Stock market linkages and the global financial crisis: Evidence from the ASEAN 5 + 3 and the U.S.

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Abstract

While much of the research done on stock market linkages among different countries were prompted by various past financial crises, relatively little research exists on the recent episode of financial disturbance emanating from the U.S. and transmitted across Asia. This study is an attempt to analyze the linkages among the stock markets of the ASEAN 5+3 countries and the U.S. before and during the current global financial turbulence. Data consisting of weekly stock index closing prices over the period August 18, 2006 (pre-crisis period) and the period September 5, 2008 to September 14, 2010 (crisis period) were treated in-depth through econometrics. Results indicate that the short-term dynamic linkages among the markets were strengthened during the crisis. However, the long-term co-integrating relationship existing among the markets somehow dissipates during the crisis. Interestingly, results show the significant influence of China in almost all the markets before and during the financial turmoil. Further, the unidirectional causal relationship running from the U.S. to the Asian countries curiously shifted to bi-directional flows in time of distress. Results of this study can be used as basis by policy makers in responding to increasing financial interactions across borders, and by international investors in choosing stocks for portfolio diversification.

Keywords: stock market interactions, global financial crisis, international portfolio diversification, econometrics

Introduction

Interactions among international stock markets have been the foci of many studies in previous years. Several terminologies were used in these studies to signify interactions such as integration (e.g. Yi and Tan, 2009; Mukhopadhyay, 2009; Maghyereh, 2006; Azman-Saini and Azali, 2002), convergence (e.g. Manning, 2002), co-movement (e.g. Candelon, Piplaca and Straetmans, 2008; Johnson and Soenen, 2002; Forbes and Rigobon, 2002), correlation (e.g. Longin and Solnik, 2001), interdependence (e.g. Lunds and Timmerman, 2004; Narayan, Smyth and Nandha, 2004; Bessler and Yang, 2003), spillover (e.g. Gelos and Sahay, 2001; Ng, 2000; Connolly and Wang, 2003), contagion (e.g. Dungey, Fry and Martin, 2006; Chancharoenchai and Dibooglu, 2006; Baig and Goldfain, 2001) and linkages (e.g. Abdul-Rahim and Mohd.Nor, 2007; Daly, 2003; Ng, 2002).
Integration is a broad economic concept which denotes unity similar to convergence. Co-movement signifies concurrent movements in the same direction while correlation means same or opposite directional flow. Interdependence implies superiority in one and dynamic dependency of the other and vice-versa. Spillover is more commonly used to account for volatility changes in inter-market prices. Contagion connotes a negative phenomenon during a period of financial turbulence and is more intense than spillover. It is more of a sudden nature unlike financial integration which is gradual (Candelon, et. al., 2008). The Asian flu is a very good example of a contagion. However, it is assumed that an increase in cross-country correlations during a period of financial turmoil is not necessarily evidence of contagion (Corsetti, Pericoli and Sbracia, 2005).

Linkages convey an idea akin to a series of links. Increased linkages between stock markets are a component of regional or international capital market integration (Jefferis and Matome, 2001). Linkages is appropriately used in the present study because it involves the interactions among nine (9) stock markets during tranquil and crisis periods without testing for contagion or discontinuities in structural transmission of financial shocks.

There are five alternate postulates behind the apparent increased linkages among international stock markets: (1) deregulation of financial markets; (2) improvements in the flow of information; (3) reduction in transaction costs; (4) gains available from international diversification of investment portfolios; and (5) evidence of the existence of stock market leaders and followers (Mukhopadhyay, 2009).

Additionally, the nearly simultaneous world-wide collapse of equity markets in October, 1987 (in Masih and Masih, 1997), the Mexican crash of 1994/1995 and its apparent transmission to other Latin American markets (in Jefferis and Matome, 2001), the economic turbulence like the 1997 Asian crisis (in Abdul-Rahim and Mohd.Nor, 2007; in Tuluca and Zwick, 2001), the 1998 Russian financial crisis (in Yang, Hsiao, Li and Wang, 2005; in Manning, 2002) and the on-going financial crisis that can be traced from the banking crisis arising out of the housing bubble in the U.S. around September, 2008 (in Mukhopadhyay, 2009) have provoked much debate on how a financial turmoil may affect the extent and the nature of linkages among stock markets. Most importantly, the effect of the on-going crisis on international portfolio investment needs to be studied. The urgency stems from the portfolio theory which posits that investing in less correlated assets especially in times of a financial panic would preserve the diversification benefits accruing to investors.

Many papers have examined stock market linkages during the past financial crises but there is a paucity of research done on the recent episode of financial market disturbance emanating from the U.S. and transmitted across Asia.

This study examines the linkages among the stock markets of the ASEAN 5+3 countries and the U.S. before and during the current global financial turbulence. The ASEAN +3 was organized in Kuala Lumpur in December, 1997, as the first regional institution involving only East Asian nations to promote political and economic cooperation (Terada, 2004). After the East Asian Financial crises of 1997, a revival of the Malaysian proposal was established in Chiang Mai, known as the Chiang Mai Initiative, which calls for better integration between the
economies of the ASEAN as well as the +3 countries: China, Japan and South Korea (Ministry of Finance, Japan; 2006). The present study focused only on the five countries that originally formed the ASEAN in August 8, 1967 because their stock markets are the most mature among the ten ASEAN member nations, including the +3 countries and the U.S.

