Stock market comovement among the ASEAN-5 : a causality analysis

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Abstract

This paper investigates the linkages between stock markets by applying the co-integration framework developed by Engle and Granger (1987) on weekly data beginning in the new millennium on a system of five ASEAN stock price indices, namely Singapore, Malaysia, Indonesia, Thailand and the Philippines. Given the new challenges in the new millennium, like political instability as well as the ability to cope with recurring and increasingly devastating natural disasters within the region, the study re-examined the co-integration trend between the ASEAN-5 markets. This study differs from other studies by incorporating the effects from the 2013 Typhoon Haiyan (known as Typhoon Yolanda in the Philippines) that ravaged 4 countries (Micronesia, Southern China, Philippines and Vietnam) and caused an estimated US$1.5 billion in damages, by implementing time series techniques including Johansen test for co-integration followed by the vector error correction and variance decomposition method which determines the exogeneity and endogeneity of the stock markets. The study finds that all ASEAN-5 stock market remains co-integrated with the stock markets of its neighbours including Philippines that experienced the 2013 typhoon. From an investment standpoint, findings imply that the long-run diversification benefits that can be earned by investors in the ASEAN region tend to diminish over time. Therefore, it is in the onus of the policy makers of ASEAN-5 nations and its other neighbours to work together to develop pre-emptive action plans and policies, as well as early warning disaster systems to mitigate the impact of natural disasters that will cause market fluctuations and exposures to regional market and environmental risks.

Key words: ASEAN market integration, Co-integration, Granger causality, Stock markets, Typhoon Haiyan

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1. Introduction: Objective and Motivation

ASEAN integration will foster cooperation among ASEAN member countries in terms of economics, environmental, social cohesion and regional security, by enhancing self-management capabilities and promoting regional competitiveness under the ASEAN Economic Community or AEC2015 initiative. This could make ASEAN a self-sufficient competitive block which allows the creation of a regional supply chain. Instead of the member countries competing against each other, more opportunities could be derived by leveraging on specialization and creating economies of scale. It is noted that the region has made significant progress in reducing tariff barriers. The result of this has been greater intra-regional trade between member countries having tripled to more than US$400billion over the last 10 years.

With an economy worth more than US$2 trillion as of last year, ASEAN is collectively the third-largest economy in Asia after China and Japan. Southeast Asian finance ministers predicted the region's economies will expand more quickly soon than the previous year, and pledged vigilance against sharp movements in capital flows. They predicted GDP growth for the region as a whole at between 5.6% and 6.3% for this year, compared with 4.5% previous year.. Downside risks to the region include weak global demand, tight liquidity, rising oil prices and volatile capital flows.

By developing a single market and regional competitiveness with respect to China and India, it will ensure ASEAN and its 10 members, economic sustainability and independence. So instead of a market of 5 million in Singapore alone, Singapore-based businesses are able to reach to the 600 million market size of ASEAN.

From here, there is an aspect that concerns investors around the world and that is the co-movement or co-integration happening among various stock markets. The reason being is that one of the fundamental tenets of investing is holding a diversified portfolio or securities with the goal to reduce one exposure's to risk. Generally, fund managers have always been on the go to look out for portfolios that do not correlate together to provide better opportunities to hedge risk. Although the increasing mobility of capital flows indicate that the all nations are moving towards a more financially and integrated world that intuitively tells us that a more efficient global financial sphere would arise, it may also mean that stock markets will impede themselves from exhibiting independent price behaviour but rather be more interdependent among each other (Khan 2011). The increasing interdependency among the stock markets suggests that stock markets move together with high correlations and subsequently make it impossible for the investors to reap benefits of the cross borders diversification. The benefits of diversification can then be only maximised if the stock markets exhibit low correlations of price behaviour (Karim et. al 2009). This situation is in line with the international portfolio diversification theories. It is then essential for portfolio managers to examine the dependencies among regional stock markets.

Due to major shocks from the financial world, namely the market crash of October 1987, the 1997 the Asian Financial Crisis and most recently the global financial crisis in 2008, ASEAN finance officials and the heads of regional central banks are naturally concerned with the possibility of economic crisis and are working out potential means of managing the risks cascading to the Southeast Asian economies. One of the steps that the officials have taken is that of doubling a regional crisis fund to US$240 billion known as the Chiang Mai Initiative Multilateralisation[1] (CMIM). Protection from the US and European economic crisis – which threatens many regional exporters exposed to the West – would come in the form of integrated finance among member states and boosted access to emergency funds and make it less reliant solely on the International Monetary Fund, officials from several Southeast Asian countries said.

