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Adwin Surja Atmadja
Universitas Kristen Petra

This study attempts to answer how the U.S and the ASEAN-5 stock markets' indices would interrelate during the periods of stock market turmoil. The multivariate time series analyses conducted on the series reveal that there are cointegrating relationships on the series of the two sub-sample periods of the 1997 and the 2002 crisis. However, the study fails to detect any cointegrating vector on the series during the 2007 crisis. The granger causality tests applied to the series reveal that the number of significant causal linkages between two variables on the series rocketed during the 2007 crisis. In addition, the accounting innovation analysis shows an increase in the explanatory power of an endogenous variable to another in the system during the latest crisis, indicating that the contagious effect of the latest crisis had dramatically changed the pattern of the short run dynamic interaction of the six capital markets.

Keywords: Stock Market Linkages, Stock Market Crisis, Cointegration.

INTRODUCTION

A number of studies have been conducted on stock market interdependence around the period of financial or stock market crises in Asia-Pacific region. The general consensus is that the degree of integration among countries tends to change with a stronger integration during crisis periods than that before and after the periods (Sheng and Tu, 2000, and Yang, Kolari, and Min, 2003). It is also interesting to note that U.S stock market has played an important role in most national and regional stock markets, including some Asian's stock markets during the 1997 crisis (Sheng et al, 2000).

This study attempts to extend the analysis and examination presented in the previous papers on the stock market interrelation during crisis periods by including the (2007) recent financial crisis. This study emphasises on whether there is a significant difference in the stock market indices interrelation during the (1997) Asian financial crisis, the 2002 stock market downturn, as well as the 2007 crisis. This is an interesting issue because those crises are quite different in terms of the phenomena and factors causing them. The Asian financial crisis is an indication of a mixture of both economic crisis and panic as a result of the weak and collapse of Asia's financial systems (Sheng et al, 2000). Triggered by the sharp depreciation in the Thai baht in the midst of 1997, the disastrous effects of the 1997 financial crisis broadly spread out to the South East Asia (ASEAN) financial markets which were dominated by bank loan and portfolio investment (DFAT, 1999:29). Market capitalization of the countries' stock market was largely contracted due to a deep depreciation in their stock prices causing their stock indices then sharply plunged. The crisis then extensively affected the world financial markets through its contagion effects.

The 2002 stock market downturn, meanwhile, originally hit the US stock markets. The downturn can be viewed as part of a larger correction in the US stock market triggered by some factors, including the September 11 attacks; an outbreak of accounting scandals; bankruptcy of some dotcom companies. This large stock market downturn, in fact, caused investors' confidence suffered, and influenced other national stock exchanges.

The (2007) recent crisis also sparked in the U.S. in the second semester of 2007. At the time, the US financial market was deeply suffered from the most significant economic shocks initiated by the sub-prime mortgage crisis leading to the downturn in housing market, and then worsened by the spike in commodity prices (Yellen, 2008). Webb (2009) mentions that this crisis is a representation of hubris or an overconfidence that the previously smooth system will never fail or even collapse. The devastating effects of the US financial market turmoil then widely spread throughout the world.

The focus of this study is particularly on the stock market interdependence among national equity indices in six countries, which are the US; Singapore; Indonesia; Malaysia; Thailand; and the Philippines, during the three crisis periods. The multivariate time series is employed to analyse the degree and the existence of the long-run equilibrium, as well as to explain the short-run dynamic interactions among the indices in three sub sample periods. The study is structured as following: Section One describes the condition of the six stock markets in different periods; Section Two reviews the literature; Section Three discusses the research methodology; Section Four presents the empirical results; Section Five concludes.

LITERATURE REVIEW

The basic theoretical concept of financial market integration is laid on the law of one price. In integrated financial markets, the assets with the same risk in different markets will result in the same yield when measured in a common currency (Stulz, 1981). However, if the yields are different across the markets, the arbitrage process will play an important role in eliminating the differences. Operationally capital markets integration refers to the extent that markets' participants are enabled and obligated to take notice of events occurring in other markets by using all available information and opportunities, while financial market integration is defined in terms of price interdependence between markets (Kenen 1976).