Specifically, this study examines (1) short-term dynamic stock returns relationships (2) individual stock market efficiency (3) long-term stock market linkages, and (4) stock prices transmission among the ASEAN 5+3 and the U.S.

**Literature Review**

Financial literature has shown a study stream of research among international stock markets. Interest in this line of research appears to have grown since the late 1980s particularly because of the October, 1987 equity market crash (Jefferis and Matome, 2001). The ensuing smaller scale financial crises such as the Mexican crash of 1994/1995, the Asian financial crisis of 1997, and the Russian financial crisis of 1998 sustained curiosity on stock market linkages.

Research interest has also been prompted by the development of new statistical techniques for the analysis of asset market efficiency and interdependence (Jefferis and Matome, 2001).

The Generalized Autoregressive Conditional Heteroscedasticity (GARCH) model was introduced by Engle in 1982 and was generalized by Bollerslev in 1986 to measure integration and spillover effects. Connolly and Wang (1999) studied the role of macroeconomic news announcements in explaining return and volatility spillovers among three major national stock markets. They generalized the standard ARCH conditional volatility model to admit asymmetries in the volatility impact of good and bad news from both domestic and foreign markets. Yi and Tan (2009) used the GARCH (1,1) model to compare the extent to which financial sector liberalization in Singapore and Malaysia each has led to integration of its domestic equity market with external markets.

The Vector Autoregressive (VAR) model was used in several studies to investigate dynamic linkages of stock markets during and after financial crises. With the use of VAR, In, Kim and Yoon (2002) in their study showed that Australia and other Asian stock markets became more closely linked during the Asian financial crises, with the exception of Malaysia. The VAR analysis in the study by Abdul-Rahmin and Mohd.Nor (2007) conducted a rolling generalized VAR analysis to confirm the findings that both the long-run price relationship and the dynamic price transmission were strengthened among the U.S., Germany, and four major Eastern European emerging stock markets after the 1998 Russian financial crisis. Even without a crisis, the VAR technique was used by researchers like Dunis and Shannon (2005) in assessing the diversification benefit of emerging markets to international investors.

Other econometric tools applied to stock market analyses were correlation analysis, unit root, co-integration and Granger causality tests. The last three mentioned tests represent recent advances in time-series econometrics. All these tools are mostly used in stock market studies so the researcher decided to formulate hypotheses anchored on them.
Market Correlation

The simplest approach to analyzing stock market linkages is to construct correlation coefficients for the levels of stock price indexes in two different markets or alternatively, for stock return levels. The existence of strong contemporaneous correlation among stock market innovations is well documented in the literature (e.g. Chen, Firth and Rui, 2002; Bessler and Yang, 2003). Earlier studies used simple cross-country correlations when assessing whether the performance of stock markets have some common trend or not (Dunis and Shannon, 2005). Findings of these studies were important in portfolio diversification because they suggest that if certain stocks were not perfectly correlated, then a reduction in the overall risk of a portfolio could possibly be achieved by combining these stocks.

The general consensus is that correlations between emerging and developed stock markets are generally on the increase (e.g. Ng, 2002; Connolly and Wang, 1999). Further, during currency and financial crises, asset price co-movements across markets and across borders tend to increase visibly compared with more tranquil periods (Corsetti, et. al., 2005). This could lead to an increase in portfolio risk for international portfolio managers. To mitigate this risk, investments in the more positively correlated markets should be switched to the least positively correlated or negatively correlated markets.

Indeed, the interdependence of the different stock markets must be established especially during a crisis as a prerequisite to effective international diversification. Hence, the researcher hypothesizes that:

$$H_1: \text{Stock market returns in the ASEAN 5+3 countries and the U.S. are less correlated during the global financial crisis than before the occurrence of the crisis.}$$

Unit Root

When using the Vector Autoregressive model to analyze stock market relationships, all variables are required to be stationary, which means the stock market returns are not random walk. Hence, it is necessary to first test for the stationarity of each stock price series in the study by conducting unit root tests such as the Augmented Dickey-Fuller (ADF) test (e.g. Azmi, Shamsuddin and Haron, 2004; Lau and Lee, 2007; Dunis and Shannon, 2005).

If the hypothesis of a unit root in stock prices in a particular country is supported, it implies that the consecutive changes in stock prices over the relevant period are random. A random walk is a time-series in which the value of the series in one period is the value of the series in the previous period plus an unpredictable random error. If the time-series is a random walk, it is not covariance stationary (De Fuso, McLeavy, Pinto and Runkle, 2004). The use of linear regression to estimate an autoregressive time-series model is not valid unless the series is covariance stationary, that is, it has no unit root. Should it become evident that the stock return series is not stationary in its level form; the first difference of the series is used in the analysis. Importantly, test must be performed to see if the series are at least co-integrated even if they are not stationary.
In selecting a sample period for estimating a time-series model, we should seek to assure ourselves that the series was stationary (no unit root) in the sample period. Hence, the researcher hypothesizes that:

H\textsubscript{2}: The stock market returns from the ASEAN 5+3 countries and the U.S. in the pre-crisis and crisis periods are not stationary (with unit root).

