefficients between Thailand and all other economies, except for Malaysia, increase significantly after July 2. The t^u (t-test for unadjusted correlation) statistics are all larger than the 5% critical

value, 1.64, with the exception of Malaysia. It implies the relationship between Thailand and other South East Asian economies (except for Malaysia) had a fundamental change after July 2, 1997. There was a contagion after the devaluation of Thai baht.

For the Malaysian case, perhaps due to a series of the government intervention on the massive supporting stock market fund, foreign exchange control and reinstituting the Ringgit peg regime[1] in 1998, the correlation coefficient between Thailand and Malaysia did not increase. Hence, according to the unadjusted correlation coefficients, there is a contagion among Asian economies.

Since the simple correlation coefficient is conditional upon the variance of an individual economy, and apparently the variance in all of the stock markets increase after the shock on July 2, 1997, it is not surprised to find larger correlation coefficients between these economies. Only the variance in Taiwan stock market decreases a little after the shock. It is critical to calculate the adjusted correlation to examine whether a contagion actually occurred. We calculate the adjusted correlation using equation (5). The results are also presented in Table 1. It is found that the adjusted correlation coefficients between Thailand and Indonesia, Japan, South Korea, Philippines, and Taiwan increase after July 2, 1997.

It is worth noted that both Indonesia and S. Korea have joined the IMF bailout months after Thailand 1997 debacle. Consequently, the initial response to the international institutional investors may increase its risk premium from all these countries. At the same time, Japan has long been one of Thailand leading trading partner whereas Philippines, as the export rival devalued its currency accordingly to Thai baht.

However, the adjusted correlation between Thailand and Hong Kong, Malaysia, and Singapore decrease. Again, it is intriguing to note that Hong Kong and Malaysia have a explicit currency peg regime to US$ with heavy government market intervention to sterilize the high volatility in stock market during the turbulence time. In the post crisis period, Singaporean dollar was also implicitly following more weight to the Japanese Yen. And its currency is not allowed to be traded internationally. This may stabilize Singapore market (relatively to the Thai market) and reduce the adjusted correlation between Singapore and Thailand.

[1] The imposition of exchange rate control and fixing of the Ringgit-US$ exchange rate at RM 3.80 per dollars was on September 1998.

Furthermore, we perform t test to examine whether these increases are significant. It is found that the increases in correlation between Thailand-Indonesia and Thailand-Philippines are significant at 10% level. Again, this is quite understandable since all the three countries were engaging in competitive devaluation and under similar speculative attacks. In short, the trio countries have similar economic development structure with tendency to compete in basic reprocessing industrial export merchandise. All other increases are not significant. According to the adjusted correlation analysis, there is a contagion among Thailand, Indonesia, and Philippines.

Table 1: Correlation Coefficient Analysis

1/1/1990 – 7/1/1997			7/2/1997 – 2/22/2001				
	ρ	σ	ρ^u	ρ	σ	t^u	t
Hong Kong	0.3007	0.0133	0.4002	0.2546	0.0231	2.73	-1.26
Indonesia	0.1575	0.0102	0.3690	0.2328	0.0445	3.87	1.38*
Japan	0.1405	0.0162	0.2450	0.1506	0.0183	3.04	0.29
S. Korea	0.1373	0.0145	0.3064	0.1905	0.0368	3.30	1.04
Malaysia	0.3607	0.0118	0.4119	0.2629	0.0302	1.22	-2.33
Philippines	0.1912	0.0157	0.4018	0.2557	0.0249	5.19	1.59*
Singapore	0.3677	0.0103	0.5297	0.3524	0.0206	5.24	-0.50
Taiwan	0.1375	0.0215	0.2381	0.1462	0.0199	2.42	0.21

Note: (1) ρ^u is the unadjusted correlation coefficient, and σ is the standard deviation.

(2) For the period 1/1/1990 to 7/1/1997 the unadjusted correlation is the same as the adjusted correlation.

