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ASEAN-5 + 3 and US Stock Markets Interdependence Before, During and After Asian Financial Crisis

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Abstract

The issues of international stock markets linkages had been investigated over the time. Since the Asian financial crisis in 1997, many economists are concerned about the relationship between Asian stock markets and others in the world. The main objective of this paper is to examine the linkages between ASEAN-5+3 namely Malaysia, Singapore, the Philippines, Thailand, Indonesia, China, Japan and Korea and US stock markets. The data consists of weekly stock indices data. The total samples are separated into three sub-periods. All the indices applied are expressed in local currencies. In conclusion, we found that ASEAN-5+3 and US stock markets are interdependence during crisis and post-crisis periods and the impact of US stock market is effective in ASEAN-5+3 stock markets only for pre- and during-crisis periods.

Keywords: Stock markets, Cointegration, Granger-causality, ASEAN

1. Introduction

Until 1997, Asia attracted almost half of the total capital inflow to developing countries. The economies of Southeast Asia in particular maintained high interest rate was attractive to foreign investors who look for a high rate of return. As a result the region's economies received a large inflow of hot money and experienced a dramatic run-up in asset prices. At the same time, the regional economies of Thailand, Malaysia, Indonesia, the Philippines, Singapore, and South Korea experienced high growth rates at 8-12%, in the late 80s and early 90s. This achievement was broadly acclaimed by economic institutions including the IMF and World Bank, and was known as part of the Asian economic miracle.

Regardless the disputed causes, the Asian crisis started in mid-1997 had affected the currencies, stock markets, and other asset prices of several Southeast Asian economies. Triggered by events in Latin America, particularly after the Mexican peso crisis of 1994, Western investors lost confidence in securities in South East Asia and began to pull money out, creating a domino effect.

At the mid of 1997, Thailand was hit by currency speculators, resulting in great damages in the financial sectors of country. What at first appeared to be local financial crisis in Thailand has escalated into a global financial crisis within few months. Initially, spreading to other Asian countries – Indonesia, Korea, Malaysia and the Philippines – then far afield to Russia and Latin America, especially Brazil. The Asian crisis, however, has turned out to be far more serious than its two predecessors in terms of the extent of contagion and the severity of resultant economic and social costs. Following the massive depreciations of local currencies, financial institutions and corporations with foreign currency debts in the afflicted countries were driven to extreme financial distress and many were forced to default.

Several factors were responsible for the onset of Asian financial crisis: a weak domestic financial system, free international capital flows, the contagion effects of changing market sentiment and inconsistent economic policies. In recent years, both developing and developed countries were encouraged to liberalize their financial markets and allow free flows of capital across countries. As Asian developing countries eagerly sourcing foreign capitals from US, Japanese and European investors, who were attracted to these fast growing emerging markets for extra returns for their portfolios. Large inflows of private capital resulted in a credit boom in the Asian countries in the early and mid-1990s. The credit boom was often directed to speculations in real estate and stock markets as well as to investments in marginal industrial projects. Fixed or stable exchange rates also encouraged un-hedged financial transactions and excessive risk-taking by both lenders and borrowers, who were not much concerned with exchange risk.

As asset prices declined (as happened in Thailand prior to the currency crisis) in part due to the government's effort to control the overheated economy, the quality of banks' loan portfolios also declined as the same assets were held as collateral for the loans. In addition, their lending decisions were often influenced by political considerations, likely leading suboptimal allocation of resources. However, the so-called crony capitalism was not a new condition, and the East Asian economies achieved an economic miracle under the same system. Meanwhile, the booming economies with a fixed or stable nominal exchange rate inevitably brought about an appreciation of the currencies. This, in turn, resulted in a market slowdown in export growth in these Asian countries like Thailand and Korea. If the Asian currencies had been allowed to depreciate in real terms which were not possible because of the fixed nominal exchange rates, discrete changes of the exchange rates as observed in 1997 might have been avoided. In Thailand, as the run on the Baht started, the Thai central bank initially injected liquidity to the domestic financial system and tried to defend the currency by drawing on its foreign exchange reserves. With its foreign reserves declining rapidly, the central bank eventually decided to devalue the baht.

International money and capital markets have become more integrated in recent years. Many studies have been undertaken to examine the integration of international stock markets. There are several reasons that contributed to the stock market interdependences, e.g. increase in capital flows across national boundaries and potential benefits from diversification of investment on international level. It is important for the investors to diversify international portfolio if they have the knowledge on the structure of equity market linkages across countries. As a large number of investors competing to earn high returns, stock prices in different countries should closely reflect the underlying economic fundamentals. Consequently, common stochastic trends in stock markets of those countries potentially mirror their economic fundamentals that are related significantly with one another (Phengpis and Apilado, 2004). According to Kearney and Lucey (2004), with increasing integration of international equity markets, the diversification benefits will tend to decline. Lack of cointegration between the stock markets may allow investors to minimise portfolio risk by international diversification.

This study consider whether ASEAN-5+3 countries namely Malaysia, Singapore, Indonesia, Thailand the Philippines, China, Korea, Japan and US are integrated with each other because of importance of their economic as trading partners and in terms of investment flows. Both the multilateral and bilateral relationship between the individual ASEAN-5+3 and US stock market is examined through the cointegration and Granger-causality techniques. In addition, we are interested to know whether US stock market has any effect on the ASEAN-5+3 stock indices before, during and after Asian financial crisis.