**Co-integration Analysis**

The unit root tests allow us to determine whether the markets are individually efficient. However, individual market efficiency does not redound to linkages between markets. Collective market efficiency can be measured using either correlation or co-integration analyses. The distinction between the two analyses is that correlation reflects short-run co-movements in returns while co-integration measures long-run co-movements in prices (Dunis and Ho, 2005). If two markets are co-integrated, there will be a long-term relationship between them, thus, the diversification benefits to investors is reduced.

The concept of co-integration was introduced by Granger in 1986 and further developed by Engle and Granger in 1987 (in Azmi, 2004). Co-integration analysis may be in the form of bi-variate tests or multivariate tests. More recent analyses of co-integration between stock markets use multivariate test (e.g. Dunis and Shannon, 2005; Chen, et. al., 2002; Phylaktis and Ravazzolo, 2002) rather than bi-variate (e.g. Corsetti, et. al., 2005). Some studies use both tests (e.g. Harding and Pagan, 2006; Jefferis and Matome, 2001). Multivariate co-integration analysis enables examination of long-run relationship between groups of markets rather than simply pairs of markets. As noted in the study of Jefferis and Matome (2001), not finding co-integration in a small system does not imply that there is no co-integration in a larger system. This can be interpreted as indicating broad linkages among international stock markets and hence, the markets are more integrated.

The multivariate test for co-integration was developed by Johansen in 1988 and by Johansen and Juselius in 1990 (Azmi, 2004). Johansen (in Chen, et. al., 2002) proposes two methods for estimating the number of co-integrating vectors: the trace test and the maximal eigenvalues test. The trace test is a likelihood ratio test for maximum (r) co-integration vectors against the alternative equal to (n). The maximal eigenvalues test has an identical null hypothesis, while the alternative is (r + 1) co-integration vectors. The maximal eigenvalues test tends to give better results when the trace tests are either large or small.

From the foregoing discussions, the researcher hypothesizes that:

H\textsubscript{3}: Stock market returns from the ASEAN 5+3 countries and the U.S. are less co-integrated in the crisis period than in the pre-crisis period.

**Granger Causality Test**

Empirical evidence has shown that returns in one market influence returns in subsequent markets manifesting the existence of stock market leaders and followers (Mukhopadhyay, 2009;
Connolly and Wang, 2003). Financial literature also attests that market volatility spills from one market to another (Corsetti, et. al., 2005; Chen, et. al., 2002; Jefferis and Matome, 2001).

After determining the long-term relationship among the international stock markets, short-term directional causality must be established specially during a crisis. Mukhopadhyay (2009) and Connolly and Wang (2003) found that markets tend to move in unison during downturns than in upswings. It means that in the recent financial crisis, bad news from one market seems to be reflected in price movements of the other markets very fast.

To test for causal interactions among stock markets, the Granger causality test can be used. Toda and Yamamoto proposed the use of modified WALD in 1995 to test for Granger non-causality as it allows inference to be conducted in the level VARs that may contain integrated or non-co-integrated processes (Lau and Lee, 2007). Following this proposal, variables can be causally linked in a two-dimensional VAR system.

Establishing directional causality from one stock market to another is important to an investor particularly in times of financial panic. Thus, the researcher hypothesizes that:

H₄: Stock market returns from the ASEAN 5+3 countries and the U.S. Granger cause each other less in the crisis period than in the pre-crisis period.

Methods

Sample Stock Markets

The study considers the stock markets in the ASEAN 5+3 countries and the U.S. based on two arguments. First, it is because the sample countries have a mix of developed and emerging markets. It is an accepted tenet among investment professionals that emerging markets offer diversification opportunities to a portfolio of securities from developed markets. The FTSE assigned emerging markets used in the study are China, Indonesia, Malaysia, Philippines and Thailand. On the other hand, FTSE assigned developed markets are Japan, Singapore, South Korea and the U.S. However, the lists from Russel Global and MSCI classify South Korea not as a developed market but rather, as an emerging market.

The second argument is that the geographical location of the sample countries with the exception of the U.S. brings about multilateralism among themselves. Importantly, the 1997 crisis serves as a wake-up call for Asian countries not only as a geographical concept but also as a regional community arrangement. The sample countries however, are limited to the five original founders of the ASEAN as they are the most mature among the current ten members. The +3 countries are China, Japan and South Korea which were appended to the ASEAN in December, 1997 to promote political and economic cooperation among them.

The U.S. market is also considered because the current global crisis can be traced from the U.S. credit crunch at the end of 2007 but became a full financial meltdown by the middle of 2008 (BBC News – Global recession timeline, 2010).
Data Measure

The data consist of weekly stock index closing prices of the Nasdaq Composite (U.S.), Nikkei 225 Index (Japan), KCI-SE (South Korea), Shanghai A Share Index (China), Straits Times Index (Singapore), LQ45-JK (Indonesia), Bursa Malaysia BHD (Malaysia), Philippine SE Composite Index (Philippines) and Thailand SET (Thailand). The closing times of the different stock markets would induce distortions in a true trading environment, but in this study, these closing prices are good enough and serve well the purpose of this study.

Weekly returns are obtained as logarithmic first differences of equity market index using Friday-to-Friday data, thus avoiding the problems of day-of-the-week effects of daily frequency data and of January/December effect of monthly frequency data. Moreover, it is possible for weekly data on equity returns in different national markets to overlap, which allows sharing among countries of market information affecting the equity market (Yi and Tan, 2009).

