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Dynamic linkages among ASEAN-5 emerging stock markets

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Abstract

Purpose – The purpose of this paper is to empirically explore market integration among five selected Association of Southeast Asian Nations (ASEAN) emerging markets (Malaysia, Thailand, Indonesia, the Philippines and Singapore) during the pre- and post-1997 financial crisis periods.

Design/methodology/approach – Employs two-step estimation, cointegration and generalized method of moments (GMM).

Findings – The study finds that the stock markets in the ASEAN region are cointegrated both during the pre- and post-1997 financial crisis. However, the markets are moving towards a greater integration, particularly during the post-1997 financial crisis. Finally, as measured by the error correction terms, except the emerging market of Indonesia, all other ASEAN markets appear to be the important bearers of short-run adjustment to a shock in the long-run equilibrium relationships in the region both during the pre- and post-crisis periods.

Research limitations/implications – The study only focuses on stock markets of the five founding members of ASEAN, i.e. Malaysia, Indonesia, Thailand, Singapore and the Philippines.

Practical implications – The paper reveals that unlike during the pre-crisis period, the long-run diversification benefits that can be earned by investors across the ASEAN markets in the post-crisis period tend to diminish.

Originality/value – The study is among the first to use two-step estimation, cointegration and GMM to re-examine market integration either in the emerging or developed markets.

Keywords Stock markets, Economic integration, South East Asia

Paper type Research paper

Introduction

The issue of dynamic linkages among stock markets has been extensively researched in the literature of financial economics. The degree of linkages or integration among the stock markets provides important implications for the potential benefits of the international portfolio diversification and financial stability of a country (Ibrahim, 2005). Prior to the 1970s, empirical studies on market integration document lower

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correlations among national stock markets (Grubel, 1968; Lessard, 1973; Solnik, 1974), implying the existence of potential benefits of international portfolio diversification. Nowadays, however, the world capital markets have been increasingly integrated and co-movements among the leading world financial markets have been rising (Blackman *et al.*, 1994; Masih and Masih, 1997; Ghosh *et al.*, 1999). Based on a survey on the available empirical evidence on market integration across national capital markets, Goldstein and Michael (1993) found that the international links have been increasing over the past decade, especially for the stocks traded actively in the major financial centres. The study also found that the emerging markets are becoming more closely integrated with markets in the rest of the world, although their integration progress has been far less than that of the industrialized countries. This implies that the potentialities of portfolio diversification benefits across the world stock markets in the long run have been diminished. In addition, an increasing integration among the national stock markets further implies that international financial instabilities are easily transmitted to domestic financial markets, a phenomenon called "financial contagion" (Ibrahim, 2005).

Unlike voluminous studies on market integration among developed countries, there have been relatively few studies exploring the issue of stock market integration in the Association of Southeast Asian Nations (ASEAN) region. For example, Roll (1995) affirmed that although Indonesia has had an active equity market for a number of years, no empirical studies on this market have appeared in the western scholarly journals. In developed economies, such as the USA, Japan and Germany, both market integration and segmentation are well documented. For the emerging economies, especially for the ASEAN stock markets, as far as we know, there have been very few empirical analyses done in this area. However, in recent years, the vast-growing economic activities and the increasing investment opportunities in some emerging markets have attracted investors' and researchers' attention. Among the studies on ASEAN stock market integration which have been done are those conducted by Barus (1997), Palac-McMiken (1997), Hee (2000, 2002), Wongbangpo (2000), Ibrahim (2000, 2005), Azman-Saini *et al.* (2002), Daly (2003) and Cheng *et al.* (2003).

By adopting the cointegration techniques, Barus (1997) explored the nature of the inter-linkages between Indonesia and other founding members of the ASEAN capital markets during the period 1985-1995. The study found that the Indonesian capital markets were weakly cointegrated with the other ASEAN capital markets. This result reveals that the social, political and economic cooperation in ASEAN does not guarantee cointegrated capital markets among the country members and the benefits of portfolio diversification within the ASEAN capital markets may be overstated. By using the cointegration approach, Palac-McMiken (1997) found that, with the exception of Indonesia, all the five founding members of the ASEAN markets were linked with each other during the period 1987-1995. Hee (2000) explored the linkages and the degree of financial market integration among the ASEAN stock markets over the period 1970-1995 through the use of correlation and cointegration analyses, a time-varying parameter model and the concepts of covered interest parity, respectively. He found no long-run relationships among the stock markets of ASEAN; however, correlation analyses indicated that the markets were becoming more integrated. Adopting a similar method of estimation, Hee (2002) extended his

investigation on stock market linkages in South-East Asia over the period 1988-1997. Hee's (2002) findings are supportive of those of Hee (2000).

Following Hee (2000) and Wongbangpo (2000) investigated the stock markets in the ASEAN region during the period of 1985-1996 through empirical investigations of the interconnection among stock markets and the interaction between stock and foreign exchange markets. The study documented that the ASEAN stock markets, except for the Philippines, share a long-run equilibrium, implying that an effective long-term diversification of an investor's portfolio among these stock markets cannot be achieved. The study also found that the stock prices and exchange rates are bound together in a long-run relationship in these markets. Ibrahim (2000) explored the degree of financial integration and benefits of portfolio diversification among the ASEAN equity markets from the Malaysian perspective from January 1988 to June 1997. From the cointegration analysis and error correction model, he found the existence of long-run co-movements among the ASEAN and the US equity markets. The short-run interactions between ASEAN markets were mostly contemporaneous. He also found that the ASEAN markets were highly integrated and the US market exerted significant influence on the ASEAN markets.

In a more recent study, Azman-Saini *et al.* (2002) empirically investigated the financial integration among the ASEAN-5 (Malaysia, Indonesia, Thailand, Singapore and the Philippines) equity markets through the use of cointegration analysis and seemingly unrelated regression based on the Toda and Yamamoto (1995) Granger noncausality test. The evidence of cointegration among the ASEAN markets was found although they did not find all the markets sharing common stochastic trends. An increase in the interdependencies (increased correlation) across the ASEAN stock markets in the aftermath of the 1997 Asian financial crisis is also supported by Daly (2003). Using closing daily indices from 1990 to 2003, he concluded that there has been no significant increase in the integration between ASEAN stock markets during the post-crisis period. Employing daily closing stock indices over the period from January 1992 to August 2002, Cheng *et al.* (2003) investigated the linkages across the stock markets of ASEAN-5 and found that the stock markets were cointegrated before and after the crisis, but not during the crisis. Finally, Ibrahim (2005) investigated integration among the ASEAN markets from the perspective of the Indonesian market using cointegration techniques and vector autoregression (VAR) for the period from January 1988 to December 2003. He documents evidence for lack of integration among the ASEAN markets.

Unlike most of the above studies that employed cointegration analysis in exploring market integration, this study adopts a two-step estimation, i.e. cointegration and generalized method of moments (GMM). The GMM is documented to be a superior technique of estimation as compared to other estimations. In the theoretical literature, the GMM provides a unified framework for the estimation theory, while in the applied literature, it provides a computationally convenient method of estimation in some models, which are burdensome to estimate with other methods (Hall, 1993). The GMM is potentially more robust than almost all the existing models because it does not suffer from the usual errors-in-variables problem (Zhou, 1999; Kan and Chu, 1999). In other words, a strong distributional assumption such as the normal distribution of disturbance terms is not necessary in the GMM estimation (Ogaki, 1993).