For ASEAN to become capable to stand up competitively to the giants of China and India instead of being crushed by them, it is imperative that ASEAN continue to make significant strides in other areas of cooperation. One of those areas concerns the environment and the crises of natural disasters. The huge effect of these natural disasters can and have been transmitted through interconnected networks that include trade markets, logistics and production chains, both in ASEAN and in its neighbours. The tragic destruction caused by Typhoon Haiyan will directly impact the economic performance of the Philippines as the damage to infrastructure, cities and livelihoods limits economic expansion towards the end of this year. The other ASEAN economies are closely integrated with the Philippines' and are hence also expected to suffer losses cascading from the event. The significant disparities in economic performance remain embedded within the eurozone (EU). For example, although the latest survey data suggest increasing manufacturing output overall in the region, they also indicate that the

[1] The ASEAN+3 (ASEAN, China, Japan, Korea) Macroeconomic Research Office (AMRO) is an independent regional surveillance unit which monitors and analyses regional economies to support CMIM decision-making, and envisioned to work jointly and smoothly with the IMF.

manufacturing sector in France is still shrinking. Shrinking output from the EU impacts demand for exports from ASEAN, which is one of its key trading partners. Hence it is becoming more and more evident that as manufacturing shifts to Asia, ASEAN member nations continue to show value and gain ground as production bases, and increase trade amongst themselves to replace dwindling demand from its traditional key trade partners. Therefore, ASEAN's interconnectivity in economy and the stock market as well as its resilience, response and management of crises owing to natural disasters are vital to its future.

In recent studies, Yang et al. (2003), Majid et al. (2008) and Oh et al. (2010) reveal that the ASEAN stock markets are going towards a greater integration among themselves particularly in the post-1997 financial crisis. Other studies, namely Yusof and Majid (2006) and Karim and Majid (2009) found that Japan is more important than the U.S. over the ASEAN markets. In contrast, in a more recent study, Karim et al. (2010) document evidence that the Islamic stock markets in the region provide opportunity for the potential benefits from international portfolio diversification, even after the subprime crisis. This paper tries to fill a gap that previous studies had not been able to fill which is looking at the five major ASEAN markets to understand its relative integration as it strives towards AEC2015 market integration in the years of the new millennium till present. As such it is imperative that the effects of external shocks like natural disasters be analyzed for the benefit of portfolio managers and policy-makers.

The structure of this paper includes five sections which are organized as follows. This first chapter introduces the study, its objectives together with the issues motivating the study. Section 2 gives an overview of the theoretical framework related to the issues in this paper while Section 3 reviews the literature on previous empirical research and analysis. Section 4 describes the statistical data and elaborates on the methodology applied, followed by Section 5 which discusses the empirical findings and interprets the results. Sections 6 and 7 gives a summary about the paper and discusses about the policy implications that can be derived from the results, respectively. Lastly, Section 8 talks about the limitations of the study and suggestions for further research.

2. Theoretical Framework

Study by Hassapis and Kalyvitis (2002) found output growth responds significantly to unanticipated changes in domestic and foreign stock returns. It would be crucial for the financial institution and policy makers to understand how shocks are transmitted across markets. Stock markets are found to react differently to good and bad news and a negative shock to one country could have a negative impact to other neighbouring countries such as the 1997 financial crisis. Using weekly and monthly data from January 1988 to February 1999, Manning (2002) found convergence of the South-East Asian equity markets from 1992 to mid-1997 and divergence occurring during the financial crisis. It would be beneficial to examine if there are signs of converging or increased correlation among stock markets in the region after the financial crisis using more recent data sampled at different frequency. This is particularly important as estimates of correlation coefficients tend to increase and may be biased upward during the crisis when markets are more volatile. Although there are advantages coming from integrated regional stock markets, it must be noted that a long run equilibrium is exhibited by the integration among stock markets which ties prices movements in national stock indices and could considerably reduce benefits from international portfolio diversification. Even international portfolio diversification theory state that if stock markets are interlinked, the long-run benefit of diversification for international investors is diminished and therefore intensifies the need for this paper to examine the dependencies among regional stock markets (Ali et. al 2011).