To ensure comparability among countries and to incorporate exchange rate fluctuations in the ensuing analyses, stock price indexes (which were calculated in national currencies) were adjusted for exchange rate changes expressed in a common currency, the US dollars.

To see if ‘external’ financial crisis has an impact on the linkages among stock market prices in the sample countries, sample data were partitioned into the pre-crisis and the crisis periods. Using the BBC News – Global recession timeline (2010) as basis, September, 2008 was used as the cut-off date for the division. To obtain a consistent sample range for all nine (9) countries, the researcher restricted the sample size such that the number of observations in the two non-overlapping periods is equal. The pre-crisis period is from August 11, 2006 to August 29, 2008 consisting of 108 observations for each country, while the crisis period is from September 5, 2008 to September 24, 2010 also consisting of 108 observations.

Data Analysis

Following the approaches of several researches on stock market linkages that were cited in the literature review, the present study used the following econometrics tools: correlation analysis, ADF unit root test of efficiency, Johansen multivariate co-integration test and the Granger causality test, all at 0.05 significance level.

The e-views software was employed in running the aforementioned tests.

Results

Correlation Analysis

The result of simple correlation analysis is shown in Table 1 for the pre-crisis period and in Table 2 for the crisis period.
For the period before the crisis, most countries have positive linear associations in their stock market returns but some are negatively correlated i.e. an increase in a country’s stock market returns leads to a decrease in the returns of another country. On the one hand, stock markets of Indonesia and Japan (-0.320) and Thailand and Japan (-0.071) have negative associations. Japan and China, on the other hand, had the weakest positive correlation of 0.06 followed by Japan and Philippines with 0.170. However, Malaysia and Philippines had the highest correlation of 0.94 followed by South Korea and China with 0.901.

Table 2
Simple Correlation of Returns for the Crisis Period

<table>
<thead>
<tr>
<th>U.S.</th>
<th>Thailand</th>
<th>Singapore</th>
<th>South Korea</th>
<th>Philippines</th>
<th>Malaysia</th>
<th>Japan</th>
<th>Indonesia</th>
<th>China</th>
</tr>
</thead>
<tbody>
<tr>
<td>U.S.</td>
<td>1.000</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Thailand</td>
<td>0.892</td>
<td>1.000</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Singapore</td>
<td>0.951</td>
<td>0.963</td>
<td>1.000</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>South Korea</td>
<td>0.950</td>
<td>0.934</td>
<td>0.982</td>
<td>1.000</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Philippines</td>
<td>0.898</td>
<td>0.989</td>
<td>0.965</td>
<td>0.935</td>
<td>1.000</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Malaysia</td>
<td>0.889</td>
<td>0.867</td>
<td>0.942</td>
<td>0.942</td>
<td>0.867</td>
<td>1.000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Japan</td>
<td>0.934</td>
<td>0.791</td>
<td>0.883</td>
<td>0.889</td>
<td>0.780</td>
<td>0.879</td>
<td>1.000</td>
<td></td>
</tr>
<tr>
<td>Indonesia</td>
<td>0.927</td>
<td>0.983</td>
<td>0.983</td>
<td>0.963</td>
<td>0.984</td>
<td>0.903</td>
<td>0.830</td>
<td>1.000</td>
</tr>
<tr>
<td>China</td>
<td>0.663</td>
<td>0.548</td>
<td>0.668</td>
<td>0.691</td>
<td>0.549</td>
<td>0.789</td>
<td>0.735</td>
<td>0.612</td>
</tr>
</tbody>
</table>

The crisis period exhibits the most number of markets with strong positive linear associations. The weakest correlation in this period is even higher than the weakest in the pre-crisis period. Thailand and China would have the lowest correlation coefficient of 0.548. Most notably, Thailand and Philippines had the strongest positive correlation of 0.989 implying that an increase in the stock market returns of Thailand would have most likely increased the returns in the Philippines, vice versa. Conversely, the stock market returns of Singapore are strongly correlated to five different markets: Indonesia (0.983), South Korea (0.982), the Philippines (0.964), Thailand (0.963), and USA (0.951). Other notables include South Korea and USA (0.95), Indonesia and Thailand (0.983), Indonesia and South Korea (0.963), and Indonesia and the Philippines (0.984).
Unit Root Test

The null hypothesis of non-stationarity and alternative hypothesis of stationarity are tested for each data series, both in the level and first difference form, using the Augmented Dickey Fuller (ADF) test. The results of the ADF unit root tests are presented in Tables 3 and 4.