These advantages make the GMM estimation method easy to implement in many empirical analyses because it neither requires strong (often unrealistic) normal distribution assumption of errors nor a specific error distribution assumption; it only needs a suitable moment. Comparing it to maximum likelihood (ML) estimation, the GMM estimation improves the statistical significance of parameter estimates. This estimation is robust to the error distribution and provides consistent estimates (Lee and Lee, 1997; Safvenblad, 1997). This motivates the present study to adopt the two-step estimation, cointegration and GMM with the intention of producing a more robust finding. This study, therefore, is among the first to use the two-step estimation to investigate market integration among ASEAN[1] emerging markets. In addition, this study also differs from the earlier studies in the sense that it relies on a longer and more recent sample period and analyses market integration both at the bivariate and multivariate[2] levels. The superiority of these adopted estimations could mitigate the shortcomings of the previous studies on this subject.

Specifically, this study attempts to probe the following questions: do the ASEAN stock markets move towards a greater integration from the pre- to the post-1997 financial crisis? Do the results of this study on the ASEAN stock markets concur with those findings of the developed countries? If not, to what extent do the results differ? A comparative investigation on the ASEAN stock markets during the pre- and post-1997 financial crisis is of interest because of the increased economic cooperation that is happening in accordance with the ASEAN agreement. Thus, this study attempts to partially fill the gap in the literature and provide current empirical evidence on market integration among the ASEAN stock markets, based on longer and more recent data and using a superior model of estimation. The findings of this study may have implications for investors and companies who diversify their investments internationally and make capital budgeting decisions in this region.

The objectives of this study are therefore to:

- explore empirically the market integration in terms of a long-run equilibrium relationship among the five founding members of the ASEAN emerging markets, namely Malaysia, Indonesia, Thailand, Singapore and the Philippines; and
- examine empirically the dynamic causal linkages among the ASEAN emerging stock markets.

The rest of this study is organized as follows. The next section discusses the empirical framework where the cointegration and GMM are outlined. The third section describes the data employed in the study. The fourth section provides the empirical results and discussions. Finally, the fifth section concludes the study by providing some implications and making some recommendations for further study.

Empirical framework

Since the main purpose of the study is to investigate the stock market integration in terms of the long-run equilibrium relationships, the adoption of a two-step estimation – cointegration analysis and GMM – in this study is suitable for this purpose. The reason is that cointegration analysis is able to detect whether the integrated markets exist or not in the sense that there is a tendency for a long-run equilibrium relationship among the markets to move together in the long run, while allowing for deviations from the short-run equilibrium. On the other hand, the GMM estimation

has more flexibility and no stringent assumption compared to other estimations such as the ordinary least squares and ML. It also has a strong distributional assumption such as error terms, u_t is not necessarily normally distributed (Ogaki, 1993). Thus, the market integration is tested in the first step with Johansen's (1988) and Johansen and Juselius's (1990) cointegration methods, whereas the dynamic causal relationships among the ASEAN markets are estimated simultaneously in the second step by the GMM.

Cointegration analysis

To test for cointegration among the national stock markets, the ML approach of Johansen (1988) and Johansen and Juselius (1990), henceforth the JJ cointegration approach, is adopted. Essentially, the JJ test started its cointegration model with a Vector Autoregressive [VAR(k)] model as follows:

$$\mathrm{Y}_t = A_1 Y_{t-1} + A_2 Y_{t-2} + \cdots + A_k Y_{t-k} + \varepsilon_{\mathrm{t}} \tag{1}$$

where $Y_t = (Y_{1t}, Y_{2t}, \ldots, Y_{mt})'$. Subtracting Y_{t-1} from both sides of the equation (1) to have:

$$\Delta \mathrm{Y}_t = (A_1 - I) Y_{t-1} + A_2 Y_{t-2} + \cdots A_k Y_{t-k} + \varepsilon_{\mathrm{t}}$$

then adding and subtracting $(A_1 - I) Y_{t-2}$ from both sides to get:

$$\Delta \mathrm{Y}_t = (A_1 - I) \Delta Y_{t-1} + (A_2 + A_1 - I) Y_{t-2} + \cdots A_k Y_{t-k} + \varepsilon_{\mathrm{t}}$$

Again, adding and subtracting $(A_2 + A_1 - I) Y_{t-3}$ from both sides to obtain:

$$\Delta \mathrm{Y}_t = (A_1 - I) \Delta Y_{t-1} + (A_2 + A_1 - I) \Delta Y_{t-2} + (A_3 + A_2 + A_1 - I) Y_{t-3} + \cdots A_k Y_{t-k} + \varepsilon_{\mathrm{t}}$$

Repeating addition and subtraction in this fashion, following the studies of Kasa (1992), Heinesen (1995) and Cheng (2000), the JJ cointegration model can therefore, be formulated as follows:

$$\Delta Y_t = \delta + \Gamma_i \Delta Y_{t-1} + \cdots + \Gamma_k \Delta Y_{t-k} + \prod Y_{t-k} + \varepsilon_{\mathrm{t}} \tag{2}$$

where $\mathrm{Y_t}$ is an $n \times 1$ vector of variables and δ is an $n \times 1$ vector of constant, respectively. Γ is an $n \times n$ matrix (coefficients of the short-run dynamics), $\Pi = \alpha\beta'$ where α is an $n \times 1$ column vector (the matrix of loadings) represents the speed of short-run adjustment to disequilibrium and β' is an $1 \times n$ cointegrating row vector (the matrix of cointegrating vectors) indicates the matrix of long-run coefficients such that Y_t converge in their long-run equilibrium. Finally, ε_{t} is an $n \times 1$ vector of white noise error term and k is the order of autoregression. As our study investigates market integration among the five founding members of ASEAN, n is equal to five.

The above process from a VAR model equations (1) and (2) is called the cointegrating transformation. The long-run information matrix Π in this equation is the key to Johansen's cointegration test because its rank r determines the number of cointegrating vectors. If rank $(\Pi) = 0$, equation (2) returns to a VAR(k) model in the first differences and the components in Y_t are not cointegrated. On the other hand, if Π

is a full rank n, all component in Y_t are stationary. In a more general case when $1 < \text{rank}\ (\Pi) < n$, the number of cointegrating vectors is equal to r, the rank of matrix Π. Since the rank of a matrix is equal to the number of Eigenvalues λ_i (or characteristic unit roots) that are significantly different from zero, Johansen proposed two statistics to test the rank of the long-run information Π, namely:

$$\lambda_{\text{trace}}(r) = -T\sum_{i=r+1}^{n} \ln(1 - \hat{\lambda i}) \tag{3}$$

$$\lambda_{\max}(r, r+1) = -T\ln(1 - \hat{\lambda}_{r+1}) \tag{4}$$

where λ_i are estimated Eigenvalues (characteristic roots) ranked from largest to smallest. The λ_{trace} in the equation (3) is called the trace statistics (TS), which is a likelihood ratio test statistics for the hypotheses that are at most r cointegrating vectors. The $\lambda_{\max}$ in the equation (4) is called the maximal Eigenvalue statistic that tests the hypothesis of r cointegrating vectors against the hypothesis of $r - 1$ cointegrating vectors. The rank of Π is equal to the number of Eigenvalues that are different from zero. If Eigenvalues λ_i's are all zero, then the λ_{trace} and $\lambda_{\max}$ will be zero. To test for the number of cointegrating vectors, this study employs Johansen and Juselius's (1990) and Osterwald-Lenum's (1992) λ_{trace} and $\lambda_{\max}$ statistics that are adjusted for the degree of freedom.

Additionally, an important requirement for implementing the JJ cointegration test is that the variables are non-stationary integrated of the same order. Accordingly, prior to the JJ test, the standard augmented Dickey-Fuller (ADF) (Dickey and Fuller, 1979) and Phillips-Perron (PP) (Phillips and Perron, 1988) unit root tests are conducted to determine the order of integration for each national stock price.