2. Literature Reviews on ASEAN-5 + 3 Stock Markets Integration

Arshanapalli et al. (1995) investigate the presence of a comman stochastic trend between US and the Asian stock market movements during pre- and post-October 1987 period. They using daily data, the sample includes index data for US, Japan, Hong Kong, Malaysia, the Philippines, Singapore and Thailand for the time period January 1, 1986 through May 12, 1992. By implying cointegration and error-correction model, they find that the influence of the US stock market innovations was found to be greater during the post-October 1987 period. The results also indicate that the Asian equity markets are less integrated with Japan's equity market than they are with the US market.

Sheng and Tu (2000) analyze the linkages among national stock markets before and during the period of the Asian financial crisis by using cointegration and variance decomposition analysis to examine the linkages. The data consist of daily closing prices for the New York S&P 500 and the following 11 major Asia-Pasific equity market indices: Tokyo Nikkei 225, Hong Kong Hang-Seng, Singapore Straits Times, Sydney All Ordinaries, Seoul Composite Index, Taiwan Composite Index, Kuala Lumpur Composite Index, Manila Composite Index, Bangkok Composite Index, Jakarta Composite Index and Shanghai B-shares Index. The prices are collected for the period from July, 1 1996 to June 30, 1998. The results show that the relationship for the South-East Asian countries is stronger than that for the North-East Asian countries. The tests also show no cointegrational relationship before the period of the financial crisis. The forecast error variance decomposition also finds that the degree of exogeneity for all countries indices has been reduced.

Manning (2002) applies both the Johansen Maximum Likelihood approach and the Haldane and Hall Kalman Filter technique to consider the co-movement of equity markets in South East Asia, at the same time taking the United States to be the external market. The two samples analyzed comprise weekly and quarterly information on equity indices and US dollar series for the US, Hong Kong, Indonesia, Japan, Korea, Malaysia, the Philippines, Singapore, Taiwan and Thailand over the period January 1988 to February 1999. He finds that in general, there are two common trends present in the eight Asian equity market indices modeled here, and also two trends when the US market in additionally included in Johansen VAR.

Jaag and Sul (2002) analyze the changes in the co-movement among the stock markets of the countries which have undergone the crisis directly and the neighboring Asian countries since the crisis seems to have common impact on the Asian countries as a whole. These countries are Thailand, Indonesia and Korea as direct crisis countries and Japan, Hong Kong, Singapore and Taiwan as neighbouring countries. The total sample of the study is 2 years from October 1, 1996 to September 30, 1998, which is divided into three 8-month sub periods. By using Granger Causality test and co-integration analysis, they find that before the crisis, there is almost no co-movement in the stock markets of 7 Asian countries. However, uni-directional and bi-directional linkage among Asian equity markets has increased sharply since the financial crisis in June 1997. During the 8 months of the post crisis, the strong co-movement is still found and in some cases, the linkage among Asian stock markets gets even stronger.

Azman-Saini et al. (2002) investigate whether or not causality is present among the ASEAN-5 equity markets in the long run. The weekly Morgan Stanley Composite Index (MSCI) indices obtained from the Kuala Lumpur Stock Exchange (KLSE) covering period of January 1988 to August 1999 are used in this study. The results of Granger noncausality test due to Toda and Yamamoto reveal that the Singapore equity market was not affected by other markets except by the Philippines in the long-run. This may help to explain why among the ASEAN-5 equity markets, Singapore was not badly affected by the Asian financial crisis as well as the effects of the Gulf War in August 1990. This result shows that there exist opportunities for beneficial international portfolio diversification within the context of the ASEAN-5 equity markets.

Click and Plummer (2005) investigate whether the ASEAN-5 markets are integrated or segmented using the time series technique of cointegration to extract long run relations. By using daily and weekly stock index quotes in local currencies data from July 1, 1998 through December 31, 2002. The results suggest that the ASEAN-5 stock markets are cointegrated and are thus not completely segmented by national borders. However, there is only one cointegrating vector, leaving four common trends among the five variables. Conclusion, the ASEAN-5 stock markets are integrated in the economic sense, but that integration is far from complete.

Choudhry et al. (2007) examine empirically the change(s) in the long run relationship(s) between the stock prices of eight Far East countries namely Thailand, Malaysia, Indonesia, Hong Kong, Singapore, the Philippines, South Korea and Taiwan around the Asian financial crisis of 1997-98. Further test are conduct to check the change in the influence of the Japanese and US stock markets in the Far East region before, during and after the crisis. Daily stock price indices ranging from January 1, 1988 to January 1, 2003 is used. Empirical investigation is conducted by means of rolling correlation coefficients, the Johansen multivariate cointegration method, causality test and band spectrum regression. Results show significant long-run relationship(s) and linkages between the Far East markets before, during and after the crisis. The most significant linkage and relationship are found during the crisis period. Results mostly indicate larger US influence in all periods but some evidence of increasing Japanese influence is also shown.

3. Methodology

Augmented Dickey Fuller (ADF) test was initially introduced by David Dickey and Wayner Fuller in 1979. The tests for unit root identify whether an individual series (Y_t) is stationary by running an ordinal least square (OLS) regression equation. The ADF test makes a parametic correction for higher-order correlation by assuming that the y series follow an AR (ρ) process and adjusting the test methodology where ρ is the number of lagged changes in Y_t necessary to make ε_t serially uncorrelated. Two types of Augmented Dickey Fuller regressions covered the non linear trend and linear trend element respectively as shown in equation 1 and 2.

$$\Delta Y_t = \beta_1 + \delta Y_{t-1} + \sum_{i=1}^{\rho} \gamma_i \Delta Y_{t-i} + \varepsilon_t \tag{1}$$

$$\Delta Y_t = \beta_1 + \beta_2 t + \delta Y_{t-1} + \sum_{i=1}^{\rho} \gamma_i \Delta Y_{t-i} + \varepsilon_t \tag{2}$$

where t is the time trend variable, Δ is the first-differenced operator, Y_t is the logarithm of the variable in period t, $\Delta Y_t = Y_t - Y_{t-1}$, ε_t is white noise error term, δ and β_2 are the constant parameters.