Table 3
ADF Test for unit root (Level Form)

<table>
<thead>
<tr>
<th>Variables</th>
<th>Pre-Crisis Period</th>
<th></th>
<th>Crisis Period</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No Trend</td>
<td>With Trend</td>
<td>No Trend</td>
<td>With Trend</td>
</tr>
<tr>
<td>Philippines</td>
<td>1.86</td>
<td>1.25</td>
<td>0.92</td>
<td>3.55</td>
</tr>
<tr>
<td>Indonesia</td>
<td>1.78</td>
<td>0.94</td>
<td>0.20</td>
<td>4.33</td>
</tr>
<tr>
<td>Malaysia</td>
<td>1.44</td>
<td>0.92</td>
<td>0.54</td>
<td>2.05</td>
</tr>
<tr>
<td>Japan</td>
<td>1.49</td>
<td>2.93</td>
<td>2.16</td>
<td>3.85</td>
</tr>
<tr>
<td>Singapore</td>
<td>1.92</td>
<td>0.75</td>
<td>0.18</td>
<td>3.47</td>
</tr>
<tr>
<td>China</td>
<td>1.32</td>
<td>0.25</td>
<td>1.53</td>
<td>1.18</td>
</tr>
<tr>
<td>Thailand</td>
<td>1.28</td>
<td>0.31</td>
<td>1.07</td>
<td>3.35</td>
</tr>
<tr>
<td>South Korea</td>
<td>1.08</td>
<td>0.36</td>
<td>0.85</td>
<td>3.27</td>
</tr>
<tr>
<td>USA</td>
<td>2.36</td>
<td>2.35</td>
<td>1.10</td>
<td>4.03</td>
</tr>
<tr>
<td>5% Critical Value</td>
<td>2.89</td>
<td>3.45</td>
<td>2.89</td>
<td>3.45</td>
</tr>
</tbody>
</table>
* Values are in absolute terms.

As seen in Table 3, the level form of stock market returns in all countries are non-stationary, with or without a trend variable, except for the Philippines, Indonesia, Japan, Singapore, and the USA in the crisis period given a trend variable. On the other hand, Table 4 relates that all data series are stationary in their first difference at 5 percent level.

Table 4
ADF test for unit root (First Difference Form)

<table>
<thead>
<tr>
<th>Variables</th>
<th>Pre-Crisis Period</th>
<th></th>
<th>Crisis Period</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No Trend</td>
<td>With Trend</td>
<td>No Trend</td>
<td>With Trend</td>
</tr>
<tr>
<td>Philippines</td>
<td>9.29</td>
<td>9.64</td>
<td>12.10</td>
<td>12.89</td>
</tr>
<tr>
<td>Indonesia</td>
<td>10.99</td>
<td>11.23</td>
<td>11.54</td>
<td>11.78</td>
</tr>
<tr>
<td>Malaysia</td>
<td>10.66</td>
<td>11.06</td>
<td>9.65</td>
<td>9.68</td>
</tr>
<tr>
<td>Japan</td>
<td>14.51</td>
<td>14.65</td>
<td>13.09</td>
<td>13.09</td>
</tr>
<tr>
<td>Singapore</td>
<td>10.09</td>
<td>10.64</td>
<td>9.70</td>
<td>9.93</td>
</tr>
<tr>
<td>China</td>
<td>8.99</td>
<td>9.85</td>
<td>10.34</td>
<td>10.39</td>
</tr>
<tr>
<td>Thailand</td>
<td>9.02</td>
<td>9.28</td>
<td>9.39</td>
<td>9.98</td>
</tr>
<tr>
<td>South Korea</td>
<td>9.78</td>
<td>10.16</td>
<td>10.46</td>
<td>10.57</td>
</tr>
<tr>
<td>USA</td>
<td>10.97</td>
<td>11.13</td>
<td>9.79</td>
<td>9.95</td>
</tr>
<tr>
<td>5% Critical Value</td>
<td>2.89</td>
<td>3.45</td>
<td>2.89</td>
<td>3.45</td>
</tr>
</tbody>
</table>
* Values are in absolute terms.

As seen in Table 3, the level form of stock market returns in all countries are non-stationary, with or without a trend variable, except for the Philippines, Indonesia, Japan, Singapore, and the USA in the crisis period given a trend variable. On the other hand, Table 4 relates that all data series are stationary in their first difference at 5 percent level.

Thus, hypothesis 2, predicting all data series in the pre-crisis and crisis periods are not stationary (with unit root) is supported.
Multivariate Co-integration Test

Even if the data series in both the pre-crisis and crisis periods are non-stationary, their long-run relationship through multivariate co-integration analysis must still be tested. Results of the co-integration procedure are presented in Table 5.

Table 5
Multivariate Co-integration Test

<table>
<thead>
<tr>
<th>Hypothesis</th>
<th>Pre-Crisis Period</th>
<th>Crisis Period</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Trace Test</td>
<td>Eigenvalue</td>
</tr>
<tr>
<td></td>
<td>Statistic</td>
<td>Statistic</td>
</tr>
<tr>
<td>H0</td>
<td>r = 0</td>
<td>r &gt; 0</td>
</tr>
<tr>
<td></td>
<td>r ≤ 1</td>
<td>r &gt; 1</td>
</tr>
<tr>
<td></td>
<td>r ≤ 2</td>
<td>r &gt; 2</td>
</tr>
<tr>
<td></td>
<td>r ≤ 3</td>
<td>r &gt; 3</td>
</tr>
<tr>
<td></td>
<td>r ≤ 4</td>
<td>r &gt; 4</td>
</tr>
</tbody>
</table>

H = the number of co-integrating vector
* indicates rejection of the null hypothesis at the 5 percent level of significance

The null hypothesis of no co-integrating vector (r = 0) in favor of at least one co-integrating equations both in the trace test and the eigenvalue test is not supported at five percent significance level. This implies that the stock market returns from the ASEAN 5+3 countries and the U.S. do not drift apart and share common stochastic trend in the long-run. This observation is more prominent in the tranquil period than in the presence of a crisis.