Generalized method of moments

This study investigates the dynamic financial interdependence among the ASEAN emerging stock markets. In so doing, the study estimates the equation (2) by GMM estimation, where the error correction terms (ECTs) (Engle and Granger, 1987) are incorporated in the models. Based on Hung and Cheung's (1995) study on the five variables JJ cointegration test, the equation (2) can then be simply reformulated in matrix form as follows:

$$\begin{bmatrix} \Delta\text{May} \\ \Delta\text{Ind} \\ \Delta\text{Sing} \\ \Delta\text{Thai} \\ \Delta\text{Phil} \end{bmatrix} = \begin{bmatrix} \delta 0 \\ \delta 1 \\ \delta 2 \\ \delta 3 \\ \delta 6 \end{bmatrix} + \sum_{i=1}^{k} \Gamma i \begin{bmatrix} \Delta\text{May} \\ \Delta\text{Ind} \\ \Delta\text{Sing} \\ \Delta\text{Thai} \\ \Delta\text{Phil} \end{bmatrix}_{t-k} + \Pi \begin{bmatrix} \text{May} \\ \text{Ind} \\ \text{Sing} \\ \text{Thai} \\ \text{Phil} \end{bmatrix}_{t-1} + \begin{bmatrix} \nu 0 \\ \nu 1 \\ \nu 2 \\ \nu 3 \\ \nu 4 \end{bmatrix} \tag{5}$$

where May, Ind, Sing, Thai and Phil indicate the stock indices of Malaysia, Indonesia, Singapore, Thailand and the Philippines, respectively.

Since our model (2) or (5) considers the possibility of the past level of parameters to have an effect on current changes in other parameters, the lagged values have to be

incorporated in the models. In this study, the Akaike (1974) information criterion (AIC) is used to determine the lag length incorporation in all the tests of this study.

It is important to note that for the GMM estimator to be identified; there must be at least as many instrumental variables Z as there are parameters θ. Following Lee and Lee (1997), this study used lags of explanatory variables as the instrumental variables. These variables were opted for use because of the difficulty in finding other instrument variables, as our study utilized daily data and for an extended period. These variables are, however, obvious instruments and in most cases, should be included in the instrumental list. Another important aspect of specifying GMM is the choice of the weighting matrix to yield a consistent and robust estimate. To get a robust estimate to heteroskedasticity and autocorrelation of unknown forms, the covariance matrix of the orthogonality conditions is estimated as suggested by Newey and West (1987) using Barlett estimators [3], while the lag truncation parameter is estimated as suggested by Newey and West (1994) with a fixed bandwidth [4], following the study of Heinesen (1995). In addition, the pre-whitening process is run to soak up the correlation in the moment conditions prior to the GMM estimation.

Data

To provide more robust and updated results, this study uses daily closing data of the ASEAN stock market indices [5], covering the period of 18 years (1 January 1988 to 31 December 2006). All these indices are denominated in local currency units [6], extracted from the Bloomberg Database (2006). In this study, the stock returns for these markets are calculated from the following indices:

- the Kuala Lumpur Stock Exchange Composite Index (KLSE-CI) for Malaysia;
- the Jakarta Stock Exchange Composite Index (JSX-CI) for Indonesia;
- the Bangkok Stock Exchange Trade Index (BSETI) for Thailand;
- the Philippines Stock Exchange Index (PSEI) for the Philippines; and
- the Singapore All Equities Index (SAEI) for Singapore.

One relevant difficulty which arises in investigating stock market integration across countries is the missing observation problem due to different stock market holidays. Since the study extensively incorporates lags in the regressions, missing data are particularly troublesome. For example, if a regression equation contains six lags; one missing observation would additionally cause six subsequent observations to be dropped. Thus, it is desirable to fill in estimate-based information from an adjacent day. Rather than using a sophisticated interpolation, this study follows the studies of Jeon and von Furstenberg (1990) and Hirayama and Tsutsui (1998) by adopting the method of Occam's razor by simply filling in with the previous day's price. Simplistic as it may be, this study justifies this method on the premise that a closed stock exchange does not produce any information on bank holidays. Since no new information is revealed, the previous day's information is carried over to the subsequent day.

During our period of study, the stock markets have experienced episodes of stock market crash and financial crisis. To avoid the disturbances of the stock markets "crash" in October 1987 and "financial crisis" in July 1997 on the stock market integration tests, the study groups the data into two periods, the pre- and post-crisis periods. The pre-crisis period covers the period from January 1, 1988 to December 31, 1996.

In this period, the data set excludes the period stock market "crash" 1987 and "East Asian financial crisis" 1997 to avoid potentially anomalous observations in the analysis. The post-crisis period runs from 1 January 1998 to 31 December 2006, covering only the period after the 1997 financial crisis. The groupings of data into periods provide answers as to whether the integration among these markets is increasing due to the crisis and whether there are any changes in the causal relationships between the stock markets during the sample period. Finally, to obtain more information from the tests of market integration among the ASEAN emerging markets, the study follows the suggestion of Allen and MacDonald (1995) to group these markets into 26 portfolio combinations [7].

Empirical findings

Table I provides summary statistics of the stock returns (i.e. stock prices in first difference) for the ASEAN markets. It is interesting to note that during the pre- and post-crisis periods, all stock markets recorded positive average daily returns with the exception of the Philippines market in the post-crisis period [8]. During the 18-year period, the Indonesian stock market earned the highest average daily returns of 0.034 per cent, followed by Malaysia 0.010 per cent, Thailand 0.005 per cent, the Philippines 0.003 per cent and Singapore 0.002 per cent. Additionally, the finding that the Indonesian market had the highest returns in the region conforms to the theory of finance, which says that the riskier (more volatile) the market, the higher would be the returns. This evidence is supported by the standard deviation, where the Indonesian stock market recorded the highest, i.e. 0.0154. However, the standard deviations of all markets range between 0.011 (Singapore) and 0.015 (the Philippines, Thailand and Malaysia). The findings from the preliminary analysis for the Indonesian stock market are in line with the studies of Palac-McMiken (1997) and Barus (1997).

To highlight the short-run relations between the movements of the stock markets in the ASEAN region, the standard correlation coefficients are reported in Table II. This was used to measure the extent of the association between the stock markets. During pre- and post-crisis periods, all 20 correlation pairs are found to be significantly

Period	Variables	Thailand	Indonesia	Malaysia	Philippines	Singapore
Pre-crisis period	Mean	0.0003	0.0006	0.0005	0.0004	0.0002
	Maximum	0.0866	0.4031	0.0971	0.0927	0.0564
	Minimum	−0.1739	−0.2253	−0.1223	−0.0938	−0.1037
	SD	0.0134	0.0143	0.0100	0.0127	0.0080
	Skewness	−0.8242	8.6103	−0.7217	−0.0412	−0.9426
	Kurtosis	19.9584	262.5795	21.2547	9.9735	21.0417
Post-crisis period	Mean	0.0001	0.0002	0.0002	−0.0004	0.0001
	Maximum	0.1023	0.1149	0.0585	0.1618	0.0466
	Minimum	−0.0735	−0.0728	−0.0634	−0.0619	−0.0835
	SD	0.0154	0.0139	0.0115	0.0126	0.0111
	Skewness	0.4152	0.6264	−0.1761	2.7364	−0.3417
	Kurtosis	8.7356	10.2067	8.9799	42.7267	8.4770

Notes: Pre-crisis period spans from 1st January 1988 to 31st December 1996; while post-crisis period spans from 1st January 1998 to 31st December 2006

Table I. Summary statistics of the stock returns

correlated, at least at the 10 per cent level of significance. Among ASEAN, Malaysia recorded the highest correlation in stock return with Singapore, while Thailand is shown to have the lowest correlated returns with Indonesia during the pre-crisis period. During the post-crisis period, again Singapore is found to have the most correlated market returns with Malaysia, whereas Malaysia and the Philippines are found to have the lowest correlated stock returns in the region. Furthermore, the correlation coefficients of the Indonesian stock returns are relatively lower than in the rest of the ASEAN markets. This indicates that geographically and economically close markets such as Singapore and Malaysia exhibit high correlations of stock returns (0.70), while the correlation coefficients between other stock markets are ranging from 0.05 to 0.50 for stock returns. In addition, compared to the pre-crisis period, we find a marked increase in short-run interactions among pairs of market returns during the post-crisis period. The increase in the market correlation is recorded for seven pairs out of ten possible pairs of equity returns. This is indicated by the italic figures in the top-diagonal of Table II. The significant increase in the correlation coefficients in the ASEAN markets indicates that there are short-term co-movements among the markets, suggesting that the benefits of any short-term diversification, or speculative activities, are limited within the region.