(3) t^u is the t-stat constructed according to equation (6) for testing unadjusted correlation coefficients, and t is the t-stat for testing adjusted correlation coefficients.

(4) 5% significance level for the t test is 1.645 and 10% significance level for the t test is 1.282.

3.3 Vector Autoregression and Cointegrating Relationship

To reduce the noise from daily data, we convert the daily data to monthly data for the purpose of testing long-run relationship. We run vector autoregression (VAR) on the returns in stock markets for the entire sample period and for two sub-periods - 1990.1-1997.6 and 1997.7-2001.2. We first examine the existence of any long-run relationship among the economies of our interest. Since a contagion occurs when an exogenous shock to one market leads to a significant increase in market co-movements, we further examine any change in the long-run relationship after the financial shock in July 1997.

Tables 2, 3 and 4 present the Johansen's LR test for cointegration. The results indicate that there is a long-run relationship between these economies for both pre- and post-crisis periods. There are 5 cointegration equations for the periods 1990.1-2001.2 and 1990.1-1997.7. Yet, there are 7 cointegration equations for the periods 1997.7-2001.2. Since there are nine countries in the system, the results imply that there are two to four cointegrating vectors that would bring the system back to its long-run equilibrium when any short-run deviation occurs.

To examine the existence of a contagion, there should be a significant change in the long-run relationship that cannot be explained by the real linkages among these economies. The normalized cointegrating vectors are examined and presented in Table 5 for the purpose of investigating any change in the long-run relationship. It is clear that the cointegrating vector changes significantly after July 1997. The magnitude (in absolute value) of the individual coefficients significantly decreases for the post-crisis period. It implies that if a short-run deviation occurs it would only take a smaller force to bring the system back to the long-run relationship. The smaller cointegrating vector indicates the system corrects any deviation from the long-run equilibrium relationship faster than it used to be. This is an indicator for an increase in market co-movements in South East Asia after July 1997. Signs of the cointegrating vector for Hong Kong, Malaysia, and Taiwan even change. Perhaps, these are due to heavy government intervention in the first former two; the latter which relied heavily on high tech industry has different economic development than Thailand's.

In order to compare the VAR results with our cross-market correlation analysis, the impulse response functions and variance decomposition are calculated. Figure 2 presents eight pairs of impulse responses to one standard deviation shock to the Thai market. Each pair includes the results for both before and after July 1997 to demonstrate the impact of baht's devaluation. Before July 1997, it took about six months for the response in the Hong Kong market to reach zero

whenever there was a shock in Thailand. After July 1997, it only took four months for the Hong Kong market to settle down. Reaction time for the Malaysian market also went down from nine and a half months to six months. The change in reaction in the Philippines is even more apparent. It went down from more than a year to only about seven months. The findings for Philippines are consistent with the cross-market correlation analysis. Singapore also has a quicker response to a Thai shock after July 1997.

In addition to the impulse responses which trace the impact of a Thai shock to other economies, Tables 6 and 7 present the variance decomposition for Thailand which indicates the impacts from other economies to the Thai market. Table 6 presents the decomposition prior to July 1997 and Table 7 is for the post-July 1997 period. It is found that before July 1997 South Korea and Philippines contribute largest variations to the Thai market within a 12-month horizon. After July 1997, the countries contributing most of the variation to the Thai markets are Taiwan, Japan, and South Korea. Before July 1997, 30 percent of the total variation in the Thai market is from foreign countries than the domestic variation. After July 1997, 46 percent of the total variation in the Thai market is from foreign countries. It shows an increase in the influence of other South East Asian markets on the Thai market. A further indicator for a significant increase in market co-movements.