Thus, hypothesis 3 which predicts that the stock market returns from the ASEAN 5+3 countries and the U.S. are less co-integrated in the crisis period than in the pre-crisis period is supported.

Granger Causality Test

Results of the Granger causality test for the pre-crisis period is shown in Table 6.

Table 6
Granger Causality Test for the Pre-Crisis Period

<table>
<thead>
<tr>
<th></th>
<th>China</th>
<th>Indonesia</th>
<th>Japan</th>
<th>Malaysia</th>
<th>Philippines</th>
<th>South Korea</th>
<th>Singapore</th>
<th>Thailand</th>
<th>U.S.</th>
</tr>
</thead>
<tbody>
<tr>
<td>China</td>
<td>8.96</td>
<td>0.55</td>
<td>8.44</td>
<td>5.95</td>
<td>11.66</td>
<td>7.33</td>
<td>3.37</td>
<td>0.32</td>
<td></td>
</tr>
<tr>
<td>Indonesia</td>
<td>5.34</td>
<td>4.13</td>
<td>1.32</td>
<td>1.81</td>
<td>2.13</td>
<td>2.17</td>
<td>0.07</td>
<td>1.47</td>
<td></td>
</tr>
<tr>
<td>Japan</td>
<td>5.69</td>
<td>15.72</td>
<td>17.18</td>
<td>25.73</td>
<td>42.55</td>
<td>55.16</td>
<td>13.49</td>
<td>3.73</td>
<td></td>
</tr>
<tr>
<td>Malaysia</td>
<td>0.13</td>
<td>2.06</td>
<td>1.08</td>
<td>0.95</td>
<td>0.18</td>
<td>1.35</td>
<td>1.91</td>
<td>0.80</td>
<td></td>
</tr>
<tr>
<td>Philippines</td>
<td>0.69</td>
<td>2.08</td>
<td>1.12</td>
<td>2.98</td>
<td>0.53</td>
<td>0.20</td>
<td>4.62</td>
<td>0.37</td>
<td></td>
</tr>
<tr>
<td>South Korea</td>
<td>2.52</td>
<td>4.91</td>
<td>2.57</td>
<td>1.31</td>
<td>0.44</td>
<td>0.70</td>
<td>3.42</td>
<td>0.14</td>
<td></td>
</tr>
<tr>
<td>Singapore</td>
<td>0.80</td>
<td>4.54</td>
<td>1.60</td>
<td>1.32</td>
<td>0.72</td>
<td>0.43</td>
<td>2.12</td>
<td>0.08</td>
<td></td>
</tr>
<tr>
<td>Thailand</td>
<td>0.59</td>
<td>2.64</td>
<td>1.11</td>
<td>0.49</td>
<td>2.73</td>
<td>3.12</td>
<td>0.21</td>
<td>0.64</td>
<td></td>
</tr>
<tr>
<td>U.S.</td>
<td>6.33</td>
<td>7.94</td>
<td>0.82</td>
<td>15.76</td>
<td>21.03</td>
<td>18.56</td>
<td>17.14</td>
<td>10.11</td>
<td></td>
</tr>
</tbody>
</table>

F-stat0.05 = 3.07
The most important findings in the pre-crisis period is the unidirectional causality detected running from the U.S. to all the Asian countries except for Japan where the one-way causality is reversed, that is, from Japan to the U.S. Additionally, the unidirectional causality also runs from Japan to all other Asian countries except for Indonesia where a bi-directional causality is detected. Similarly, China has a unidirectional causality detected running to all other Asian countries except for the reversed flow from Japan as mentioned beforehand, and Indonesia in the presence of 2-way causality.

Independence or absence of causality is noted in the following countries: Malaysia versus Indonesia, the Philippines, South Korea, Singapore and Thailand; the Philippines versus Indonesia, South Korea and Singapore; Singapore versus South Korea and Thailand; and Thailand versus Indonesia.

Table 7 shows the results of the Granger causality test for the crisis period.