Tests of the unit root hypothesis

In order to obtain credible and robust results for any conventional regression analysis, the data to be analyzed should be stationary (Pankratz, 1983; Harvey, 1990; Gujarati, 1995). Hence, to test for stationarity, the ADF and PP tests are performed based on model with constant and trend. Table III reports the ADF and PP tests statistics that examine the presence of unit roots (non-stationary) for all stock indices.

The study finds that all stock indices contain a unit root, implying that the null-hypothesis of the presence of a unit root at level cannot be rejected even at the 1 per cent significance level. Since the indices are found to be non-stationary at levels, the first differences for whole models are taken. The same tests are applied to the first differences of the indices and the results show that all the indices become stationary after first differencing. This result indicates that all index levels are integrated of order one, $I(1)$ and, therefore, we can proceed to the cointegration analysis with these indices because they are all integrated in the same order as required for cointegration. For our present analysis, this therefore, serves as a prerequisite for our empirical models.

	Thai	Ind	May	Phil	Sing
Thai	–	*0.226*	0.276	*0.239*	*0.494*
Ind	0.048	–	*0.192*	*0.220*	*0.276*
May	0.409	0.106	–	0.169	0.498
Phil	0.199	0.114	0.214	–	*0.247*
Sing	0.404	0.084	0.690	0.242	–

Table II.
Correlation of the stock returns during pre- and post-crisis periods

Notes: The bottom diagonal provides correlation coefficients for the pre-crisis period, while the top diagonal provides correlation coefficients for the post-crisis period. The figures in italics in the top-diagonal indicate the cases of increased correlations

Having identified that all stock indices for the ASEAN markets are stationary at first difference, we now proceed to test for cointegration, aiming at investigating whether there exist long-run relationships among the ASEAN stock markets. In order to get more insights into the long-run relationships among the stock markets under study, as explained earlier, 26 portfolio combinations of stock markets are grouped to test for cointegration. In addition, these portfolio combination groupings allow us to test cointegration both in bivariate and multivariate analyses.

Cointegration analysis

Table IV reports selected cointegration tests for portfolio combinations during the pre- and post-crisis periods. Based on the tests for 26 portfolio combinations [9], we found only two cointegrating portfolio combinations (models) during the pre-crisis period, namely: Model 4 (May, Ind, Thai and Phil) and Model 7 (May, Ind and Phil). For both models, the null-hypothesis of no cointegration is rejected at least at the 5 per cent level of significance, indicating that their residuals are in the stationary process. Despite the fact that both models have one cointegrating vector, the former model is only significant using the maximum Eigenvalue statistics (MES) test, while the latter model is found significant in both tests, MES and TS. This finding implies that there exists a long-run equilibrium relationship among the stock markets of Malaysia, Indonesia and the Philippines from early 1988 to end-1996, and these markets move in the same direction [10]. On the other hand, during the post-crisis period, seven cointegrating portfolio models are found among the ASEAN stock markets. They are: Model 1 (May, Ind, Sing, Thai and Phil); Model 2 (May, Ind, Sing and Thai); Model 3 (May, Ind, Sing and Phil); Model 5 (May, Sing, Thai and Phil); Model 6 (Ind, Sing, Thai and Phil); Model 8 (Ind, Sing and Thai); and Model 9 (Sing, Thai and May). From these findings, at least two implications can be drawn.

First, the ASEAN stock markets have become more cointegrated after the 1997 financial crisis [11], findings similar to those of Sheng and Tu (2000). In the aftermath of the crisis, Sheng and Tu (2000) found that the cointegrating relationship has improved in the Asian countries as a whole. This could be partly due to a remarkable rising proportion of bilateral trade among the countries in the region from pre- to post-crisis periods.

This finding seems to be consistent with the view that the stronger the bilateral trade ties among the countries, the higher the degree of co-movements (Masih and Masih, 1999; Bracker *et al.*, 1999; Pretorius, 2002; Ibrahim, 2003; Kearney and Lucey, 2004).

	Pre-crisis period				Post-crisis period			
	Level		First-difference		Level		First-difference	
Variable	ADF	PP	ADF	PP	ADF	PP	ADF	PP
May	− 2.873	− 2.837	− 53.63*	− 53.67*	− 1.987	− 1.997	− 11.68*	− 34.04*
Ind	− 2.740	− 2.543	− 9.98*	− 50.53*	− 2.175	− 2.003	− 8.38*	− 33.97*
Thai	− 1.579	− 1.706	− 15.58*	− 54.32*	− 1.531	− 1.756	− 12.22*	− 34.61*
Sing	− 2.742	− 2.547	− 12.50*	− 54.56*	− 2.495	− 2.617	− 14.33*	− 34.94*
Phil	− 2.436	− 2.282	− 20.80*	− 49.22*	− 2.309	− 2.224	− 19.17*	− 33.88*

Notes: *Significance at the 1 per cent level. The lag lengths included in the models are based on the AIC. The above tests of ADF and PP are based on model with constant and trend

Table III.
Unit root tests

Model no.	Portfolio combinations	Null hypothesis	Pre-crisis period TS	Pre-crisis period MES	Post-crisis period TS	Post-crisis period MES
1	May, Ind, Sing, Thai and Phil	$r \leq 0$	82.67	33.63	*121.91* **	*69.76* **
		$r \leq 1$	49.04	21.77	52.15	22.18
		$r \leq 2$	27.26	17.29	29.96	13.34
		$r \leq 3$	9.97	6.66	16.62	9.24
		$r \leq 4$	3.31	3.31	7.38	7.38
				(5)		(6)
2	May, Ind, Sing and Thai	$r \leq 0$	51.62	22.41	*79.20* **	*41.35* **
		$r \leq 1$	29.21	18.69	37.85	20.99
		$r \leq 2$	10.52	7.73	16.87	10.70
		$r \leq 3$	2.79	2.79	6.17	6.17
				(8)		(2)
3	May, Ind, Sing and Phil	$r \leq 0$	64.94	27.12	*63.05* *	28.08
		$r \leq 1$	37.81	16.82	34.97	14.67
		$r \leq 2$	20.99	14.14	20.30	11.59
		$r \leq 3$	6.85	6.85	8.71	8.71
				(18)		(2)
4	May, Ind, Thai and Phil	$r \leq 0$	60.17	*32.64* *	61.97	24.20
		$r \leq 1$	27.53	18.18	37.78	20.25
		$r \leq 2$	9.35	5.98	17.53	9.87
		$r \leq 3$	3.37	3.37	7.65	7.65
				(4)		(2)
5	May, Sing, Thai and Phil	$r \leq 0$	57.60	24.63	*72.38* **	*44.97* **
		$r \leq 1$	32.97	17.99	27.41	12.64
		$r \leq 2$	14.98	9.39	14.77	8.02
		$r \leq 3$	5.59	5.59	6.75	6.75
				(18)		(2)
6	Ind, Sing, Thai and Phil	$r \leq 0$	63.83	29.91	*78.10* **	*51.18* **
		$r \leq 1$	33.92	21.35	26.92	13.14
		$r \leq 2$	12.57	9.83	13.78	9.29
		$r \leq 3$	2.73	2.73	4.50	4.50
				(18)		(2)
7	May, Ind and Phil	$r \leq 0$	*44.10* *	*25.54* *	32.60	16.00
		$r \leq 1$	18.56	13.37	16.60	10.25
		$r \leq 2$	5.11	5.19	6.35	6.35
				(5)		(8)
8	Ind, Sing and Thai	$r \leq 0$	34.04	21.02	*50.37* **	*36.55* **
		$r \leq 1$	13.03	9.72	13.82	10.58
		$r \leq 2$	3.31	3.31	3.24	3.24
				(18)		(2)
9	Sing, Thai and May	$r \leq 0$	36.66	21.27	36.49	*50.37* **
		$r \leq 1$	15.39	9.42	15.40	13.82
		$r \leq 2$	5.97	5.97	6.23	3.24
				(18)		(6)
Total	May, Ind, Sing, Thai and Phil			2		7