Roca (2000) states that stock market integration is affected by some factors, such as economic integration (Eun and Shim, 1989), multiple listing of stocks, regulatory and information barriers, institutionalisation and securitisation, and market contagion (King and Wadwhani 1990), which may significantly determine the dynamic relationships among stock markets (Climent and Meneu, 2003), even though in the case of emerging markets, the contagion effect could be smaller than what is widely perceived (Pretorius 2002).

Much research has been carried out in order to find and analyse the existence of integration or long-run equilibrium in stock market across countries. The results are different depending on where, when, and how the research has been conducted. Palac-McMiken (1997) also reveals the existence of cointegration in ASEAN markets[1] (Malaysia, Singapore, Thailand, and the Philippines), except Indonesia, during 1987 to 1995. The result is confirmed by Masih and Masih (1999) who report that some of ASEAN countries (Thailand, Malaysia, and Singapore) have a high degree of interdependence with other Asian (Hong Kong and Japan) and developed (the U.S. and the U.K.) stock markets. Furthermore, Masih and Masih (2001) also find one cointegration vector among several major Asian stock markets (Hong Kong, Korea, Singapore, and Taiwan) and major developed markets.

Somewhat contradicts with those of Chung and Liu (1994) and Masih et al. (1999), Chan, Gup and Pan (1992) and DeFusco, Geppert and Tsetsekos (1996) also mention that there is no cointegration between the U.S and several Asian emerging stock markets (Hong Kong, Taiwan, Singapore, Korea, Malaysia, Thailand, and the Philippines) in the 1980s and early 1990s. Interestingly, Pretorius (2002) reports that the stock markets of countries in the same region are more interdependent than those in different regions. Consistent with this finding, Roca (2000) reveals the existence of interdependency among all the ASEAN stock markets in the short run, but not in the long run, during 1988-1995. These findings imply that the interdependence among stock markets is not stable over time as it is also mentioned by Arshanapalli and Doukas (1993).

Arshanapalli, Doukas and Lang (1995), furthermore, show that after the 1987 crisis the stock markets in emerging markets (Malaysia, the Philippines, and Thailand) and developed markets (Hong Kong, Singapore, the U.S., and Japan) are more interdependent as they found cointegration in the post-crisis period, but not in the pre-crisis period. Other researchers, Liu, Pan and Shieh (1998) also confirm that there is an increase in the interdependence within Asian-Pacific regional markets and the stock markets post-the 1987 crisis. Similarly, Sheng et al (2000) document one cointegration vector between the U.S. and several Asian stock markets (Taiwan, Malaysia, China, Thailand, Indonesia, South Korea, the Philippines, Australia, Japan, Hong Kong, and Singapore) during the crisis, but none in the years before the crisis, when they observed the stock markets using daily data.

A research conducted by Yang et al (2003) examine the long-run relationship and short-run dynamic causal linkages among the U.S, Japanese, and ten Asian emerging markets using daily data of 1997-1998 periods. They confirm that the stock markets in those countries had been more integrated after the 1997 Asian financial crisis than before the crisis. Both long-run cointegration relationship and short-run causal linkages in those markets become stonger during the period of crisis. Meanwhile, Atmadja, Wu and Juli (2009) find cointegration relationship among the eight Asia – Pacific (the U.S, Australia, Japan, Taiwan, Hongkong, China, Korea, and Indonesia) stock indices in the 2007 crisis period, but not in the 1997 crisis. Moreover, they also reveal that the short run dynamic interaction among the indices to be more intense along the examination periods.

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[1] Other researchers, which have also been conducted some studies on ASEAN stock market integration, are Hee (2000, 2002), Wongbangpo (2000), Ibrahim (2000, 2005), Azman-Saini et al. (2002), Daly (2003) and Cheng, Leng, and Lian (2003).