<table>
<thead>
<tr>
<th></th>
<th>China</th>
<th>Indonesia</th>
<th>Japan</th>
<th>Malaysia</th>
<th>Philippines</th>
<th>South Korea</th>
<th>Singapore</th>
<th>Thailand</th>
<th>U.S.</th>
</tr>
</thead>
<tbody>
<tr>
<td>China</td>
<td>7.15</td>
<td>5.46</td>
<td>5.41</td>
<td>8.50</td>
<td>9.12</td>
<td>6.95</td>
<td>1.96</td>
<td>6.29</td>
<td></td>
</tr>
<tr>
<td>Indonesia</td>
<td>0.78</td>
<td>3.57</td>
<td>2.44</td>
<td>1.94</td>
<td>3.54</td>
<td>3.63</td>
<td>1.76</td>
<td>8.75</td>
<td></td>
</tr>
<tr>
<td>Japan</td>
<td>1.14</td>
<td>32.11</td>
<td>15.73</td>
<td>25.95</td>
<td>78.37</td>
<td>51.17</td>
<td>20.56</td>
<td>3.93</td>
<td></td>
</tr>
<tr>
<td>Malaysia</td>
<td>0.60</td>
<td>0.03</td>
<td>4.74</td>
<td>1.52</td>
<td>0.92</td>
<td>0.99</td>
<td>0.23</td>
<td>6.48</td>
<td></td>
</tr>
<tr>
<td>Philippines</td>
<td>0.65</td>
<td>0.23</td>
<td>2.66</td>
<td>1.29</td>
<td>2.92</td>
<td>3.01</td>
<td>0.40</td>
<td>7.92</td>
<td></td>
</tr>
<tr>
<td>South Korea</td>
<td>1.04</td>
<td>4.64</td>
<td>3.31</td>
<td>5.95</td>
<td>1.98</td>
<td>0.31</td>
<td>3.79</td>
<td>6.81</td>
<td></td>
</tr>
<tr>
<td>Singapore</td>
<td>1.12</td>
<td>5.60</td>
<td>6.56</td>
<td>5.07</td>
<td>6.23</td>
<td>4.08</td>
<td>4.48237</td>
<td>8.52</td>
<td></td>
</tr>
<tr>
<td>Thailand</td>
<td>0.26</td>
<td>2.81</td>
<td>3.41</td>
<td>3.25</td>
<td>8.09</td>
<td>2.89</td>
<td>1.99</td>
<td>5.30</td>
<td></td>
</tr>
<tr>
<td>U.S.</td>
<td>5.13</td>
<td>28.8598</td>
<td>5.58</td>
<td>14.07</td>
<td>22.82</td>
<td>65.02</td>
<td>55.09</td>
<td>13.56</td>
<td></td>
</tr>
</tbody>
</table>

F-stat = 3.07

The most important findings in the crisis period are the bilateral causality detected between the U.S. and all the Asian countries. Bi-directional causality is also detected between Japan and all other Asian countries except for the Philippines where a one-way causality is detected and China where the unidirectional causality is from China to Japan. This unidirectional causality from China is also detected running to all other Asian countries except for Thailand where independence is noted. Absence of causality is also noted in the following countries: Indonesia versus Malaysia, the Philippines versus Thailand; and the Philippines versus Malaysia and South Korea.

The main emphasis in this study is to determine the channel through which the financial disturbance in the U.S. spills over to the ASEAN 5+3 countries. These causal interactions are visible explained in the diagram in Figure 1. This phenomenon is the exact opposite of the unidirectional causality detected in the pre-crisis period running from the U.S. to the ASEAN5+3 countries except for the reverse flow from Japan.
Worth noting here is the way China (though not classified as a developed market) has influenced the other stock markets. Independence among the stock markets also has significantly decreased during the crisis.

From these findings, hypothesis 4, which states that the stock market returns from the ASEAN 5+3 countries and the U.S. granger cause each other less in the crisis period than in the pre-crisis period is not supported.

**Discussion**

The argument that during currency and financial crises, price co-movements across markets and across borders tend to increase visibly compared with more tranquil periods is supported in several studies (e.g. Corsetti, et. al., 2005; Chattejie, Ayadi and Maniam, 2003; Yang, Kolari and Min, 2003; Fang, 2002). The investment implication of the world equity markets becoming more integrated is that gains from diversification through investing
internationally is reduced significantly. However, some studies found no increased interdependencies during and after a crisis (e.g. In, Kim and Yoon, 2002; Manning, 2002; Chen, et. al., 2002; Tuluca and Zwick, 2001).

All of the foregoing inconsistent findings were observed during varying degrees of past financial crises. The present study is done in the light of the recent episode of financial market disturbance emanating from the U.S. and transmitted across Asia.

Results of this study exhibit an increase in the number of markets with strong positive linear association during the crisis period. This is similar to the findings of Longin and Sohnik (1995) noting that volatility is contagious and international correlation increase during periods of high stock market volatility. Thus, this substantial increase in correlation among returns in the ASEAN 5+3 countries and the U.S. could lead to an increase in portfolio risk for international portfolio managers. This observation however, is for the short-term only because correlation reflects short-run co-movements in returns.

The study tested for the hypothesis that each country’s stock market returns are non-stationary (with unit root) both on the level and on the first difference of the data series. Overall, the test indicates that all series are non-stationary in level (w/o trend), but stationary when first differenced. This is in agreement with the literature (Dunis and Shannon, 2005).

When stock returns are non-stationary, they are random walk thus, price movements cannot be predicted. This does not mean however, that stock prices are wayward but rather, it is expected as a normal occurrence in stock markets denoting market efficiency. In efficient markets, information is available to everybody consequently, over-valuation or under-valuation of prices is minimized. Accordingly, investors cannot take advantage of perceived mispricing among assets available in the market.

While it is true that unit root test allows us to determine if markets are individually efficient, it does not measure long-term collective market efficiency. Co-integration analysis is a better gauge to employ.

Results of the co-integration procedure in the trace test and the maximum eigenvalue leads to same conclusion for both the pre-crisis and the crisis periods – the presence of at least one co-integrating vector. This indicates that there is a significant long-term stock return linkage among the ASEAN 5+3 countries and the U.S. Since less co-integrating vectors are present in the test for the crisis period, less common stochastic trends are exhibited by the markets. At first sight, this could suggest that diversification across these markets may be more beneficial for international investors in the presence of a financial disturbance. However, Yang, et. al. (2005) contend, that while an increase (decrease) in the number of co-integrating vectors is sometimes interpreted as evidence for strengthening (weakening) of the long-run price relationship, they found such interpretation questionable because they maintain that the strength of the long-run relationship (s) does not correspond with the number of co-integrating equations.