4 Conclusions

This paper utilizes two different approaches to examine whether there is a contagion among South East Asian economies. According to the cross-market correlation analysis, there is a contagion between Thailand, Indonesia and Philippines. Right after the devaluation of baht on July 2, 1997, the Philippine central bank had to raise the overnight lending rate to 24 percent from 15 percent to defend its peso on July 3. The Indonesian rupiah was also affected within a week of the devaluation of baht, and hit the historical low value of 2,682 to the dollar on August 13, 1997. The very next day Indonesia abolished its system of managing the exchange rate through the use of a band and allowed it to float. The rupiah plunges to 2,755 on August 25, 1997. All of these events show that there are market co-movements which simply cannot be explained by the fundamental linkages between these economies. Perhaps, market interventions and/or international portfolio reallocation can regionally distort market mechanism from an economic fundamental basis.

A contagion is also detected by the cointegration analysis. The long-run relationship among South East Asian countries and Japan significantly changed after July 1997. Both impulse response

analysis and variance decomposition confirm the changes in market co-movements. The findings suggest that multinational investment managers may need to re-design their strategies for South East Asia. The findings also suggest that a quick move by IMF approving Philippines' request for an extension of its Extended Fund Facility (EFF), Chieng Mei initiative on foreign exchange swap and other arrangement proposed by Chaipravat and Bhanich Supapol [2000] and commissioned by ASEAN secretariat and massive financial packages to Thailand and Indonesia are among justifiable measures during the turbulent time.

Table 2 Cointegration Test for 1990.1 - 2001.2

	Likelihood	5 Percent	1 Percent	Hypothesized
Eigenvalue	Ratio	Critical Value	Critical Value	No. of CE(s)
0.481874	318.4105	192.89	204.95	None **
0.421861	233.5884	156.00	168.36	At most 1 **
0.332746	162.9040	124.24	133.57	At most 2 **
0.267776	110.7126	94.15	103.18	At most 3 **
0.198894	70.50733	68.52	76.07	At most 4 *
0.143683	41.90005	47.21	54.46	At most 5
0.110714	21.89031	29.68	35.65	At most 6
0.045324	6.753929	15.41	20.04	At most 7
0.005955	0.770469	3.76	6.65	At most 8

*(**) denotes rejection of the hypothesis at 5%(1%) significance level

L.R. test indicates 5 cointegrating equation(s) at 5% significance level

Table 3 Cointegration Test for 1990.1 - 1997.6

	Likelihood	5 Percent	1 Percent	Hypothesized
Eigenvalue	Ratio	Critical Value	Critical Value	No. of CE(s)
0.586493	285.8540	192.89	204.95	None **
0.507412	210.7922	156.00	168.36	At most 1 **
0.406809	150.6052	124.24	133.57	At most 2 **
0.318120	106.2149	94.15	103.18	At most 3 **
0.284717	73.66827	68.52	76.07	At most 4 *
0.228593	45.18674	47.21	54.46	At most 5
0.164860	23.12594	29.68	35.65	At most 6
0.084261	7.812713	15.41	20.04	At most 7
0.003883	0.330713	3.76	6.65	At most 8

*(**) denotes rejection of the hypothesis at 5%(1%) significance level

L.R. test indicates 5 cointegrating equation(s) at 5% significance level

Table 4 Cointegration Test for 1997.7 - 2001.2

	Likelihood	5 Percent	1 Percent	Hypothesized
Eigenvalue	Ratio	Critical Value	Critical Value	No. of CE(s)
0.917539	425.1951	192.89	204.95	None **
0.846342	315.3960	156.00	168.36	At most 1 **
0.785923	232.9828	124.24	133.57	At most 2 **
0.702889	165.1604	94.15	103.18	At most 3 **
0.614864	111.7598	68.52	76.07	At most 4 **
0.579711	69.77685	47.21	54.46	At most 5 **
0.386696	31.63712	29.68	35.65	At most 6 *
0.197214	10.12575	15.41	20.04	At most 7
0.010409	0.460410	3.76	6.65	At most 8