More weight was given to the Phillips-Perron unit root test as this test has been shown to be more reliable than Dickey-Fuller test in the presence of large amounts of heteroscedasticity. The PP unit root test proposed by Phillips and Perron (1988) and has an advantage as it propose a nonparametric method of controlling for higher-order serial correlation in a series. The PP unit root test is performed by conducting the following regressions:

$$Y_t = \alpha_0 + \beta_1 Y_{t-1} + \eta_t \tag{3}$$

$$Y_t = \alpha_0 + \alpha_1 t + \beta_1 Y_{t-1} + \eta_t \tag{4}$$

Formally, if two or more non-stationary time series share a common trend, then they are said to be cointegrated. The theoretical framework highlighted are expressed as following: the component of the vector $Y_t = (y_{1t}, y_{2t}, \ldots, y_{nt})'$ are considered to be cointegrated of order *d,b,* denoted $Y_t \sim CI\ (d,b)$ if (i) all the component Y_t are stationary after n difference, or integrated of order *d* and noted as $Y_t \sim I(d)$. (ii) presence of a vector $\beta = (\beta 1, \beta_2, \ldots, \beta_n)$ in such that linear combination $\beta Y_t = \beta_1 y_{1t} + \beta_2 y_{2t} + \ldots + \beta_n y_{nt}$ wherby the vector β is named the cointegrating vector. A few major characteristics of this model are that the cointegration relationship obtained indicates a linear combination of non-stationary variables, in which all variables must be integrated of the same order and lastly if there are *n* series of variables, there may be as many as *n*-1 linearly independent cointegrating vectors.

Johansen's (1991) cointegration test is adopted to determine whether the linear combination of the series possesses a long-run equilibrium relationship. The numbers of significant cointegrating vectors in non-stationary time series are tested by using the maximum likelihood based λ_{trace} and λ_{max} statistics introduced by Johansen (1991) and Juselius (1990). The advantage of this test is it utilises test statistic that can be used to evaluate cointegration relationship among a group of two or more variables. Therefore, it is a superior test as it can deal with two or more variables that may be more than one cointegrating vector in the system. Prior to testing for the number of significant cointgrating vectors, the likelihood ratio (LR) tests are performed to determine the lag length of the vector autoregressive system. In the Johansen procedure, following a vector autoregressive (VAR) model, it involves the identification of rank of the *n* X *n* matrix ∏ in the specification given by:

$$\Delta Y_t = \delta_0 + \sum_{i=1}^{k-1} \Gamma_i \Delta Y_{t-i} + \Pi Y_{t-k} + \varepsilon_t \tag{5}$$

where Y_t is a column vector of the *n* variables, Δ is the difference operator, Γ and ∏ are the coefficient matrices, *k* denotes the lag length and δ is a constant. In the absence of cointegrating vector, ∏ is a singular matric, which means that the cointegrating vector rank is equal to zero. On the other hand, in a cointgrated scenario, the rank of ∏ could be anywhere between zero. In other words, the Johansen Cointegration test can determine the number of cointegrating equation and this number is named the *cointegrating rank*. The Johansen Maximum likelihood test provides a test for the rank of ∏, namely the trace test (λ_{trace}) and the maximum eigenvalue test (λ_{max}). Firstly, the λ_{trace} statistic test whether the number of cointegrating vector is zero or one. Then, the λ_{max} statistics test whether a single cointegration equation is sufficient or if two are required. Both test statistics are given as follows:

$$\lambda_{trace}(r, r+1) = -T \sum_{i=r+1}^{\rho} \ln(1-\hat{\lambda}) \tag{6}$$

$$\lambda_{trace}(r, r+1) = -T \ln(1-\hat{\lambda}_{r+1}) \tag{7}$$

where ρ is the number of separate series to be analysed, T is the number of usable observations and λ is the estimated eigenvalues obtained from the (i+1) x (i+1) cointegrating matrix.

4. Data

The data set consists of the weekly stock markets for ASEAN-5+3 and US stock markets covering the period from 1st January 1990 to 31st May 2007. The stock markets are Jakarta SE Composite (Indonesia), Kuala Lumpur Composite Index (Malaysia), Straits Times Index (Singapore), Bangkok SET (Thailand), Philippines SE Composite (Philippines), Nikkei 225 Stock Average (Japan), Kospi Composite Index (Korea), Shanghai SE Composite Index (China) and Dow Jones Industrial Average Index (US). All stock markets are denominated in local currencies. The analysis of data is divided into three sample periods: (Note 1) first, pre-crisis period spanning from 1st January 1990 to 30th June 1997; second, crisis-period from 1st July 1997 to 30th June 1998; and third, post-crisis period from 1st July 1998 to 31st May 2007.

5. Empirical Results

For one to proceed with cointegration tests, it is important to first examine the univariate properties of the individual time series. Notably, Johansen-Juselius cointegration procedure requires that all variables are *I(1)*. As reported in Table 1, all series are non-stationary in their level form since the null hypothesis of unit root fail to be rejected at conventional significant level except for Japan at the pre-crisis period. For during-crisis period and post-crisis period, stock indices of ASEAN-5+3 and US are stationary after first differences, that is integrated of first order and thereby implying a clear *I(1)* process. The confirmation of *I(1)* process has provided a requisite for the forthcoming cointegration analysis.