Table IV.
Cointegration tests on each portfolio combination

Notes: *Significance at the 5 per cent level, **significance at the 1 per cent level. r denotes the number of cointegrating vectors. The numbers in the parentheses show the optimal lag length based on the AIC. TS and MES refer to Trace statistic and Max-Eigen Statistic tests, respectively. Since the study utilizes monthly data, the maximum lag-length considered in the study is 30

In addition, from the finance aspect, it seems that during the pre-1997 crisis period, the financial investors in the ASEAN markets were inclined to diversify their investments domestically or internationally out the region. Therefore, there were no significant flows of portfolio investments within the region. The reverse trend seems to prevail in the post-1997 crisis period where the investors can gain more benefit by diversifying regionally. The cointegration test results show that the number of significant cointegrating vectors increases after the 1997 Asian financial crisis, a result that is consistent with the contagion effect.

Second, Thailand, Malaysia and Singapore [12] play a dominant role for the long-run stock market equilibrium in the region, while the Philippines and Indonesia [13] seem to play trivial roles for long-run stock market equilibrium in this region from early 1998 to end-2006. Once again, our finding is consistent with the findings of Sheng and Tu (2000) who found cointegrating relationships after including Thailand in their models [14]. In his study, Wangbangpo (2000) also found that the ASEAN stock markets, except for the Philippines, shared a long-run equilibrium during the period from 1985 to 1996.

From the above findings, we find that there is still room for gains from international investment diversification into the stock markets of Singapore and Thailand during the pre-crisis period. However, the investment diversification benefit is much less in the cointegrated markets of Malaysia, Indonesia and the Philippines. In the post-1997 crisis period, the ASEAN stock markets have become more cointegrated whereby Thailand, Malaysia and Singapore show strong long-run relationships. The non-cointegration between the Philippine and the Indonesian markets in that period indicates their trivial roles in the region for the long-run stock market equilibrium.

At this juncture, it is important to note that although Malaysia and Singapore are found to be the most cointegrated markets in the region, their correlation in the post-1997 crisis period has slightly decreased [15]. This finding is in line with that of Janakiramanan and Asjeet (1998) who documented that geographically and economically close markets exhibit high correlations. Since Malaysia and Singapore are known as the two markets in the region that are geographically and economically close to each other, the highest correlation coefficients are found between them. However, the adoption of capital controls by the Malaysian Government during the period 1998 to 2005 might be among the contributors towards a decrease in the degree of integration between these two neighbouring countries.

Bivariate causalities

Since the results of the cointegration tests are very sensitive to the inclusion or exclusion of a stock market (Allen and MacDonald, 1995), one should be cautious when drawing conclusions from cointegrating analysis because different country combinations could lead to different results. Therefore, before concluding the test results, we use the information from bivariate tests in constructing larger portfolios and carry out the tests at each stage to obtain more complete information regarding the benefits of diversification. In other words, the bivariate analysis serves as a prerequisite for a more thorough analysis within a multivariate framework. This study, therefore, provides bivariate analysis before proceeding to the multivariate analysis.

Table V summarizes the results of the bivariate Granger causality tests based on the standard *F*-test framework. The study finds that during the pre-crisis period, Singapore

No.	Pre-crisis period	Post-crisis period
1	Ind ======= Thai	Ind <======> Thai
2	May ======= Thai	May <======> Thai
3	Phil ======= Thai	Phil <====== Thai
4	Sing ======> Thai	Sing ======> Thai
5	May ======> Ind	May <====== Ind
6	Phil ======> Ind	Phil ======> Ind
7	Sing <======> Ind	Sing ======> Ind
8	Sing ======> Phil	Sing <======> Phil
9	Phil <====== May	Phil <======> May
10	Sing ======> May	Sing <======> May

Table V.
Summary of bivariate granger causality tests

Notes: <======> indicates a bi-directional Granger causality between the stock markets; ======> or <====== indicates a unidirectional Granger causality from one stock market to another; and ===== indicates no Granger causality between the stock markets

Granger-caused all the other ASEAN markets, while Indonesia is Granger-caused by other ASEAN markets with the exception of Thailand, implying the leading and lagging roles of Singapore [16] and Indonesia in the region. The Thai market is found relatively to have no causalities with the rest of the ASEAN markets. In short, in this period we find that there are no causalities running between the Philippines and Thailand, Indonesia and Thailand, and Malaysia and Thailand. Similar to the finding from the pre-crisis period, Singapore is once again found to have Granger-caused all other ASEAN markets in the post-crisis period. Meanwhile, Malaysia was at the same time having bidirectional causality with other ASEAN markets during this period. Nevertheless, the results are found to be mixed between other ASEAN markets; both unidirectional and bidirectional causalities between them are documented. The existence of bidirectional causalities during the study period, which started in the aftermath of the 1997 financial crisis are, however, along the lines of the evidence found by Jang and Sul (2002) who found bidirectional causalities in the Asian markets, except for Singapore with Indonesia, Thailand with Singapore and Thailand with Indonesia during early 1998 to end-2000 period. It is interesting to note that the absence of interdependence between these markets could be due partly to the different risks and returns that exist among these markets. Although the differential returns between these markets are very small, the risk is significantly higher for the Philippines and Indonesia compared to the Malaysian market. Thus, investors in this region may consider reasonable risk for higher expected returns in the Malaysian market but would consider the level of risk in the Philippines and Indonesia as beyond their acceptable risk level (Palac-McMiken, 1997).

Multivariate analysis using GMM

The existence of cointegration among the ASEAN stock markets rejects non-causality among them. This implies that at least one of the markets reacted to deviations from the long-run relationship. The study then needs to explore whether the market corrects the disequilibrium. Which market then bears the brunt of short-run adjustment to the long-run equilibrium in the ASEAN markets? Accordingly, the vector error correction model (VECM) is used to investigate the short- and long-run dynamic linkages among the ASEAN stock markets. Out of nine cointegrating portfolio models, the VECM

analysis based on the GMM estimation is conducted for only two selected cointegrating portfolio models [17], one for the pre- and post-crisis periods, respectively.

The results from the VECM which provide information on both short- and long-run relationships among the ASEAN markets during the pre- and post-crisis periods are reported in Tables VI and VII, respectively. The existence of the short and long-run multivariate Granger causalities among the stock markets is indicated by significance of the *F*-statistics through joint tests of lagged differences and statistic significance of the *t*-statistic tests for ECT.