*(**) denotes rejection of the hypothesis at 5%(1%) significance level

L.R. test indicates 7 cointegrating equation(s) at 5% significance level

Table 5 Normalized Cointegrating Coefficients

1990.1-2001.2								
Thailand	Hong Kong	Indonesia	Japan	Korea	Malaysia	Philippines	Singapore	Taiwan
1.000	-2.731	0.369	-1.511	-2.765	0.575	-2.857	5.292	2.609
	(0.484)	(0.117)	(0.420)	(0.254)	(0.286)	(0.248)	(0.680)	(0.289)
Log likelihood	-3363.587							
1990.2-1997.6								
1.000	-3.454	0.160	0.753	-3.747	1.218	-2.352	4.320	1.902
	(0.845)	(0.122)	(0.306)	(0.373)	(0.559)	(0.354)	(0.705)	(0.258)
Log likelihood	-2058.830							
1997.7-2001.2								
1.000	0.161	0.025	0.334	-0.357	-0.195	-0.698	0.068	-0.083
	(0.099)	(0.046)	(0.100)	(0.054)	(0.079)	(0.050)	(0.080)	(0.054)
Log likelihood	-1013.614							

Numbers in the parentheses are asymptotic standard errors.

Table 6: Variance Decomposition of Thailand Stock Market 1990.1-1997.6

Period	S.E.	Thailand	Hong Kong	Indonesia	Japan	Korea	Malaysia	Philippines	Singapore	Taiwan
1	13.22	100.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	23.06	95.36	0.22	0.04	0.67	0.70	0.49	1.97	0.07	0.44
3	30.75	87.01	0.71	0.09	1.55	1.91	0.31	6.98	0.08	1.32
4	35.67	82.96	0.80	0.10	1.38	4.00	0.30	8.87	0.07	1.49
5	39.16	80.13	0.72	0.08	1.66	5.75	0.38	9.71	0.07	1.45
6	42.51	76.88	0.71	0.10	2.27	7.86	0.48	9.81	0.33	1.52
7	46.21	73.17	0.70	0.24	2.93	9.74	0.49	9.69	1.29	1.71
8	49.66	70.39	0.61	0.38	3.14	11.25	0.48	9.59	2.25	1.88
9	52.70	68.90	0.57	0.53	3.20	12.04	0.43	9.31	3.01	1.97
10	55.41	68.61	0.68	0.67	3.18	12.15	0.39	8.96	3.32	2.00
11	58.04	69.08	0.94	0.81	3.06	11.76	0.35	8.67	3.30	1.98
12	60.73	69.82	1.29	0.95	2.87	11.16	0.33	8.49	3.11	1.94

Table 7: Variance Decomposition of Thailand Stock Market 1997.7-2001.2

Period	S.E.	Thailand	Hong Kong	Indonesia	Japan	Korea	Malaysia	Philippines	Singapore	Taiwan
1	6.00	100.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	9.03	85.75	3.87	0.63	3.02	1.72	1.76	0.35	0.05	2.79
3	10.48	78.05	4.57	2.36	7.49	2.05	1.73	0.27	0.20	3.25
4	11.10	71.90	4.29	4.64	10.06	1.84	1.63	0.71	0.29	4.61
5	11.54	66.75	4.05	6.00	10.88	1.75	2.10	1.57	0.33	6.53
6	11.92	62.57	3.88	6.10	10.65	2.41	2.71	2.24	1.00	8.39
7	12.29	59.04	3.70	5.76	10.04	4.19	3.20	2.49	2.03	9.50
8	12.64	56.39	3.94	5.48	9.53	6.16	3.39	2.50	2.67	9.90
9	12.89	54.97	4.29	5.36	9.24	7.37	3.34	2.49	2.83	10.06
10	13.01	54.42	4.43	5.40	9.11	7.70	3.28	2.53	2.81	10.28
11	13.06	54.13	4.42	5.49	9.06	7.65	3.26	2.60	2.80	10.55
12	13.11	53.72	4.40	5.57	9.02	7.80	3.24	2.64	2.86	10.72