Test of cointegration has been quite a standard means of investigating long-run stationary relationship between non-stationary variables. Two or more non-stationary time series are cointegrated if a linear combination of these is stationary. Table 2 presents the cointegration tests results for the pre-crisis (part A), crisis (part B) and post-crisis (part C) periods. For each period, cointegration tests are conducted on two models: the first model includes all the ASEAN-5 with China, Korea and Japan in the VAR and in the second model the US stock index is added in the VAR. In this way, the second model check for the presence of the US index in the long-run relationship between the stock indices of the ASEAN-5 with China, Korea and Japan: before, during and after financial crisis.

For the pre-crisis period in Table 2 (part A), both the trace test and maximum eigenvalues statistics in model 1 failed to reject the null hypothesis of no cointegrating vector. Thus, the first result from the pre-crisis period is failed to show any possible significant long-run stationary relationships between the ASEAN-5 with Korea (excluding Japan due to its stationary properties and China due to lack of data). This result change when US index is added in model 2. Trace test show two significant vectors whereas maximum eigenvalues test show only one significant vector. Therefore, since both test agreed upon one significant vector, this may imply that US is a crucial element in the cointegrating vector(s) and would indicate interdependence among these ASEAN-5 and Korea stock markets with the larger market of US during the pre-crisis period. All the eigenvalues in all the tests are less than unity, implying that the system as a whole is stable.

Results from the crisis period are shown in Table 2 (part B). Once again, two models are tested. In the first model (ASEAN-5 with China, Korea and Japan), the trace test indicates three vectors whereas maximum eigenvalues indicates two vectors at 1% significant level. Thus, result shows two stationary long-run relationships between the ASEAN-5 with China, Korea and Japan stock indices. (Note 2) In the second model, when US is added in the VAR, both trace test and maximum eigenvalues test indicate six vectors and three vectors at 1% significant level. As compared to pre-crisis period, the number of cointegrating vector increased from 1 to 3. This indicates an increase in the degree of linkages of these stock markets. According to Ratanapakorn and Sharma (2002), globalization increased during the Asian crisis and the larger number of long run relationship during the period may be due to increased globalization of the stock markets. They also find evidence of increased linkages between the markets during the crisis period. Larger number of cointegrating vectors implies that during the crisis period diversification and portfolio risk management may not reduce risk by much. Also, including the US index may not help in reducing the risk of the portfolio. Most previous studies also find significant linkages between the Asian stock markets during the crisis. Once again, eigenvalues in all tests are less than unity.

Table 2 (part C) presents the post-crisis results. Both the trace and maximum eigenvalues statistics for model 1 and 2 show that only one significant cointegrating vector exists. Thus, during the post-crisis period, only one stationary long-run relationship is found between the ASEAN-5 with China, Korea and Japan with or without the US index in the VAR. The number of cointegrating vector had decreased if we compared to during-crisis period. This decrease in the degree of linkages of these markets could be due to specific risks, such as liquidity, political, economic policy and currency risk, and macroeconomic instability in the region. All these factors may have discouraged foreign investors and lowered the globalization in the region.

Comparing the cointegration results between the three periods, the results indicate that stationary long-run relationships existed among the stock indices. (Note 3) For all three sub-periods, more nonzero cointegration vectors are found during the crisis period. Higher number of nonzero cointegration vectors (lower number of common trends) implies that diversification and minimizing portfolio risk by investors was harder during the crisis period compared to other periods. In addition, the results show that the relationships between the stock indices of the region did not change much before the Asian crisis and after it. Common stochastic trends in stock markets of those countries potentially mirror their economic fundamentals that are related significantly with one another. Overall, based on cointegration results, the inclusion of the US index in a portfolio of ASEAN-5 with China, Korea and Japan markets may not help to reduce portfolio risk.

The next step would be identifying the direction of causality among these ASEAN-5+3 and US stock markets. Granger causality tests based on VECM for pre-crisis period are conducted and the results are reported in Table 3. For Singapore, Korea and the Philippines, the error correction terms (ECTs) are negative and statistically significant at 95% significance level. The temporal causality effect are active, consequently, these three countries are endogenously determined in the model and share the burden of short-run adjustment to long run equilibrium. The temporal Granger-causality channels are abstracted from Table 3 and summarized in Figure 1. There are unidirectional causal effect running from Thailand to Indonesia and Indonesia to US before the risk spread to other countries. Changes in the Philippines and Malaysia stock market is being led by changes in US stock market. From Figure 1, it's clearly show that when the Asian financial crisis in 1997 started in Thailand, this crisis spread to Indonesia, Malaysia and the Philippines.

During-crisis period, the results in Table 2 (part B), for the second model indicates that there are three significant cointegrating vectors among ASEAN-5, China, Korea, Japan and US stock markets. Table 4 reports the results of Granger causality test based on VECM for these nine markets. With regard to ECTs, our discussion will focus only on negative and significant ECTs within the three ECTs. China is the only stock market which had negative significant ECTs without mixture with positive significant ECTs. Therefore, China stock market is clearly endogenous determined in the system and bear the burden of short-run adjustment towards the long-run equilibrium. Korea and the Philippines stock markets had mixture positive and negative significant ECTs while Indonesia, Malaysia and Singapore stock markets had positive significant ECTs. The temporal Granger-causality channels are abstracted from Table 4 and summarized in Figure 2. Since there are three significant long run relationships between the variables, therefore we get three groups of short run relationships. For the first group, changes in Thailand stock market will affect Korea stock market and indirectly affected Malaysia stock market too via Korea. There is one bidirectional causal effect between Malaysia and China stock markets. In the second group, the Philippines spread out the risk to Indonesia and US stock markets. Meanwhile, the last group has a unidirectional causal effect running from Singapore to the US stock market.