RESEARCH METHODOLOGY

Data and Samples

The daily closing stock price indices of the NYSE Composite of New York Stock Exchange-USA (NYSEALL) and the five ASEAN countries, which are Jakarta SE Composite (JAKCOM) of Indonesia; Kuala Lumpur SE Composite (KLSE) of Malaysia; Philippine SE Index (PSEi) of the Philippines; Straits Times Index (STI) of Singapore; and Bangkok - SET Composite of Thailand, would be used as measurement of the countries' daily stock index movements in the observed periods.

The indices data would then be transformed into natural logarithm forms before conducting the analyses, and be clustered into three sub-sample periods. The first period is the 1997 crisis: from July 1997 – March 1999. This period classification of somewhat similar with the one suggested by some researches (Kamin, 1999, Corsetti, Pesenti and Roubini,1999, Sheng et al., 2000, and Yang et al., 2003). The second period is the 2002 Stock market downturn period begun in March 2002 and ended in December 2003 when the level of indices sat back at their same level before the crisis. The third is the 2007 crisis period: from July 2007 – June 2009, as it is mentioned by Yellen (2008).

Empirical Framework

The two most appropriate models of multivariate time series analysis framework that one of which may suitable for this study are VAR and VECM. In the Vector autoregressive model (VAR) all variables are endogenous, and symmetrically treated. A VAR could be very large, however, in standard form, it could be written as:

$$x_t = \delta + \sum_{i=1}^{p} \Gamma_i x_{t-i} + \varepsilon_t \quad \text{...(1)}$$

where x_t is an n x 1 vector of variables and δ is an n x 1 vector of constant. Γ is an n x n matrix (coefficients of the short-run dynamics), ε_t is an n x 1 vector of white noise error term, and p is the order of autoregression.

VAR requires that all variables be stationary[2], and the appropriate lag length is data driven (Brooks, 2002). To define the appropriate lag length, some tests of information criteria will be applied, including the likelihood ratio (LR) test; Akaike Information Criterion (AIC); and Schwarz Bayesian Criterion (SC).

The LR test is based on asymptotic theory and is an F-type approximation. This test actually compares a restricted VAR (less lags) to an unrestricted VAR (more lags), which the null hypothesis is that the restricted model is correct[3]. However, the shortcoming of the test is that it may not be useful in small samples.

Because of the limitation of the likelihood ratio test, multivariate generalization of AIC and SC may be the most suitable alternatives. The minimum values of AIC and/or SC could validly indicate the appropriate lags length, as long as the model's residual does not suffer from serial correlation problem. Otherwise, the lag length may be too short. Thus, it is necessary to re-estimate the model using lag length that is serially uncorrelated.

In VAR, a block causality test, which is the Pairwise Granger Causality / Block Exogenity Wald Tests based on VAR, would be used to examine whether the lags of one variable enter into the equation for another variable. If y_1 granger-causes y_2, the parameters of lags of y_1 should then not equal zero in the equation of y_2. However, it is noteworthy that granger-causality basically means a correlation between the current value of one variable and the past (lags) value of others. Thus, granger causality simply implies a chronological ordering of movements of the series.

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[2] There are several available tests for testing for a unit root, however the Augmented Dicky-Fuller (ADF) test would be carried out to test the series.
Non-stationary variables may be made stationary by differencing or detrending process.

[3] It is worth noting that the LR test is only valid when the restricted model is tested.

As an alternative of VAR, the vector error correction model (VECM) or cointegration framework analysis would properly analyze the series, if only the series contain unit root. The VECM basically is a VAR augmented by the error correction term, and its result is also sensitive to its lags length. The VECM takes the form as:

$$\Delta x_t = \delta + \sum_{i=1}^{p} \Gamma_i \Delta x_{t-i} + \alpha\beta' x_{t-1} + \varepsilon_t \quad \text{.......(2)}$$

where α is an n x 1 column vector (the matrix of loadings), representing the speed of short-run adjustment to disequilibrium. If the parameters speed of adjustment (α) in VECM, is statistically zero, the components in x_t are not cointegrated, thus VECM reverts to a VAR in first differences[4]. Otherwise, the larger the speed of adjustments, the greater the response to previous periods' deviation from the long run equilibrium. β is an 1 x n cointegrating row vector (the matrix of cointegrating vectors) indicates the matrix of long-run coefficients such that x_t converge in their long-run equilibrium. A cointegration relationship is a long term or equilibrium phenomenon, since it is possible that cointegrating variables may deviate from their relationship in the short run, but their association would return in the long run (Enders, 2004).