3. Literature Review

Early studies of stock market interdependences date back to the early seventies. Authors such as Granger and Morgenstern (1970), Ripley (1973) or Panto et al. (1976) investigated short-run linkages using correlation analysis. With the emergence of the co-integration framework first suggested by Granger (1981) and consequently developed by Granger and Weiss (1983) and Engle and Granger (1987), the methodology of stock market linkages improved. Along with the Autoregressive Conditional Heteroskedasticity (ARCH) approach developed by Engle (1982) and extended by Bollerslev (1986), co-integration has now become the main tool in analysing the relationship between stock markets. Further methodological improvements by Johansen (1988, 1991) eased the treatment of multivariate co-integration and provided a unified approach to estimation and testing.

Kasa (1992) first used Johansen's co-integration test to study the linkages of stock markets. Using a long VAR specification, the author finds strong evidence for a single common trend in the markets of the US, Japan, Germany, Britain and Canada for the period 1974-1990. Corhay et al. (1993) investigate European stock markets between 1975-1991 and also provide empirical evidence for long-run equilibria. In a broader study of 16 markets, Blackman et al. (1994) find co-integration relationships for the 1980s. However, the study by Koop (1994) using Bayesian methods rejects a common stochastic trend between the stock markets of the five aforementioned countries. Fu and Pagani (2010) revisit Kasa's (1992) result and use more accurate small sample corrections on the same data. Though the evidence for co-integration is weaker than in the original paper, the authors still find a co-integration relationship.

The focus of stock market co-integration studies subsequently shifted from more established to the emerging markets especially those of Asia. The rise of East and Southeast Asian stock markets due to financial deregulation in the early 1990s gave way to numerous studies of Asia's newly industrialized countries (NIC). Masih and Masih (1997) investigate the linkages of Taiwan, Hong Kong, Singapore and South Korea with the mature markets of Japan, USA, the UK and Germany and find evidence for a co-integration relationship. Maysami and Koh (2000) observe a co-integration relationship between the markets of Singapore, Japan and the US. The results of Sheng and Tu (2000) in contrast do not suggest a statistically significant co-integration vector for Asian stock markets. Other studies on emerging markets include Chen et al. (2000) find evidence for co-integration among a system of six Latin American markets. Yang, Kolari and Min (2002) investigated the Asian financial crisis and find evidence for changing degrees of co-integration. Estimating the vector error correction for different periods, they find that the markets move closer together in the post-crisis period. Wong et al. (2004) also conclude that market linkages in Asia intensified with the crisis of 1997. Lim (2007) concurs with these results for the ASEAN countries. The analysis of stock market linkages improved with further methodological achievements. Gregory and Hansen (1996) developed a residual-based test for co-integration when a single structural break is present in the data. Applications of this method on the issue of stock market co-integration are for example Siklos and Ng (2001) who nd that the 1987 stock market crash and the Second Gulf War (1991) were significant break points in the co-integration relationship. Fernandez and Sosvilla (2001) are unable to find co-integration between Asian markets using conventional tests, but find long-run relationships for some countries when accounting for a structural break. Voronkova (2004) finds extensive previously undetected linkages of Central European stock markets with their mature counterparts in Europe and the US using the Gregory and Hansen co-integration test.

In addition, Ng (2002) noted that this might be due to geographic proximity and close relationship between the markets. Apart from that, Janakiramanan and Lamba (1998) provided empirical evidence that the geographically and economically close countries should exhibit higher levels of market integration. In addition, we should note that Association of Southeast Asian Nations (ASEAN) aims to remove trade barriers among its member countries. Taylor and Tonks (1989) noted that a stronger financial integration would be expected among countries that reduce trade barriers and develop stronger economic ties.