From Table VI, we find that for Model 4 (May, Ind, Thai and Phil) during the pre-crisis period, along with Malaysia, all other markets were statistically endogenous. It is also interesting to note that both ECTs and short-term channels of Granger-causality were significant for the stock markets of Malaysia, the Philippines and Thailand (Granger, 1988). Although the ECT is insignificant in the Indonesian equation, this market is still influenced by significant short-run causal influences from other markets. The relative independence of the Indonesian market from the other ASEAN markets in the short-run may have been driven by the continuing political and economic uncertainties experienced by the country during the crisis and post-crisis periods. Moreover, due to these uncertainties, international investors may have perceived the Indonesian market as a separate market from the rest of ASEAN. However, due to the significant participation and increasing caution of international investors in investing in emerging markets, the developments in the other markets have become more important for Indonesia (Bekaert and Harvey, 1997).

As for short-run causalities among the ASEAN markets during the pre-crisis period, we find that except for the stock markets of Thailand and Indonesia, which are independent of each other, all markets in the system are found to have Granger-causal linkages running from one to another. Another important finding is that Indonesia is the only market in this system in which the ECT is statistically insignificant. This suggests that any deviation from the equilibrium cointegrating relationships, as measured by the ECT, is mainly caused by changes in the Malaysian, Philippine and Thai markets. According to Masih and Masih (1997, 1999), the markets that have significant ECTs, i.e. Malaysia, the Philippines and Thailand will bear the brunt of short-run adjustment to long-run equilibrium.

As reported in Table VII, we identified that during the post-1997 crisis period, all markets in the system are found to have Granger-causal linkages running from one to another. Unlike the stock markets of Thailand and Malaysia that are not Granger-caused by the stock markets of the Philippines and Indonesia, respectively; all other ASEAN markets have pairwaise bi-directional causalities running from one market to the other. The stock markets of Thailand and Singapore; Indonesia and Singapore; Indonesia and the Philippines; Malaysia and Indonesia; Malaysia and Singapore; Malaysia and Thailand; Singapore and the Philippines; Thailand and the Philippines are all found to have bi-directional causalities between them. During the post-crisis period, we also found that, with the exception of Indonesia, all the other ASEAN markets are documented as the markets in Model 1 (May, Ind, Sing, Thai and Phil) in which the ECTs are statistically significant. This suggests that any deviations from the equilibrium cointegrating relationships are caused by changes in the Malaysian, Thai, Philippine and Singaporean markets, i.e. these ASEAN-4 markets bear the brunt of short-run adjustment to long-run equilibrium. Although the ECTs are

Table VI.
Multivariate "VECM" causality analysis using GMM (pre-crisis period)

	Lags = 3 independent variables					
	F-statistics				*t*-statistics	
Dependent variables	ΔMAY	ΔIND	ΔTHAI	ΔPHIL	ECT_{t-1}	Diagnostic test
ΔMAY	–	2.1522*	22.1393***	5.8703***	−0.0048**	Adj R^2 = 0.1930
		[0.0719]	[0.0000]	[0.0001]	(−2.2433)	DW = 2.0226
						J-stats = 0.0006
ΔIND	8.0634***	–	1.0148	4.6298***	0.0009	Adj R^2 = 0.1634
	[0.0000]		[0.3982]	[0.0001]	(−0.2927)	DW = 1.9938
						J-stats = 0.0002
ΔTHAI	28.4287***	0.5604	–	4.57678***	−0.0053*	Adj R^2 = 0.1802
	[0.0000]	[0.6914]		[0.0011]	(−1.7543)	DW = 2.0238
						J-stats = 0.0004
ΔPHIL	13.1393***	5.5015***	5.4962***	–	−0.0105***	Adj R^2 = 0.1992
	[0.0000]	[0.0002]	[0.0002]		(−3.2661)	DW = 2.1413
						J-stats = 0.0016

Notes: *Significance at the 10 per cent level, **significance at the 5 per cent level, ***significance at the 1 per cent level. ECT_{t-1} is derived by normalizing the cointegrating vectors on the Kuala Lumpur Stock Index (KLCI) as proxy for Malaysian stock index, producing residual *r*. By imposing restriction on the coefficients of each variable and conducting the Wald test, we obtain *F*-statistics for each coefficient in all equations. Figures in the parantheses and square bracket represent *t*-statistics and probabilities for *F*-statistics, respectively. The optimal lag-length included in the models is based on the AIC. DW is the D-W *d*-test for autocorrelation, and *J*-stats is the Hansen *J*-statistic test for correct specification (over-identifying restrictions) of the model

Table VII. Multivariate "VECM" causality analysis using GMM (post-crisis period)

Dependent variables	Lags = 5 independent variables						
	F-statistics					*t*-statistics	
	ΔMAY	ΔIND	ΔSING	ΔTHAI	ΔPHIL	ECT_{t-1}	Diagnostic test
ΔMAY	–	3.0053** [0.0499]	16.3630*** [0.0000]	6.7417*** [0.0012]	1.1277 [0.3241]	− 0.0186*** (− 4.0527)	Adj $R^2 = 0.1562$; DW = 1.9627; *J*-stats = 0.0029
ΔIND	4.2681* [0.0692]	–	7.0117*** [0.0031]	4.3283* [0.0599]	4.1239*** [0.0002]	− 0.0132 (− 1.1131)	Adj $R^2 = 0.1923$; DW = 2.0311; *J*-stats = 0.0021
ΔSING	10.3321*** [0.0000]	10.0320*** [0.0000]	–	32.7908*** [0.0000]	3.9213** [0.0470]	− 0.0053** (− 2.7478)	Adj $R^2 = 0.2001$; DW = 2.111; *J*-stats = 0.0003
ΔTHAI	8.4320*** [0.0005]	2.4762 [0.1132]	31.5424*** [0.0000]	–	5.1407*** [0.0004]	− 0.0111*** (− 3.6330)	Adj $R^2 = 0.1212$; DW = 1.9981; *J*-stats = 0.0011
ΔPHIL	1.9983* [0.0699]	4.3210*** [0.0017]	4.0127* [0.07564]	8.3756*** [0.0001]	–	− 0.0067** (− 2.6903)	Adj $R^2 = 0.1702$; DW = 1.896; *J*-stats = 0.0010

Notes: *Significance at the 10 per cent level, **significance at the 5 per cent level, ***significance at the 1 per cent levels. ECT_{t-1} is derived by normalizing the cointegrating vectors on the Kuala Lumpur Stock Index (KLCI) as proxy for Malaysian stock index, producing residual *r*. By imposing restriction on the coefficients of each variable and conducting the Wald test, we obtain *F*-statistics for each coefficient in all equations. Figures in the parantheses and square bracket represent *t*-statistics and probabilities for *F*-statistics, respectively. The optimal lag-length included in the models is based on the AIC. DW is the D-W *d*-test for autocorrelation, and *J*-stats is the Hansen *J*-statistic test for correct specification (over-identifying restrictions) of the model

statistically insignificant in the Indonesian equation, this market still leads and is led by significant short-run causal influences from other markets.

It is important to note that the stock market of Singapore is not included in any cointegrated models (Models 4 and 7) in the pre-crisis period, but this market was found to be among the important components of all seven models (Models 1-3, 5, 6, 8 and 9) that established cointegration in the post-crisis period. This could be partly due to a growing proportion of bilateral trade between Singapore and the ASEAN-5 markets from the pre- to the post-crisis periods. In addition, from the finance aspect, it seems that during the pre-1997 crisis period, the financial investors in the Singaporean markets were inclined to diversify their investments domestically or internationally out the ASEAN region; therefore there were no significant flows of portfolio investments within the region. The reverse trend seems to prevail in the post-1997 crisis period where the investors can gain more benefit by diversifying in the stock markets across the ASEAN region.