The results of cointegration during post-crisis period in Table 2 (part C), for second model indicates that only one significant long run relationship exist among ASEAN-5, China, Japan, Korea and US stock markets. Table 5 provides result of Granger causality tests based on VECM. Statistically significant ECT only in the equations for Singapore, China and Indonesia. However, only the ECTs for Singapore and China carried the correct sign. The economic intuition arising from the findings imply that when there is a deviation from the equilibrium cointegrating relationships in this system, it is mainly the changes in Singapore and China stock markets that adjusts to clear the disequilibrium, i.e., bears the brunt of short-run adjustment to long-run equilibrium. The temporal Granger-causality channels are abstracted from Table 5 and summarized in Figure 3. It's clearly showed that US stock market is exogenous whereas Thailand stock market is endogenous in the short run. There is unidirectional causal effect running from US to Japan and US to Singapore. At the same time, Singapore stock market also affected by Japan stock market. Malaysia stock market is Granger-caused by Japan and Singapore stock markets. There also causal effect from Singapore to the Philippines. Lastly, changes in Thailand stock market caused by changes in Malaysia, Singapore and the Philippines stock markets.

6. Conclusions

This study attempts to examine the linkages between the ASEAN-5+3 and U.S. stock markets. The empirical analysis of this study begins with the Augmented Dickey-Fuller and Phillips-Perron stationarity tests in order to determine at which level do the data exhibit stationarity for the purpose of cointegration analysis application. Results show that the long-run relationships between ASEAN-5+3 stock markets occur only for during- and post-crisis period. For the pre-crisis period, there is no significant cointegrating vector among the ASEAN-5+3 stock markets. Before and during-crisis, the number of cointegrating vector increased after US stock market had been included in the model during the crisis. This implied that the system is more interdependence. Hence, by adding US stock market is not helping investors to reduce the portfolio risk. The results of short-run Granger-causality based on VECM showed that Thailand stock market is the most exogenous markets. Surprisingly, China and Korea stock markets are active in short-run only during-crisis but not before and after crises. These probably due to most of the markets are more sensitive to changes in other's market during the crisis period.

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Notes

Note 1. Choudhry *et al.* (2007) also divide their total sample into sub-samples of pre-crisis and post-crisis.

Note 2. Both test show different significant level. Therefore, we only consider when both statistics agreed upon at two significant cointegrating vectors.

Note 3. Except ASEAN-5 with Korea before crisis.

Table 1. DF/ADF and PP unit root tests

Countries	DF/ADF								PP							
	Level				1st Difference				Level				1st Difference			
	Constant	k	Trend	k	Constant	k	Trend	k	Constant	k	Trend	k	Constant	k	Trend	k
Pre-crisis period (I Jan, 1990 - 30 June, 1997)																
Malaysia	-0.89	0	-2.14	0	-18.38**	0	-18.35**	0	-0.94	2	-2.22	1	-18.36**	4	-18.33**	4
Singapore	-0.87	0	-2.23	0	-18.12**	0	-18.09**	0	-1.00	3	-2.49	4	-18.12**	0	-18.09**	0
Thailand	-1.23	0	-0.92	0	-18.74**	0	-18.76**	0	-1.42	7	-1.11	6	-18.80**	5	-18.80**	5
Indonesia	-0.74	2	-1.58	2	-10.34**	1	-10.43**	1	-1.01	11	-1.66	11	-18.46**	11	-18.39**	10
The Philippines	-2.22	0	-2.46	0	-12.51**	0	-12.48**	0	-2.34	1	-2.46	0	-12.51**	5	-12.48**	5
Japan	-3.31*	0	-2.88	0	-20.53**	0	-20.65**	0	-3.31*	4	-2.93	5	-20.53**	5	-20.63**	4
Korea	-1.84	0	-2.38	0	-19.96**	0	-19.95**	0	-1.83	1	-2.38	0	-19.96**	3	-19.95**	3
US	1.60	0	-1.36	0	-21.04**	0	-21.23**	0	1.97	13	-1.23	10	-21.04**	9	-21.32**	11
During-crisis period (7 July, 1997 - 29 June, 1998)																
Malaysia	-1.40	0	-1.95	0	-7.72**	0	-7.64**	0	-1.35	3	-1.94	3	-7.75**	2	-7.67**	2
Singapore	-0.68	0	-2.56	0	-8.17**	0	-8.11**	0	-0.57	3	-2.68	4	-8.20**	2	-8.14**	2
Thailand	-0.26	0	-1.14	0	-6.30**	1	-6.24**	0	-0.56	3	-1.59	4	-6.39**	3	-6.34**	3
Indonesia	-2.45	0	-2.15	0	-8.78**	0	-8.98**	0	-2.40	1	-2.00	1	-8.74**	2	-8.98**	2
The Philippines	-2.34	0	-2.20	0	-7.96**	0	-7.96**	0	-2.30	1	-2.14	1	-7.96**	0	-7.95**	1
Japan	-2.17	0	-2.04	0	-7.54**	0	-7.70**	0	-2.10	5	-1.94	3	-7.57**	4	-7.93**	6
Korea	-0.81	0	-1.75	0	-8.36**	0	-8.29**	0	-0.81	3	-1.93	4	-8.25**	4	-8.18**	4
China	-1.11	0	-2.84	1	-5.66**	0	-5.65**	0	-1.25	2	-2.23	2	-5.61**	7	-5.67**	8
US	-0.89	0	-2.63	2	-9.32**	0	-9.29**	0	-0.78	4	-2.20	3	-9.23**	1	-9.20**	1
Post-crisis period (6 July, 1998 - 28 May, 2007)																
Malaysia	-1.39	1	-2.07	1	-19.09**	0	-19.07**	0	-1.65	7	-2.35	7	-19.37**	6	-19.35**	6
Singapore	-1.11	0	-1.43	0	-20.16**	0	-20.14**	0	-1.27	7	-1.64	7	-20.24**	6	-20.22**	6
Thailand	-1.27	0	-1.94	0	-13.01**	1	-13.00**	1	-1.36	3	-2.13	4	-21.56**	3	-21.54**	3
Indonesia	0.66	0	-1.36	0	-20.04**	0	-20.14**	0	0.24	11	-1.69	11	-20.49**	11	-20.53**	11
The Philippines	0.04	0	-0.69	0	-19.09**	0	-19.21**	0	-0.49	7	-1.10	7	-19.46**	6	-19.52**	5
Japan	-1.04	0	-0.82	0	-21.92**	0	-22.03**	0	-1.06	6	-0.82	5	-21.92**	6	-22.02**	5
Korea	-1.88	0	-2.39	0	-23.22**	0	-23.20**	0	-1.90	9	-2.49	10	-23.15**	10	-23.13**	10
China	1.78	0	1.54	0	-19.80**	0	-19.98**	0	1.09	8	1.01	7	-20.23**	9	-20.26**	8
US	-1.67	0	-2.10	0	-23.20**	0	-23.20**	0	-1.44	8	-1.95	7	-23.38**	9	-23.39**	9