Figure 1: Stock Market Indices in US$ - After July 2, 1997 Thai Baht Devaluation

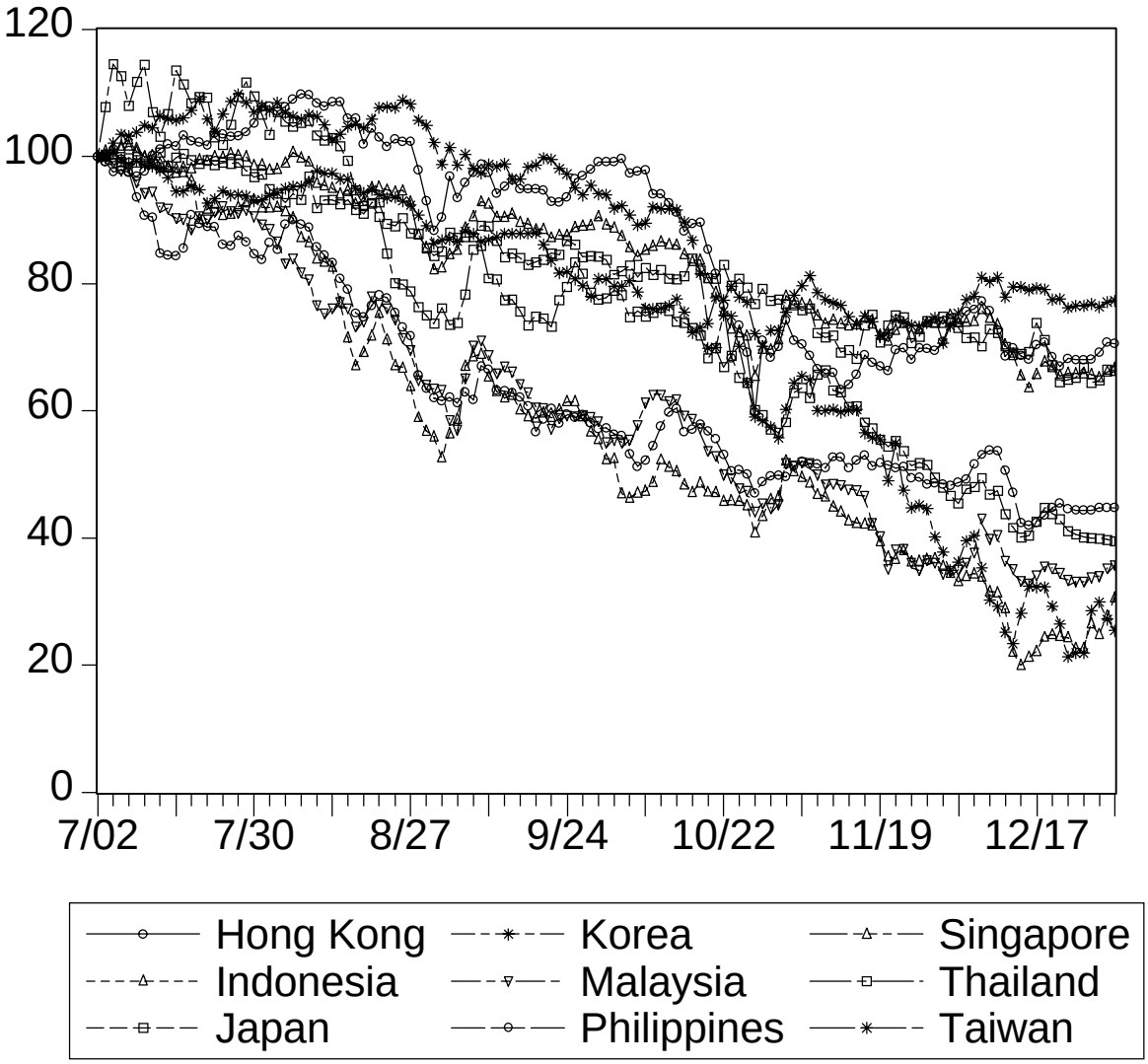
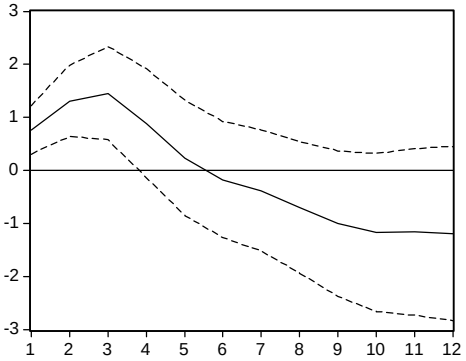
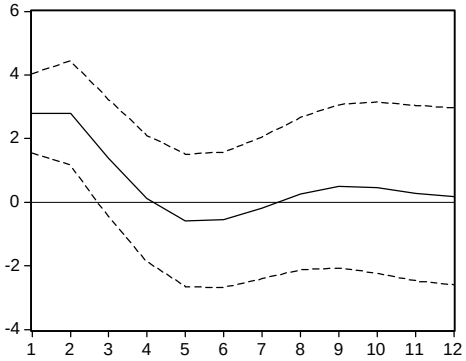