Another study, Azman-Saini et al. (2002) empirically examined the financial integration among the ASEAN-5 equity markets. Employing the Toda and Yamamoto's (1995) approach of Granger non-causality test and weekly data from January 1988 to August 1999, he found the dominance of Singapore market in the region. In addition, with the exception of Malaysia, the Indonesian market is affected by other ASEAN markets but does not significantly influence the other markets. Using daily data over the period of January 1992 to August 2002, Chen et al. (2003) found that the ASEAN-5 stock markets are integrated before and after the crisis but not during the crisis. The results are consistent with Click and Plummer (2005) who also found that the markets were integrated. Ibrahim (2005) investigated integration among the ASEAN markets from the perspective of the Indonesian market using co-integration techniques and vector auto regression (VAR) for the periods of January 1988 to December 2003. However, he found evidence for lack of integration among the ASEAN markets. In recent studies, Yang et al. (2003), Majid et al. (2008) and Oh et al. (2010) reveal that the ASEAN stock markets are going towards a greater integration among themselves particularly in the post-1997 financial crisis. As the results reported in the previous studies were mixed, this topic is thus still open for further examination. Unlike previous studies, we re-visit the issue of stock market integration among ASEAN-5 (Malaysia, Indonesia, the Philippines, Singapore and Thailand) utilizing recent and larger weekly data from the new millennium onwards.

4. Data and Methodology

This research employs a time series technique including co-integration, long run structural modelling, error correction modelling and variance decomposition. These tests help this study to find theoretical relationships among variables; stock markets, exchange rates, interest rates and industrial productions. The reasons why we prefer to use a time series other than a regression model are as follows;

Firstly, the time-series techniques based on co-integration with vector error correction model and variance decomposition methods for testing granger causality of relationships among variables. It means that co-integration techniques does not assume theory and causality before it is proven by the data. On the other hand, in a regression model, the endogeneity and exogeneity of variables are predetermined by the researcher based on theories.

Secondly, when we test finance variables, generally the results could be statistically invalid because of the non-stationarity of variables. Using time series techniques, we can solve this problem by transforming variables to I(1) form with the differenced form of variables. However, traditional regression models assume that all variables are stationary. This assumption is not realistic in real markets, and the results could possibly mislead the conclusion as the statistical tests are not statistically valid when non-stationary variables are applied.

In this study, the data used are weekly stock indices spanning from April 2001 to April 2014. The reason for this beginning from 2001 is to focus solely on the co-integration effects of the new millennium for ASEAN. Weekly data is employed rather than higher daily frequency data in order to deter the situations of non-synchronous data since daily data captures with it unwanted noise which may lead to an flawed deduction of the lead-lags relationship among the variables. Furthermore, the transmission of shocks may take place within a few days and thus, monthly data is not employed in this study as it cannot fully capture the transmission of the intense short-duration shocks (Karim et. al 2010). The following indices are used to represent the markets : the Kuala Lumpur Composite Index (KLCI) for Malaysia, the Philippines Stock Exchange (PSX), the Bursa Indonesia (IDX), the Stock Exchange of Thailand (SET) and the Singapore Stock Exchange (SGX). All indices are have been extracted from the Data Stream database, and there were 678 observations in this study. Another important aspect to our data is that a dummy variable was introduced to represent the duration effects of the typhoon Haiyan in the Philippines (denoted as DUM) from 4 November 2013 to 25 November 2013. The duration was selected in order to capture its initial effects, and the immediate aftermath of the typhoon. According to the Joint Typhoon Warning Centre (JTWC), the typhoon formed on 3 November and dissipated on the 11 November, and its peak intensity was on the 7th November, originating from an area of low pressure several hundred kilometres east-southeast of Pohnpei in the Federated States of Micronesia on November 2, and eventually moving north-westward striking northern Vietnam as a severe tropical storm on November 10.

In terms of the methodology applied, it has almost become a standard procedure aided by standard software packages that any regression analysis should not begin by mechanical means but by testing the stationary and co-integration properties. It has also been well established that most economic/financial time series are non-stationary in their original level form. If the variable are non-stationary, the co-relational statistical test such as the R square and t-test statistics are invalid. But if the variables are non-stationary but co-integrated, the ordinary regression without the error-correction term derived from the co-integrating equation will be mis-specified. However, an ordinary regression within "differenced variables" (which are stationary) can be estimated if the variables are non-stationary but co-integrated. The conclusions that are drawn from such an analysis will be valid only in the short run and no conclusions can be made in the long run regarding the variables studied since the theory has typically nothing to say about the short run relationship, The reason being is that the 'differenced' time series variables do not contain any information about the long-run relationship between the trend components of the original series since this long-run trend has been removed implying that long-run co-movement between the variables cannot be captured by differenced variables.