There are several reasons why different countries’ stock prices may have a significant long-run relationship. The presence of strong economic ties and policy coordination between the
relevant countries can indirectly link their stock prices over time (Chen, et. al., 2002). With
technological and financial innovations, the advancement of international trade, and deliberate
regional and global cooperation, the geographical divide among various national stock markets
are less obvious (Gelos and Sahay, 2001). The formations of common trading blocs like the
ASEAN +3 also foster closer linkages of stock markets within the constituent countries.
However, as noted by Van Rijckegheen and Weder (in Yang, et. al., 2005), trade is unlikely to
account for the stock market linkages between Russia and the other markets. They contend that
the contagion theory of King and Wadhani (in Yang, et. al., 2005) and the herding theory of
Froot, et. al. (in Yang, et. al., 2005) may shed more light. According to these theories, financial
crisis can enhance the perception of risks and may increase risk aversion by investors. As a
result, the percentage of short-term speculators might increase after the crisis, due to the concern
for the long-term investment commitment. These short-term investors may herd on the perceived
information from investors in other markets and create stronger market linkages, regardless of
the link between economic fundamentals.

Masih and Masih (1999), for their part, found that certain markets set the trend for
specific geographical regions. In addition, several studies found that the international
transmission in stock returns change after some turbulence in world equity markets (Abdul-
Rahim and Mohd.Nor, 2007).

The Granger causality for short-run analysis was employed in the present study and a key
finding is that during a crisis, stock returns granger cause each other more than before a crisis.
Two patterns of causality becomes evident: the bi-directional causality between the U.S. and the
Asian markets during the crisis, and the unidirectional flow before the crisis running from the
U.S. to almost all the Asian markets. This may be construed to mean that stock market returns
are causing each other to change either way when a financial shock emanate from the most
developed market among them. However, in the absence of a disturbance, the most developed
market would cause the returns from the less developed or emerging markets to react.

This observation is corroborated by the findings of Mukhopadhyay (2009) where it was
evident that market integration was mostly lead by developed markets, and that emerging
markets were more vulnerable during times of distress. Other studies also found strong
dominance of the U.S. market in the Asia-Pacific region (Yi and Tan, 2009).

The present study also provided evidence suggesting increasing influence of China and
Japan in the Asian region even during the current global financial panic. The significant impact
of China to other Asian countries before and during a crisis may be due to economic reasons as
explained by Lau and Lee (2007). They stated that for many ASEAN countries, the Asian crisis
has weakened their own economies, but the linkage between China and the ASEAN countries
focusing on high growth and investment could help them grow further in the regional context
and also in a global economy.

Several studies also provide evidence of the impact of Japan to other Asian countries (e.g.
Phylaktis and Ravazzolo, 2005; Johnson and Soenen, 2002). On the other hand, Yi and Tan
(2009) studied the spillover effects of the volatility of equity returns from the Asian economies
excluding Japan on equity markets in developed economies or on domestic markets of Singapore.
and Malaysia. In the case of Malaysia, results showed that country-specific factors explain a significant part of the volatility of its stock market returns, specifically during the financial crisis. This may partly explains why in the present study, Malaysia continued to be independent from the markets in Indonesia and the Philippines.

The analyses in this paper have implications for international portfolio diversification. If stock markets share a common trend, it implies that markets move together and any one market will be representative of the behavior of that group of markets (Phylaktis and Ravazzolo, 2002). This means that short-term gains from international diversification would be limited because markets are constrained by common shocks manifesting temporary effects. Despite this proposition, international investors might still make long-term speculative investments if they were able to observe permanent deviations from the common trend. This move however, must be tempered with the idea that the use of econometrics to test for relationships does have limitations.

**Conclusion**

This study examines the linkages among the stock markets of the ASEAN 5+3 countries and the U.S. before and during the current global financial crisis. In general, the empirical results reveal that the short-run dynamic linkages among these markets were strengthened during the turbulence but not the long-run co-integrating relationships. This is due perhaps to the stock market becoming more efficient individually but not collectively. These also exists significant influence of China in almost all the markets before and during the financial disturbance. The unilateral influence of the U.S. is noticeable in all the Asian markets before the crisis but not during the turmoil. The Asian markets responded noticeably to the financial shocks emanating from the U.S. as evidenced by the bi-directional granger causality running between them.

The present study has some limitations. Firstly, the results of the current research may disagree with some of the results of previous studies because of differences in the selection of sample stock markets, the sample period chosen, the frequency of observation (daily, weekly or monthly) and the preferred econometric tools employed to investigate the linkages. Secondly, the results of the test for long-run relationship indicating that the markets are less co-integrated during the crisis could suggest that diversification across the markets may be beneficial to international investors while there is a global panic. However, the Johansen multivariate test for co-integration used in the present study cannot prove gradual movement towards or away from an existing relationship.

Both the results and the limitations of the study point to further research with the following suggested changes: sample countries preferably must include all the ASEAN member countries +6 and the U.S., post-crisis period must be added to the previous pre-crisis and crisis periods, vector autoregressive model (VAR), impulse response analysis and other econometric tools must be employed to see if stock returns have been more closely linked over time.
References