Figure 2: Impulse Response Analysis

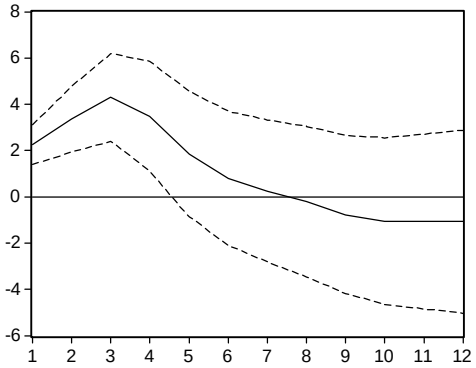
Response of Hong Kong to One S.D. Thai Innovation
1990.1-1997.6



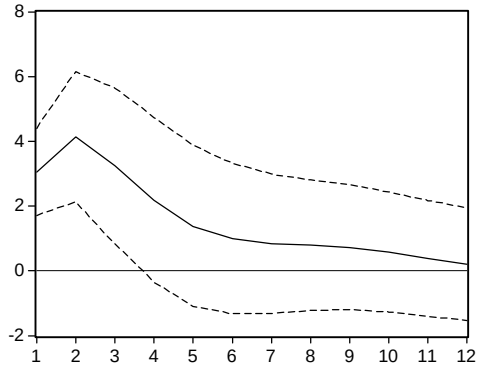
Response of Hong Kong to One S.D. Thai Innovation
1997.7-2001.2



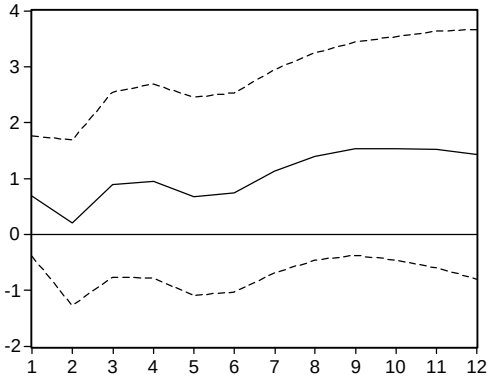
Response of Indonesia to One S.D. Thai Innovation
1990.1-1997.6