Notes: Asterisk (**) and (*) denotes 99% and 95% of significant level.

Table 2. Cointegration Tests Results

Vectors	r = 0	r ≤ 1	r ≤ 2	r ≤ 3	r ≤ 4	r ≤ 5	r ≤ 6	r ≤ 7
Part A : Pre-crisis results (Jan 1, 1990 - June 30, 1997), Lags = 5								
Model 1: ASEAN-5 with Korea in the VAR								
Trace	97.844	60.684	39.742	21.414	8.212	0.076	-	-
Critical Value (1%)	103.18	76.07	54.46	35.65	20.04	6.65	-	-
Max-Eeigen	37.16	20.942	18.328	13.202	8.136	0.076	-	-
Critical Value (1%)	45.1	38.77	32.24	25.52	18.63	6.65	-	-
Eigenvalues	0.202	0.119	0.105	0.077	0.048	0	-	-
Model 2: ASEAN-5 with Korea and U.S. in the VAR								
Trace	145.177[a]	92.771	60.592	38.334	17.079	5.399	0.7	-
Critical Value (1%)	133.57	103.18	76.07	54.46	35.65	20.04	6.65	-
Max-Eeigen	52.407[a]	32.179	22.258	21.255	11.679	4.7	0.7	-
Critical Value (1%)	51.57	45.1	38.77	32.24	25.52	18.63	6.65	-
Eigenvalues	0.272	0.177	0.126	0.121	0.068	0.028	0.004	-
Part B : Crisis results (July 1, 1997 - Jun 30, 1998), Lags = 3								
Model 1: ASEAN-5 with China, Korea, Japan in the VAR								
Trace	230.413[a]	169.929[a]	118.119[a]	73.133	42.051	20.883	6.738	0.005
Critical Value (1%)	168.36	133.57	103.18	76.07	54.46	35.65	20.04	6.65
Max-Eeigen	60.484[a]	51.810[a]	44.986	31.083	21.168	14.144	6.733	0.005
Critical Value (1%)	57.69	51.57	45.1	38.77	32.24	25.52	18.63	6.65
Eigenvalues	0.747	0.692	0.64	0.507	0.382	0.275	0.142	0.000
Model 2: ASEAN-5 with China, Korea, Japan and U.S. in the VAR								
Trace test	378.608[a]	272.429[a]	200.273[a]	137.640[a]	95.281[a]	58.550[a]	27.126	7.894
Critical Value (1%)	204.95	168.36	133.57	103.18	76.07	54.46	35.65	20.04
Max-Eeigen	106.179[a]	72.157[a]	62.633[a]	42.358	36.731	31.424	19.232	6.847
Critical Value (1%)	62.80	57.69	51.57	45.1	38.77	32.24	25.52	18.63
Eigenvalues	0.91	0.806	0.759	0.618	0.566	0.51	0.354	0.144
Part C : Post-crisis results (July 6, 1998 - May 28,2007), Lags = 6								
Model 1: ASEAN-5 with China, Korea, Japan in the VAR								
Trace test	192.575[a]	128.098	81.915	49.077	29.283	14.872	4.509	0.747
Critical Value (1%)	168.36	133.57	103.18	76.07	54.46	35.65	20.04	6.65
Max-Eeigen	64.477[a]	46.183	32.838	19.794	14.411	10.363	3.761	0.747
Critical Value (1%)	57.69	51.57	45.1	38.77	32.24	25.52	18.63	6.65
Eigenvalues	0.16	0.117	0.085	0.052	0.038	0.028	0.01	0.002
Model 2: ASEAN-5 with China, Korea, Japan and U.S. in the VAR								
Trace test	229.335[a]	161.961	116.318	79.069	45.881	24.531	10.796	2.169
Critical Value (1%)	204.95	168.36	133.57	103.18	76.07	54.46	35.65	20.04
Max-Eeigen	67.374[a]	45.643	37.249	33.188	21.35	13.735	8.627	1.303
Critical Value (1%)	62.80	57.69	51.57	45.1	38.77	32.24	25.52	18.63
Eigenvalues	0.166	0.116	0.096	0.086	0.056	0.036	0.023	0.004

Note: [a] denotes respectively, the significance at 99% confidence interval.