From the above findings, we find that all the ASEAN stock markets seem to be unambiguously endogenous throughout the models. Among the ASEAN markets, Indonesia was found to be relatively independent of other ASEAN markets. Singapore, Malaysia and Thailand appeared to have close causal linkages running between them. Finally, the Philippines was also found to have Granger-caused other ASEAN markets and at the same time is affected by other markets either in the unidirectional or bidirectional directions. In all the models, except for Indonesia, the rest of the ASEAN markets appear to be the important bearers of short-run adjustments to a shock in the long-run equilibrium relationships in the ASEAN stock markets both during the pre- and post-crisis periods.

The overall performances of our estimated models seem to be acceptable[18]. All ECTs' coefficients are found with the expected negative signs, implying that in the long-run, stock markets have a tendency to return to their equilibrium relationships. The Durbin-Watson (D-W) *d*-statistics are all insignificant; hence we do not reject the null-hypothesis of having no auto-correlation among the disturbance terms. Although the adjusted R^2 values are relatively low, they are still regarded as acceptable given that the estimates are based on first differenced values. The estimated models are also far from being rejected by the test of over-identifying restrictions (Hansen, 1982; Gallant, 1987). Additionally, our models do not reject the over-identifying restrictions since Hansen's *J*-statistics are smaller than our critical values[19].

Finally, to assess the stability of the models and constancy of the parameters and variances, the cumulative sum of recursive residuals (CUSUM) and the CUSUM of square (CUSUMSQ) tests proposed by Brown *et al.* (1975) are conducted. The plots of the CUSUM and CUSUMSQ for both the pre- and post-crisis periods lie inside the area between two critical lines, indicating that both short- and long-term parameters and variances in our models are stable. In conclusion, based on the above batteries of diagnostic tests, therefore, we can conclude that the performances of our estimated models are satisfactory enough to provide information pertaining to the issue of market integration among the ASEAN stock markets (Figure 1).

Conclusion and policy implications

This study empirically explores the integration among five selected ASEAN emerging stock markets (i.e. Malaysia, Thailand, Indonesia, the Philippines and Singapore) based on a two-step estimation, cointegration analysis and GMM (IFC, 1998).

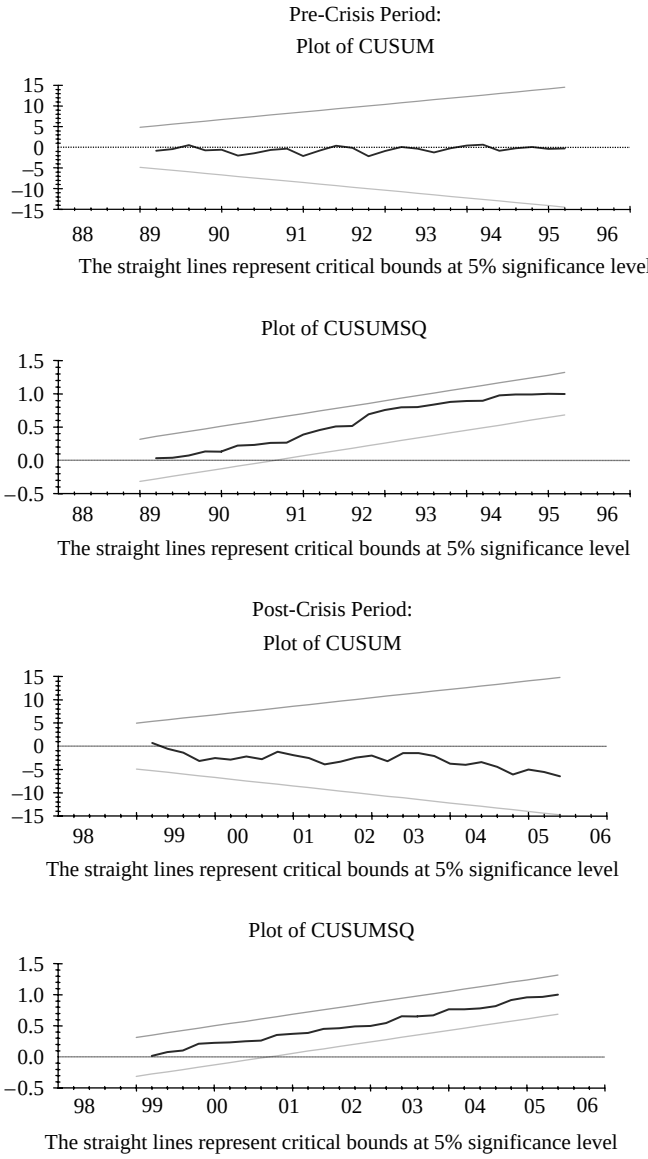

Figure 1.
CUSUM and CUSUMSQ plots

The integration among the markets is tested in the first step by Johansen's cointegration method, whilst the relationships among the ASEAN markets are estimated simultaneously in the second step by the GMM.

In line with many studies on international interdependences of stock markets, our study found that the ASEAN stock markets are moving towards more integration among themselves, especially following the 1997 financial crisis. This might be due to a remarkable rise in the proportion of bilateral trade among the countries in the region

from the pre- to post-crisis periods. This finding seems to be consistent with the view that the stronger the bilateral trade ties among the countries, the higher the degree of co-movements (Masih and Masih, 1999; Bracker *et al.*, 1999; Pretorius, 2002; Ibrahim, 2003; Kearney and Lucey, 2004). In addition, from the finance factor, it seems that during the pre-1997 crisis period, the financial investors in the ASEAN markets were inclined to diversify their investments domestically or internationally out the region and, therefore, there were no significant flows of portfolio investments within the region. The reverse trend seems to have prevailed in the post-1997 crisis period where the investors can gain more benefit by diversifying regionally.

The stock markets in the ASEAN region are found to be cointegrated during the pre- and post-1997 financial crisis. However, the degrees of short- and long-run integration have significantly increased; particularly during the post-1997 financial crisis period. This implies that investors who diversified their investments across the ASEAN markets could only gain limited benefits during the period. Our findings are similar to the findings by Cheng *et al.* (2003). In their study on ASEAN-5 (Malaysia, Indonesia, Singapore, the Philippines and Thailand), they found that these markets were cointegrated before and after the crisis. This result indicated that during the pre- and post-crisis periods, the ASEAN stock markets were driven by a common international factor and country-specific factors have become less important than the international factors, leading to the long-run co-movements among the stock markets.

In addition, among the ASEAN markets, Malaysia, Singapore and Thailand are found to have strong long-run relationships in the region. The finding of higher cointegration between Malaysia and Singapore is in line with the finding by Janakiramanan and Asjeet (1998) who documented that geographically and economically close markets exhibit high correlations. Since Malaysia and Singapore are known as the two markets in the region that are geographically and economically close to each other, the highest correlation coefficients are found between them. From the causality analysis, the study found that the Granger (1986) causal relations among the markets kept changing over the period, whereby Singapore was found to dominantly cause other ASEAN markets, a finding similar to that of Azman-Saini *et al.* (2002). The different findings over different sub-periods of the study may be due, *inter alia,* to differences in the countries' external capital controls (Cheung and Mak, 1992), financial deregulation (Chowdhury, 1994), financial factors (Ibrahim, 2003), and trade bilateral dependencies (Pretorius, 2002). The countries with severe capital control were not responsive to innovations in the foreign markets (Sheng and Tu, 2000).