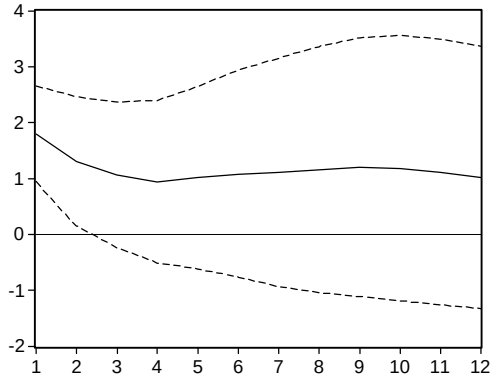
Response of Indonesia to One S.D. Thai Innovation
1997.7-2001.2



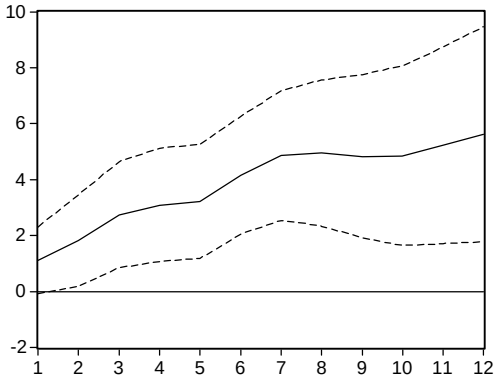
Response of Japan to One S.D. Thai Innovation
1990.1-1997.6



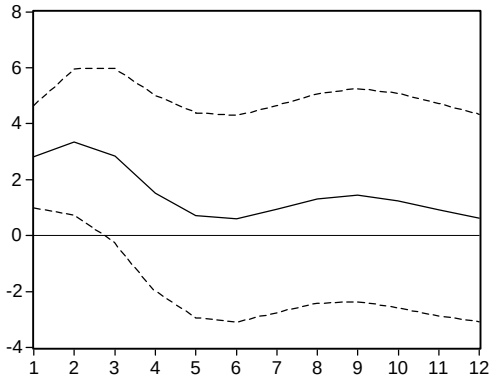
Response of Japan to One S.D. Thai Innovation
1997.7-2001.2



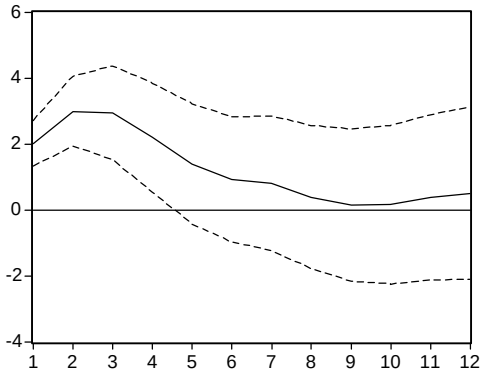
Response of Korea to One S.D. Thai Innovation
1990.1-1997.6



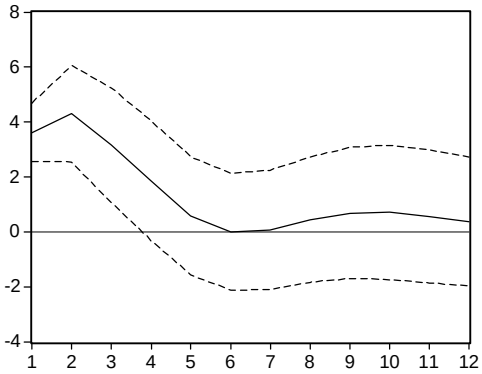
Response of Korea to One S.D. Thai Innovation
1997.7 2001.2



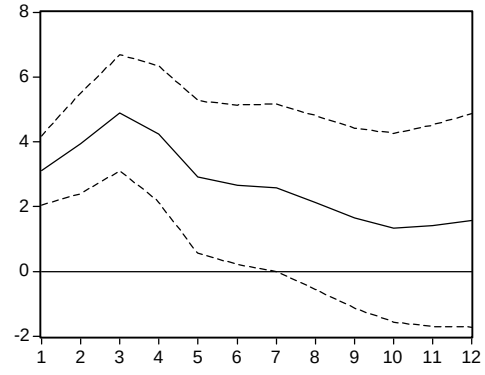
Response of Malaysia to One S.D. Thai Innovation
1990.1-1997.6