Table 3. Granger-causality based on VECM [pre-crisis (with US)]

k=5, r=1	Independent variables							
Dependent Variables	Δ *US*	Δ *MAS*	Δ *SIN*	Δ *PHI*	Δ *IND*	Δ *THAI*	Δ *KOR*	*ECT*
				F-statistics				
Δ *US*		2.142	2.239	0.752	2.900^{b}	1.217	0.949	-0.001
		[0.079]	[0.068]	[0.558]	[0.024]	[0.307]	[0.438]	
Δ *MAS*	2.564^{b}		1.367	2.629^{b}	1.541	1.419	1.375	-0.010
	[0.041]		[0.249]	[0.037]	[0.194]	[0.231]	[0.246]	
Δ *SIN*	2.177	0.479		1.207	1.175	0.441	0.742	-0.059^{a}
	[0.075]	[0.751]		[0.311]	[0.325]	[0.779]	[0.565]	
Δ *PHI*	2.594^{b}	0.183	1.510		2.310	1.836	0.523	-0.055^{b}
	[0.039]	[0.947]	[0.203]		[0.061]	[0.126]	[0.719]	
Δ *IND*	1.638	0.425	0.893	0.199		2.943^{b}	0.860	0.010
	[0.168]	[0.791]	[0.470]	[0.938]		[0.023]	[0.490]	
Δ *THAI*	0.797	0.528	0.337	0.652	0.253		0.480	0.050
	[0.529]	[0.715]	[0.853]	[0.627]	[0.907]		[0.751]	
Δ *KOR*	1.377	0.875	0.713	1.833	1.594	0.081		-0.084^{a}
	[0.245]	[0.481]	[0.584]	[0.126]	[0.179]	[0.988]		

Notes: The ECT was derived by normalizing the cointegration vector on *US*, with the residual checked for stationarity by way of unit root tests and inspection of its ACF. Figures presented in the final column are coefficient values associated with estimated *t*-statistics testing the null that the ECT is statistically insignificant for each equation. All other estimates are asymptotic Granger *F*-statistics. ^{a} and ^{b} indicate significance at the 1% and 5% levels. P-values are presented in the parenthesis [ ]. The following notations apply in the table: US=United States, MAS=Malaysia, SIN=Singapore, PHI=Philippines, IND=Indonesia, THAI=Thailand and KOR=Korea.

Table 4. Granger-causality based on VECM [during-crisis (with US)]

k=3, r=3	Independent variables											
Dependent	Δ *CHI*	Δ *JAP*	Δ *KOR*	Δ *IND*	Δ *MAS*	Δ *PHI*	Δ *SIN*	Δ *THAI*	Δ *US*	ECT_1	ECT_2	ECT_3
variables					*F* -statistics							
Δ *CHI*		2.755	1.110	0.905	4.113^{b}	0.090	0.938	0.342	0.067	-0.219	-0.625^{a}	0.131
		[0.086]	[0.347]	[0.419]	[0.030]	[0.914]	[0.406]	[0.714]	[0.936]			
Δ *JAP*	0.693		1.104	0.155	0.776	1.182	0.565	1.323	2.891	-0.218	0.053	0.105
	[0.510]		[0.348]	[0.858]	[0.472]	[0.325]	[0.576]	[0.286]	[0.076]			
Δ *KOR*	3.161	0.552		1.198	0.876	2.664	0.411	7.837^{a}	1.832	-1.902^{a}	-1.252^{b}	0.694^{a}
	[0.061]	[0.583]		[0.320]	[0.430]	[0.091]	[0.668]	[0.003]	[0.183]			
Δ *IND*	1.179	2.679	2.702		1.159	4.313^{b}	2.539	0.877	1.518	0.090	1.792^{a}	-0.095
	[0.326]	[0.090]	[0.089]		[0.331]	[0.026]	[0.100]	[0.430]	[0.240]			
Δ *MAS*	3.418^{b}	2.156	5.332^{b}	0.470		0.935	0.032	0.632	0.222	0.534	1.232^{b}	-0.374
	[0.050]	[0.139]	[0.013]	[0.631]		[0.407]	[0.969]	[0.541]	[0.803]			
Δ *PHI*	0.996	2.206	1.638	0.381	0.570		1.033	2.001	0.256	0.897^{b}	1.595^{a}	-0.658^{a}
	[0.385]	[0.133]	[0.216]	[0.687]	[0.573]		[0.372]	[0.158]	[0.777]			
Δ *SIN*	1.082	2.531	1.671	0.265	0.952	0.624		1.022	0.214	0.566	1.066^{b}	-0.396
	[0.355]	[0.102]	[0.210]	[0.769]	[0.401]	[0.545]		[0.376]	[0.809]			
Δ *THAI*	1.599	0.421	3.019	1.226	0.076	1.531	3.178		2.037	0.434	0.660	-0.216
	[0.224]	[0.661]	[0.069]	[0.312]	[0.927]	[0.238]	[0.060]		[0.153]			
Δ *US*	0.169	0.216	0.668	0.538	0.265	7.553^{a}	7.016^{a}	1.504		-0.102	-0.138	0.012
	[0.846]	[0.808]	[0.522]	[0.591]	[0.770]	[0.003]	[0.004]	[0.243]				

Notes: The ECT_1 was derived by normalizing the cointegration vector on *CHI*, The ECT_2 was derived by normalizing the cointegrating vector on *JAP* whereas The ECT_3 was derived by normalizing the cointegrating vector on *KOR,* with the residual checked for stationarity by way of unit root tests and inspection of its ACF. Figures presented in the final column are coefficient values associated with estimated t-statistics testing the null that the lagged ECT is statistically insignificant for each equation. All other estimates are asymptotic Granger *F*-statistics. ^{a} and ^{b} indicate significance at the 1% and 5% levels. P-values are presented in the parenthesis [ ]. The following notations apply in the table: CHI=China and JAP=Japan.