On the other hand, if the variables are taken in their 'non-stationary' form at their original level forms, the conventional statistical tests are not valid because the variances are changing and the estimated relationship will be 'untrue'. In contrast to that, if the variables taken are transformed into their stationary form through 'first-differencing' the long term trend contained in each variable has been removed causing the relationship estimated to only give the short-run relationship between the variables and regression then does not test any theory.

Therefore, the regression analysis that has been applied for many years in time-series studies is now considered to have either estimated a untrue relationship (if the original 'level' form of the variables was non-stationary) or estimated a short-run relationship (if the variables were differenced to make the original variables stationary). This detrimental limitation of the traditional regression analysis has been addressed by the recent and on-going co-integration time series techniques with significant contributions made by time-series co-integration techniques starting with the publication of the influential paper by Engle and Granger (1987) which are now well recognised. Although the recent time series techniques have a limitation whereby the error correction and variance decomposition are based on estimates of the co-integrating vectors which are atheoretical[2] in nature, this problem has been solved by the long-run structural modelling technique which estimates theoretically the meaningful long run relations by imposing on those long run relations and then testing both exact-identifying and over-identifying restrictions based in theories and a priori information of the economies (Masih and Algahtani 2008).

In short, by using this developed time series techniques, this study will try to find out whether the stock market of Singapore moves together with the stock markets of its major Asian trading partners (China, Japan and Malaysia) through the Johansen Co-integration tests after examining the unit root tests and order of vector auto regression. The co-integrating estimated vectors will then be subjected to exact and over identification restrictions based on a priori information of the economy. The test of the vector error correction model (VECM) will then indicate the causal relationship between the co-integrating stock markets. In addition to that, the variance decomposition would determine the relative exogeneity and endogeneity of each variable. Next, the impulse response function will then map out the dynamic response path of a variable to a one period standard deviation shock to another variable. Finally, the persistence profile step would estimate the speed with which the stock markets get back to equilibrium when there is a system wide shock.

5. Results and Analysis

In this section of this paper, the eight steps of the time series techniques were carried out and the empirical results obtained consequently explained and analyzed in detail.

5.1 Stationarity test

To test the unit roots of all the variables, we conducted both the Augmented Dickey-Fuller (ADF) test and the Phillips-Perron (PP) Test. For the first stage, we tested whether these variables are I(1) which non-stationary in their level form and stationary in their differenced form. The empirical testing is started with the ADF test to test the stationarity of the variables in order to avoid the untrue regression (Karim and Karim 2008). The differenced form for stock indices are determined by taking a difference of their log level forms [e.g. DPSX = ($LPSX_t$ - $LPSX_{t-1}$) x 100]. The results of the ADF test show that all indices became stationary after first differencing since they are able to reject the null hypothesis of non-stationarity since the test

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[2] not based on or concerned with theory

statistics of the differenced variables are more than the 95% critical value.

The results as shown below in table 1, determine that all the variables used for this study are I(1). The results were obtained by comparing test statistics with the 95% critical value for the ADF statistic. We chose the test statistics for each variable based on the highest computed value of AIC and SBC. In our case, the AIC and SBC gave different orders, and we determined the highest t-stat values as the measure against the critical value.

Table 1. Stationary test results

Variables in level form			
Variable	**Critical value**	**Test statistics**	**Results**
LNKLCI	-3.4186	-2.7517	Non-stationary
LNPSX		-2.1954	Non-stationary
LNIDX		-2.5373	Non-stationary
LNSET		-2.0768	Non-stationary
LNSGX		-1.9766	Non-stationary
Variables in differenced form			
DKLCI	-2.8662	-8.8563	Stationary
DPSX		-9.6596	Stationary
DIDX		-8.6010	Stationary
DSET		-9.5085	Stationary
DSGX		-8.4146	Stationary

In addition to the ADF test, the PP test was used as an alternative non-parametric model to control for serial correlation. Using the PP test ensures that the higher order serial correlations in the ADF equation were handled properly (Valadkhani and Chancharat 2007). In the PP test, the null hypothesis is 'the variable is non-stationary', and we can reject the null when the p-value of the test result is smaller than the selected significance level. We set the critical value here as 1%. This means the p-values of log level form should be greater than 0.01; the p-values of differenced form should be smaller than 0.01. As tested all the variables, we were able to get the results that all our variables are I(1). For detailed results, please refer Appendix 1C and 1D.