Cointegration requires that all variables in a model be integrated with the same order. Ones may use the Engle-Granger (EG) test, which is basically a residuals-based approach, or the Johansen Cointegration Test to test the existence of cointegrated variables. Johansen (1988, 1991) proposed the maximum likelihood based two statistics to test the rank of the long-run information, namely:

$$\lambda_{\max}(r, r+1) = -T \ln(1 - \lambda_{r+1}) \quad \text{.......(3)}$$

$$\lambda_{\text{trace}}(r) = -T \ln(1 - \lambda_i) \quad \text{.......(4)}$$

where λ_i are estimated Eigenvalues (characteristic roots) ranked from largest to smallest. The λtrace is a likelihood ratio test statistics for the hypotheses that are at most *r* cointegrating vectors. The λmax is the maximal Eigenvalue statistic that tests the hypothesis of *r* cointegrating vectors against the hypothesis of *r* – 1 cointegrating vectors. If Eigenvalues λ_i's are all zero, then the ltrace and λmax will be zero. To test for the number of cointegrating vectors, this study employs Johansen and Juselius's (1990) λtrace and λmax statistics that are adjusted for the degree of freedom. In the case of a

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[4] VAR in first difference could be formulated as :

$$\Delta x_t = \Gamma_0 + \sum_{i=1}^{p} \Gamma_i \Delta x_{t-i} + \varepsilon_t$$

cointegration relationship does not exist, a VAR analysis in first difference will then be the correct specification to conduct the estimation.

Following the VECM estimation, the VEC Pairwise Granger Causality / Block Exogenity Wald Tests is applied to reveal block-causality relationship between two variables. If there is a block causality relationship between the both variables, then lags of a variable should be significant in the equation for another.

A direct interpretation of the cointegration relations, may be difficult or misleading (Lutkepohl and Reimers, 1992, Runkle, 1987). As in a traditional VAR analysis, innovation accounting analysis, which consists of Impulse Response and Variance Decomposition Analysis, can provide a solution to the interpretation problem, and might be the most appropriate method to explore the short run dynamic structure of market linkages (Yang et al., 2003). This analysis would answer whether changes in the value of a given variable have positive or negative effect on the other variables in the system, or how long it would affect the variable to work through the system.

An impulse response analysis, traces the effect of a one-time shock to one of the innovations on current and future values of the endogenous variables. A shock to the i-th variable not only affects the i-th variable directly, but it is also transmitted to all of the other endogenous variables through the dynamic (lag) structure of the VAR. The analysis reveals the responsiveness of the dependent variables in VAR to shocks on individual error terms. This study employs the generalized[5] type of impulse responses analysis since the orthogonalized type is sensitive to the ordering of the variable in the system.

Forecast error variance decomposition analysis, meanwhile, refers to the proportion of the movements in a sequence due to its own shock versus shocks to the other variables. The analysis separates the variation in an endogenous variable into the component shocks to the system. The variance decomposition, therefore, provides information about the relative importance of each random innovation in affecting the variables in the system. It determines how much of the s-step ahead forecast error variance of a given variable is explained by innovations to each explanatory variable. To some extent, impulse responses and variance decompositions offer very similar information.