Table 5. Granger-causality based on VECM [post-crisis (with US)]

k=6, r=1	Independent variables									
Dependent variables	Δ *THAI*	Δ *MAS*	Δ *PHI*	Δ *SIN*	Δ *JAP*	Δ *US*	Δ *CHI*	Δ *IND*	Δ *KOR*	*ECT*
	F -statistics									
Δ *THAI*		3.864[a]	2.825[b]	3.734[a]	2.152	2.188	2.237	0.966	0.999	-0.007
		[0.002]	[0.016]	[0.003]	[0.059]	[0.055]	[0.051]	[0.439]	[0.418]	
Δ *MAS*	0.675		1.485	4.727[a]	2.773[b]	2.135	0.265	1.638	1.509	-0.009
	[0.642]		[0.194]	[0.000]	[0.018]	[0.061]	[0.932]	[0.149]	[0.186]	
Δ *PHI*	1.239	2.161		3.522[a]	1.910	1.111	0.447	0.569	0.373	-0.005
	[0.290]	[0.058]		[0.004]	[0.092]	[0.354]	[0.815]	[0.724]	[0.867]	
Δ *SIN*	0.654	0.709	1.922		2.667[b]	3.603[a]	0.341	0.929	0.915	-0.019[a]
	[0.659]	[0.617]	[0.090]		[0.022]	[0.004]	[0.888]	[0.462]	[0.472]	
Δ *JAP*	0.863	0.114	0.955	1.275		3.631[a]	0.521	0.077	1.087	0.010
	[0.506]	[0.989]	[0.445]	[0.274]		[0.003]	[0.760]	[0.996]	[0.367]	
Δ *US*	0.948	0.616	0.574	0.643	1.334		0.446	0.726	0.991	0.003
	[0.450]	[0.688]	[0.720]	[0.667]	[0.249]		[0.816]	[0.604]	[0.423]	
Δ *CHI*	0.491	0.475	0.477	1.287	1.361	0.570		2.238	0.666	-0.017[b]
	[0.783]	[0.795]	[0.793]	[0.269]	[0.239]	[0.723]		[0.051]	[0.650]	
Δ *IND*	0.538	1.312	1.206	1.280	0.391	0.949	0.968		0.966	0.026[a]
	[0.747]	[0.259]	[0.306]	[0.272]	[0.855]	[0.449]	[0.437]		[0.439]	
Δ *KOR*	1.228	0.741	0.468	0.848	0.718	2.024	1.208	1.024		-0.011
	[0.295]	[0.593]	[0.800]	[0.517]	[0.610]	[0.075]	[0.305]	[0.403]		

Notes: The ECT was derived by normalizing the cointegration vector on *THAI*, with the residual checked for stationarity by way of unit root tests and inspection of its ACF. Figures presented in the final column are coefficient values associated with estimated t-statistics testing the null that the lagged ECT is statistically insignificant for each equation. All other estimates are asymptotic Granger *F*-statistics. [a] and [b] indicate significance at the 1% and 5% levels. P-values are presented in the parenthesis [ ].

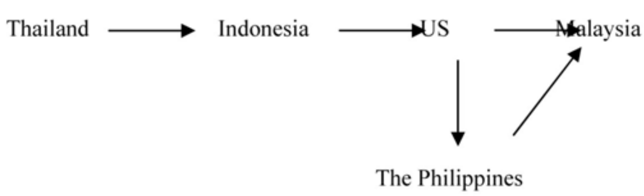

Figure 1. Short-run causality effect [pre-crisis (with U.S.)]

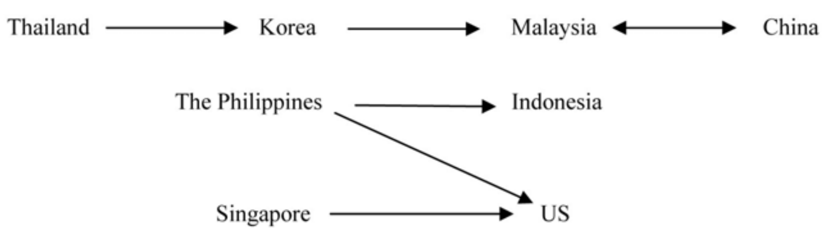

Figure 2. Short-run causality effect [during-crisis (with U.S.)]

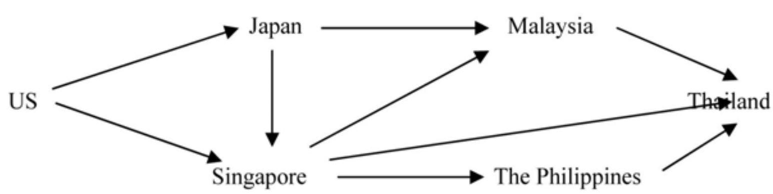

Figure 3. Short-run causality effect [post-crisis (with US)]