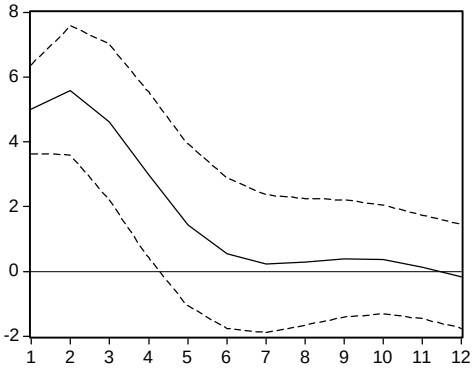
Response of Malaysia to One S.D. Thai Innovation
1997.7 2001.2



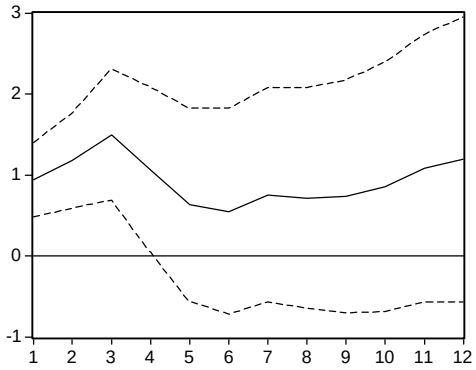
Response of Philippines to One S.D. Thai Innovation
1990.1-1997.6



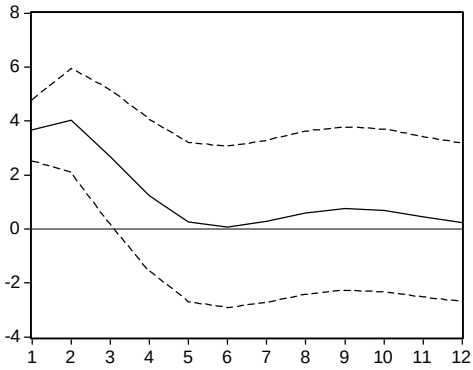
Response of Philippines to One S.D. Thai Innovation
1997.7-2001.2



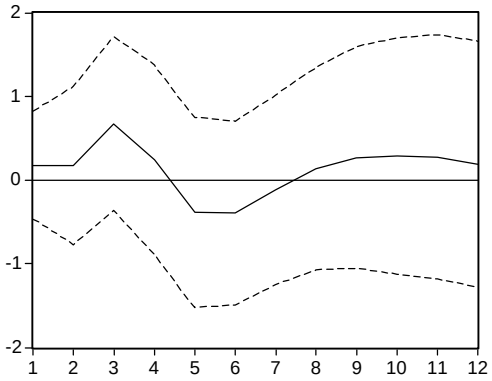
Response of Singapore to One S.D. Thai Innovation
1990.1-1997.6



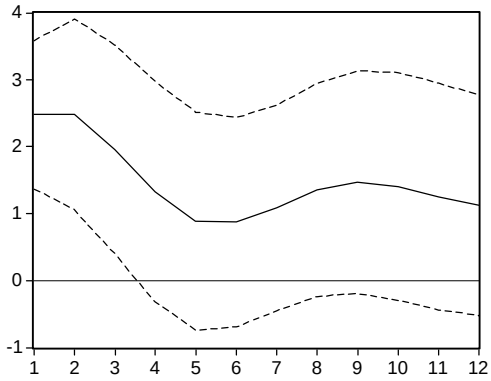
Response of Singapore to One S.D. Thai Innovation
1997.7-2001.2



Response of Taiwan to One S.D. Tahi Innovation
1990.1-1997.6



Response of Taiwan to One S.D. Thai Innovation
1997.7-2001.2



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