DISCUSSIONS AND ANALYSIS

The ADF tests applied on the series of each of the three sub-sample periods result in that all series contain unit root, meaning that they are non stationary. The examination then continues with determining the appropriate lags length of the series by using the information criteria (LR, AIC, and SC) tests. The tests give some conflicting results. However, as the rule of thumb, one should choose the shortest lags length provided by the tests as long as there is no problem of serial correlation. The appropriate lags length are reported in Table 1

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[5] The Generalized Impulses as described by Pesaran and Shin (1998) constructs an orthogonal set of innovations that does not depend on the VAR ordering. The generalized impulse responses from an innovation to the j-th variable are derived by applying a variable specific Cholesky factor computed with the j-th variable at the top of the Cholesky ordering. Dekker, Sen and Young (2001) found that the generalized approach provided more accurate results than the traditional orthogonalized approach for both impulse response and forecast error variance decomposition analysis.

TABLE 1. Lags Order and Number of Cointegrating Vector Tests

Periods	Lag Order	Number of Cointegrating Vector(s)
1997 crisis	3	2
2002 crisis	2	1
2007 crisis	4	0

Note:the tests based on sequential modified LR test statistic (each test at 5% level)

Considering the number of appropriate lags, the number of cointegrating vectors is tested by using Johansen and Juselius's (1990) Itrace and Imax statistics. In case of there are conflicting results between Imax and Itrace statistic, it is suggested that the Itrace tends to have more power than the Imax because Itrace takes into account all degrees of freedom (n-r) of the smallest eigenvalues, then the number of cointegrating vectors suggested by the Itrace statistic would be employed,. With exclusion of linear trend, Table 1 also presents the test outcomes.

As can be seen in Table 1, all series have cointegrating vector, except the one in the 2007 crisis period. The absence of cointegrating vector on the series of the 2007 crisis, in fact, has implication that the indices would not converge to their long run equilibrium. However, it does not necessarily mean that the dynamic short run interrelations are not possible to exist among the indices. The absence of cointegrating relationship has a consequence that the cointegration analysis framework is not appropriate to examine the series. Instead, the VAR in first difference would be the most suitable measurement.

In contrast, for the series, on which the cointegrating vector does exist, the cointegration analysis would then be properly employed. Table 1 implicitly shows that degree of cointegrating relationship in the first crisis was very high as it contained two cointegrating vectors. This could happen because the 1997 crisis originally emerged in South East Asia region, greatly affected the ASEAN stock markets, as a result of some indifferences in macroeconomic; stock market characteristics; geographical condition of the countries, that most likely had enlarged the contagious effect of the crisis (Eun et al, 1989; King et al, 1990; Pretorius, 2002).

Considering the outcomes of the Johansen Cointegration test, the cointegration analysis would then validly be used to estimate the series of the 1997 and the 2002 crisis periods. The NYSE Composite is treated as the world index in this analysis. Based on t-statistic at the 5% level of significance, Table 2 shows that during the 1997 crisis, all indices, except STI and JAKCOM, had significant influence on the first cointegrating relation. Meanwhile, STI; KLSE; and SET significantly affected the second cointegrating vector. In addition, NYSEALL; STI; JAKCOM; and SET significantly contributed to the long run equilibrium of the observed indices in the second crisis period. The significant contributions of KLSE and PSEI to the cointegrating relation in the previous period, however, vanished during this crisis.

TABLE 2. Estimates of Cointegrating Vector

Cointegrating Equation:	PERIODS		
	1997 crisis		2002 crisis
	CointEq1	CointEq2	CointEq1
NYSEALL	1.000000	0.000000	1.000000
STI	0.000000	1.000000	-0.503147 (0.18572) [-2.70911]
JAKCOM	0.186180 (0.18019) [1.03327]	0.919703 (0.50488) [1.82163]	-0.342422 (0.11381) [-3.00877]
KLSE	1.308215 (0.27975) [4.67629]	2.811024 (0.78387) [3.58609]	0.321668 (0.25670) [1.25307]
SET	-0.543931 (0.24413) [-2.22800]	-3.410506 (0.68406) [-4.98568]	0.162479 (0.05878) [2.76419]
PSEI	-1.394674 (0.22680) [-6.14936]	-0.951992 (0.63549) [-1.49804]	-0.188458 (0.16500) [-1.14218]
C	-4.332850	-3.224246	-4.570477

Note: cointegration with unrestricted intercepts and no trends in CE and VAR.
Standard errors in ( ) & t-statistics in [ ], level of significance 5%

Table 3 presents the speed of adjustment coefficients of the error correction term (α_i) that have important implications for the dynamics of the system. A negative value of the significant speed of adjustment would indicate a downward long run adjustment, while the positive one implies an upward long run adjustment.