Accordingly, the implication of our findings on cointegrated ASEAN markets is that, investors who allocated their investment across the stock markets of ASEAN could not totally enjoy long-run diversification benefits. Our findings are consistent with those of Ibrahim (2000; 2005), Azman-Saini *et al.* (2002) and Daly (2003). It is important to note that the existence of cointegration among the ASEAN markets does not rule out the possibility of arbitrage profits through diversifying portfolios across these countries in the short-term, which may last for quite a while (Dwyer and Wallace, 1992; Yang and Siregar, 2001). Thus, because of varying degrees of business and financial risks of different securities and various security cash flows covarying less than perfectly across the ASEAN stock markets (and even within the same country), the diversification benefits in the ASEAN markets in the long-term may be reduced but are not likely to be fully eliminated in practice.

The existence of cointegration among the ASEAN stock markets also implies a common stochastic trend in those markets (Kasa, 1992; Blackman *et al.*, 1994; Lee and Jeon, 1995; Jang and Sul, 2002). Since each ASEAN stock price series contains information on the common stochastic trends (which bind all the ASEAN markets together), the predictability of one country's stock prices can be enhanced significantly by utilizing information on the other countries' stock prices. The presence of common stochastic trends among all these stock markets implies that once new information on a stock price is available prior to other stock prices, the other stock prices will deviate from that trend through a transitory component. Individual prices cannot wander too far away from each other over time (Masih and Masih, 1999).

Finally, our evidence of the extent of cointegration or interdependencies among these markets has important implications for the macro stabilization policies of each of the ASEAN members. The extent of the effectiveness of the macroeconomic policies of each of the ASEAN markets in dealing with its stock market imbalances will depend crucially on the extent of financial integration of each ASEAN stock market with the rest. In particular, since the ASEAN markets are integrated, then a country's economy cannot be insulated from foreign shocks and this reduces the scope for independent monetary policy. Moreover, effective diversification among international markets cannot be achieved and the integrated markets can be considered as one market set by long-term investors. The integration of the ASEAN stock markets in the long-run points to the limitation associated with the pursuit of interdependent policy, especially the financial policy. Rather, as the ASEAN economies become more integrated regionally, there is a need for policy coordination among ASEAN to mitigate the impact of financial fluctuations, as the stock markets are interdependent. Finally, greater policy coordination, along with the reduction or removal of trade and investment barriers, will be essential if these countries are to exploit the advantages of greater economic and financial interdependence. The knowledge of financial market integration could be used by the government or policy makers to determine the decision for monetary union, a current topic of debate.

Similarly, the extent of integration among the ASEAN market will have important bearings on the formulation of the financial policies of multinational corporations. Take the example of the 1997 East Asian crisis that started in Thailand. While initially it was the currency and stock markets that were affected, many firms in the ASEAN countries later found themselves in financial distress. It is a well-known fact that stock markets and foreign markets are very much connected. Mundell (2000), the 1999 Nobel Laureate, writes that exchange rate volatility is a major threat to global prosperity that causes unnecessary volatility in capital markets. Therefore, knowing the co-movement among the stock markets would give an idea of exchange rate risk between countries. Such knowledge can, therefore, help managers to mitigate international risks and managing economic, transaction and translation of risks.

To further add to the existing literature on market integration in the ASEAN region, further empirical studies on the issue can cover broader areas of market integration and explore factors accounting for market integration. A further possible extension of the study is to quantify and compare the diversification benefits investors can gain when diversifying their investments across the ASEAN markets. Since cointegrated tests are only able to detect linear long-run equilibrium relationships, but fail to detect

non-linear cointegration (Okunev and Wilson, 1997), a more advanced test is needed to discover the existence of non-linear cointegration among the ASEAN markets.

Notes

1. Out of ten members of ASEAN, only the five founding members of ASEAN – Malaysia, Indonesia, Thailand, the Philippines and Singapore – are investigated in this paper. The rest of the five ASEAN members, namely: Vietnam, Brunei Darussalam, Myanmar, Cambodia and Laos are excluded from this study in view of the unavailability of data for the study period. Though Singapore is the most developed country in the region, it is still categorized as an emerging market (Yang and Siregar, 2001). Masih and Masih (1997) called Singapore an "emerging Newly Industrialized Country (NIC) market".
2. Focusing only on bivariate or multivariate cointegration analysis might miss some important information. The markets can be segmented using bivariate analysis, but they become integrated using multivariate analysis, or vice versa. This was a shortcoming in the studies of Palac-McMiken (1997) and Jang and Sul (2002).
3. We have also tried the quadratic spectral kernel estimation as suggested by Andrews (1991); the estimation results are very much the same.
4. More specifically, it is estimated solely based on the number of observations in the sample. We have also tried bandwidth selection as suggested by Andrews (1991); the estimation results are very much the same.
5. We opt to use these indices in our study because all the indices are calculated based on the capitalization-weighted method.
6. It is important to note that "there is nothing in the cointegration methodology that requires the two series to be in the same currency" (Ding *et al.*, 1999, p. 322). This study therefore ignores currency issues.
7. All 26 possible portfolio combinations are tested. They are for example: (1) May, Ind, Thai, Phil and Sing; (2) May, Ind, Thai and Phil; (3) May, Ind, Thai and Sing; (4) May, Ind, Phil and Sing; and so on.
8. During a year of the 1997 financial crisis (January to December 1997), all stock markets of ASEAN witnessed negative average daily returns.
9. To save space, the study only reports the cointegrating portfolio combinations. However, the cointegration tests for all portfolio combinations are available with the authors upon request.
10. We do not conclude that Thailand cointegrated with May, Ind and Phil because if we look at the significant cointegrating models, Thailand is only significant in one model (Model 4) and in a single test MES compared to Model 7 that found it cointegrated in both tests, MES and TS.
11. During the pre-crisis period, the study finds only one cointegrating vector based on the TS and two cointegrating vectors based on the MES. However, the number of cointegrating vectors based on both TS and MES tests has, respectively, increased to six after the 1997 Asian financial crisis.
12. In all seven cointegrating models, both Singapore and Thailand are found to be significantly cointegrated, with the exception of only one model, Model 3 where Thailand was absent. Meanwhile, Malaysia is only found insignificantly cointegrated in Model 7, where Thailand and Singapore were absent.
13. Out of seven models, the Philippines is only found cointegrated in four cointegrating portfolio combinations; Models 1, 3, 5 and 6. Although Indonesia is found in five models to be cointegrated, in some models they are only significant in one test and at a lower level. This indicates that the Indonesian stock market is quite isolated from other ASEAN markets. This finding is similar to those of Barus (1997) and Palac-McMiken (1997).

14. It is important to note that the results of the cointegration tests are sensitive to the inclusion and exclusion of countries, similar to the findings by Allen and MacDonald (1995).
15. As reported in Table II, the correlation coefficients between Malaysia and Singapore decreased from 0.690 in the 1997 pre-crisis period to 0.498 in the post-1997 crisis period. It was only slightly higher than the correlation coefficient of 0.494 between Thailand and Singapore.
16. This finding is, to some extent, similar to the finding by Azman-Saini *et al.* (2002). They found that Singapore stock prices were not affected by other countries in the long run, except for the Philippines.
17. It is believed that the two selected cointegrating portfolio models investigated in this study, for our further analyses, are representative enough to provide comprehensive information on the short- and long-run relationships among the ASEAN stock markets. The main considerations used in selecting these two portfolio combinations are the representativeness of cointegrating portfolio combinations and the higher level of significance of cointegrating portfolio models using both MES and TS tests.
18. As compared to the results from OLS, we find that the GMM estimation has improved the statistical significance of parameter estimates. However, the signs of the variables and direction of causalities among variables analysed using OLS and GMM are found to be no different. Owing to space constraints, we do not report the findings from OLS, but these results are available with the authors upon request.
19. To save space, we do not report the results of the whole battery of tests. However, they are available from the authors upon request.

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