During the 1997 crisis, the speed of adjustment coefficients for the first cointegrating vector for NYSEALL; JAKCOMP; and KLSE are statistically zero. This means that the first cointegrating vector had no contribution to the convergence of those indices to their long run path, although NYSEALL and KLSE had significant contribution to the first cointegrating vector. In contrast, STI would positively react to a disequilibrium among the other indices. For the second cointegrating vector, the speeds of adjustment coefficients for all ASEAN-5 indices are statistically significant showing that the cointegrating vector had significant contribution to the convergence of the indices to their long run equilibrium.

In the 2002 crisis, all of the ASEAN indices still preserved their significant speed of adjustment coefficients, except for KLSE and PSEI. The cointegrating vector, meanwhile, did not seem to have significant influence on the convergence of NYSEALL to its long run equilibrium as the speed of adjustment coefficient for NYSEALL was statistically insignificant during the period.

TABLE 3. Speed of Adjustment Parameter of the Error Correction Term

Error Correction:	NYSEALL	STI	JAKCOM	KLSE	LNSET	PSEI
1997 crisis						
ecm1(a1)	-0.001414 (0.00742) [-0.19072]	0.033795 (0.01286) [2.62792]	0.011531 (0.01721) [0.66991]	-0.001078 (0.02040) [-0.05283]	0.055495 (0.01650) [3.36353]	0.057323 (0.01329) [4.31277]
ecm2 (a2)	-7.78E-05 (0.00261) [-0.02981]	-0.014345 (0.00452) [-3.17061]	-0.016303 (0.00606) [-2.69228]	-0.019001 (0.00718) [-2.64725]	-0.014772 (0.00580) [-2.54486]	-0.022338 (0.00468) [-4.77702]
2002 crisis						
ecm3 (a4)	-0.013544 (0.01743) [-0.77690]	0.041917 (0.01587) [2.64118]	0.086862 (0.01770) [4.90725]	0.016842 (0.00993) [1.69635]	0.047704 (0.01623) [2.93950]	0.024071 (0.01425) [1.68957]

Note : 5% Level of significance, Standard errors in ( ) & t-statistics in [ ]

As it was discussed in the previous section, a VECM does not seem to be appropriate for estimating the series of the 2007 crisis, since there is no cointegrating vector could be found. To overcome this circumstance, it is commonly suggested that a VAR analysis in first difference would be the correct specification to examine the series. The VAR analysis, however, requires that all variable must be stationary. Therefore, it is necessary to change the non stationary variable into the stationary one by differencing process. Following the alteration, re-identifying the appropriate lag length is a must. Three lags length is then found to be the most suitable lags length to analyze the series using the VAR in first difference[6].

After estimating the series using the correct approaches, the analysis will be continued to search the existence of granger causality among the indices for each of sub sample period. The objective is to examine whether the lags of one variable (y_1) enter into the equation for another variable (y_2)

Because the cointegrating relation does not always appear in all sub sample periods, it is necessary to conduct the Pairwise Granger Causality on its both different approaches. For the series containing cointegrating vector, the Pairwase Granger Causality based on Vector Error Correction (VEC) test is employed. Alternatively, the Pairwise Granger Causality based on VAR will test the series without cointegrating vector.

Table 4 shows that NYSEALL was the only stock index that significantly granger caused all the ASEAN-5 indices during the three crises. It suggests that changes or movements in the ASEAN-5 indices appeared to lags those of NYSEALL. On the other hand, none of the ASEAN indices, except KLSE and JAKCOM during the 2007 crisis, significantly granger caused NYSEALL. Thus, the past values of those indices were unable to forecast the present value of NYSEALL accurately. In the ASEAN-5's standpoint, only JAKCOM (in both the 1997 crisis and the 2002 crisis) and PSEI (in the 1997 crisis) significantly granger caused the other ASEAN indices.

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[6] Please contact the author for the VAR in first difference calculation result.

Interestingly, in the 2007 crisis, the number of block causality occurred on the series was almost twice as many as those in the previous periods. This outcome provides evidence that the short run interactions among the observed indices seemed to be more intense during the latest period of crisis.

TABLE 4. Pairwise Granger Causality/Block Exogeneity Wald Tests

Dependent variable	Exclude	Jul 1997 – Mar 1999 (df 3)*		Mar 2002 – Dec 2003 (df 2)*		Jul 2007 – Jun 2009 (df 3) #	
		Chi-sq	Prob.	Chi-sq	Prob.	Chi-sq	Prob.
NYSEALL	STI	2.614057	0.4550	0.259004	0.8785	7.008255	0.0716
	JAKCOM	4.110158	0.2498	1.418158	0.4921	13.66118	0.0034
	KLSE	5.374683	0.1463	2.997849	0.2234	16.87942	0.0007
	SET	6.061856	0.1086	4.742836	0.0933	4.098122	0.2511
	PSEI	1.172762	0.7595	3.679920	0.1588	0.371651	0.9460
STI	NYSEALL	56.86908	0.0000	24.27098	0.0000	121.9620	0.0000
	JAKCOM	7.067365	0.0698	8.003272	0.0183	2.471488	0.4805
	KLSE	5.904097	0.1164	0.741172	0.6903	12.96837	0.0047
	SET	6.950347	0.0735	0.841263	0.6566	15.64265	0.0013
	PSEI	11.17655	0.0108	1.890638	0.3886	1.140004	0.7674
JAKCOM	NYSEALL	34.67810	0.0000	12.50674	0.0019	68.24393	0.0000
	STI	6.337616	0.0963	5.084310	0.0787	3.933439	0.2687
	KLSE	1.968028	0.5791	0.775022	0.6787	6.005274	0.1114
	SET	4.271720	0.2336	2.255533	0.3238	2.755744	0.4308
	PSEI	1.882381	0.5972	4.978605	0.0830	0.564257	0.9046
KLSE	NYSEALL	36.75879	0.0000	38.06731	0.0000	84.53254	0.0000
	STI	5.044251	0.1686	3.302697	0.1918	0.742099	0.8633
	JAKCOM	14.96232	0.0018	0.750906	0.6870	17.60023	0.0005
	SET	0.303004	0.9595	0.084195	0.9588	7.050857	0.0703
	PSEI	2.274629	0.5174	0.173394	0.9170	4.619372	0.2019
SET	NYSEALL	20.70345	0.0001	21.95185	0.0000	78.32838	0.0000
	STI	4.482087	0.2139	0.637977	0.7269	6.313837	0.0973
	JAKCOM	6.402052	0.0936	0.110408	0.9463	16.09597	0.0011
	KLSE	1.720465	0.6324	3.403435	0.1824	17.00103	0.0007
	PSEI	0.613935	0.8932	0.972966	0.6148	2.451477	0.4841
PSEI	NYSEALL	53.92290	0.0000	21.18853	0.0000	239.5704	0.0000
	STI	5.037041	0.1691	0.917941	0.6319	2.662475	0.4466
	JAKCOM	9.208058	0.0266	3.819756	0.1481	12.86560	0.0049
	KLSE	3.041454	0.3853	1.547243	0.4613	4.420627	0.2195
	SET	2.726896	0.4357	3.543533	0.1700	4.515097	0.2109

Note :

* Pairwise Granger Causality based on VEC

Pairwise Granger Causality based on VAR

The results of the generalized impulse responses analyses[7] indicate that SET and STI had played significant roles to the movements of the other indices during the 1997 crisis. A shock to SET, where the crisis initially occurred, would result in the second greatest contemporaneous response of STI, JAKCOM, and KLSE after their own shock. Meanwhile, a shock to STI would be reacted by NYSEALL, SET, and PSEI.

After its own shock, a shock to STI would result in the second largest contemporaneous response of NYSEALL and all ASEAN-5 indices during the 2002 crisis. This may imply that Singaporean stock exchange had still played dominant role in the ASEAN stock markets at that time. Meanwhile, responses of the ASEAN indices to a shock to NYSEALL were lower during the period compared to those before, although NYSEALL showed its dominance among the observed indices in a period later. A shock to NYSEALL had larger impact on all ASEAN indices movements, while NYSEALL gave a very little or even no reaction to a shock to the ASEAN-5 indices in the period. Interestingly, STI's response to a shock to NYSEALL was greater than its own shock. Thus, in general, an immediate response of an index to a shock to another increased during the 2007 crisis, even though the responses would, in fact, fade away quicker than those before.

While impulse response function traces the effect of a shock to one endogenous variable on to the other variables in the system, the variance decomposition separates the variation in an endogenous variable into the component shocks to the system. The forecast error variance decomposition, thus, tells the proportion of the movements in a sequence due to its own shock versus shock to the other variable. This implies that a shock to the *i*-th variable will not only affect that variable, but can also be transmitted to all other variables in the system.

The results of the forecast error variance decompositions for the six share indices[8] reveal that, in general, the highest percentage of the variance decomposition for an index was caused by its domestic shocks. Moreover, the results also show that there was no specific trend on the value along the sample periods.

The second largest percentage values of the forecast error variance for most ASEAN indices were due to an innovation in STI during the 1997 crisis. In contrast, the movements of STI were largely influenced by the innovation in NYSEALL. During the 2002 crisis, an innovation in STI was accounted for the second largest proportion of the error variance for the ASEAN stock indices' movements, except for the PSEI, after their own shocks. However, the values of the forecast error variance of STI were somewhat lower during this period compared to those before.

The proportions of the movements of the indices due to a shock to NYSEALL and STI rocketed during the 2007 crisis. NYSEALL greatly influenced STI, SET, and PSEI movements. Meanwhile, STI had more influence than NYSEALL on JAKCOM and KLSE movements. The higher values of this forecast error variance during the latest crisis compared to those before indicate the higher degree of short run interdependence among the indices. In general, it may be concluded that the influence of an index to the movement in another increased during the 2007 crisis, while the percentage value of the error variance attributable to own shocks generally declined.

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[7] Please contact the author for this information.

[8] Please contact the author for this information.

CONCLUSION

The study finds two cointegrating vectors on the series of the 1997 crisis, and one cointegrating vector on the series of the 2002 crisis. This implies that the stock markets were integrated and had long run equilibrium in the both periods. The VECM estimation results show that most indices had significant contribution to the cointegrating relationship during the both crises. However, the study also detects no indication of cointegrating relationship on the indices during the 2007 crisis. These findings prove that the US and the ASEAN-5 stock markets integration had been removed by the latest crisis, and confirm that stock market interdependence is unstable and tend to change overtime.

The block causality tests reveal that more significant causal linkages were discovered during the 2007 crisis period compared to those before. The tests together with accounting innovation analysis results give evidences that STI apparently had more explanatory power to the other ASEAN indices' movements during the 1997 crisis, while NYSEALL had played dominant role in the 2007 crisis. These outcomes also clarify that the short run dynamic interactions among the indices seem to be more intense during the latest period of crisis.

The general conclusion that may be withdrawn from this study is that the effects of the 1997 and the 2002 crisis had influenced the six stock market prices' movements both in the short run and in the long run. Meanwhile, the contagious effect of the 2007 crisis had greatly affected the six indices' movements in the short run, but not in the long run periods. The latest crisis had removed the cointegrating relationship of the stock markets.

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