Variables in level form			
Variable	**p-value**	**5% sig. lvl.**	**1% sig. lvl.**
LNKLCI	0.208	Non-stationary	Non-stationary
LNPSX	0.546	Non-stationary	Non-stationary
LNIDX	0.182	Non-stationary	Non-stationary

LNSET	0.104	Non-stationary	Non-stationary
LNSGX	0.166	Non-stationary	Non-stationary
Variables in differenced form			
DKLCI	0.000	Stationary	Stationary
DPSX	0.000	Stationary	Stationary
DIDX	0.000	Stationary	Stationary
DSET	0.000	Stationary	Stationary
DSGX	0.000	Stationary	Stationary

5.2. Determination of Order of the VAR

Prior to doing co-integration test, we needed to determine order of the VAR which determines the number lags that needs to be used in this study. In VAR test, the results gave us AIC(2) and SBC(1). This presents an ideal situation (between 2 to 3) where we choose the VAR lags to be 2. In cases where AIC is zero (or even 1), serial correlation would be an issue, and would result in the Microfit software to not give full results for the vector error correction model whereby Microfit will only give the error correction term. However, if higher lags are chosen, the result possibly will incur over-parameterisation[3] risks. It is possible that in our case, the set of data used as well as the long time series (678 observations) have helped us to be within an ideal range.

5.3. Co-integration test

Upon establishing that all the variables are I(1) and determining that the optimal order of VAR is 2, the study can proceed to test for co-integration. There are two type of tests for co-integration which is the Johansen and the Engle-Granger test.

<u>JOHANSEN TEST FOR CO-INTEGRATION</u>

In Johansen co-integration test with 2 lags, it was found that the trace statistic and HQC indicated that there is one co-integrating vector whereas the Maximal Eigen value and SBC shows zero co-integrating vectors, while the AIC shows 3 co-integrating vectors (refer to the

[3] A demonstration of over-parameterization is to put some points on an x-y plot, then fit a series of polynomials with more and more terms to those points. It becomes obvious that too many terms actually make prediction of a new point (especially one extrapolated outside the range of the current points) worse, not better.

tables below and see appendix 3A).

Table 2. Co-integration test result

Null	Alternative	Statistic	95% critical value	90% critical value
Maximum Eigenvalue				
r=0	r=1	38.7229	37.8600	35.0400
r≤1	r=2	21.7274	31.7900	29.1300
Trace Statistic				
r=0	r≥1	86.9851	87.1700	82.8800
r≤1	r≥2	48.2622	63.0000	59.1600

Table 3. Co-integration test result

Criteria	No. of co-integrating vectors
Maximal Eigen value	1
Trace	1
AIC	3
SBC	4
HQC	1

ENGLE-GRANGER FOR CO-INTEGRATION

Next, the Engel-Granger test was carried out to test of the results were consistent with the Johansen method. In the Engel-Granger test, we assumed an OLS regression based on theories and empirical studies; 'LKLCI = α + β_1 LNPSX + β_2 LNIDX + β_3 LNSET + β_4 LNSGX + e_t'. Again, we found one co-integration from E-G test as in Johansen test as table 3 above[4].

Table 4. Engel-Granger test result

	Test statistics	DF critical value at 95%
AIC	-4.4317	-3.4186
SBC	-4.1648	

Based on both Johansen and Engel-Granger co-integration test, evidence of co-integration implies that there is a theoretical relationship among stock indices of ASEAN 5 nations. It means that they affect each other, and are in equilibrium in the long term. It implies that each stock market contains information for the prediction of others and will have implication for

[4] The result was made by comparing test statistics of the highest value of AIC and SBC with DF critical value at 95%. In this result, we assume that there is one cointegration among variables based on SBC value (-4.91) which is greater than DF critical value (-4.14).

portfolio diversification by the investors since the possibility of gaining abnormal profits in the long term through diversifying investment portfolio is limited within co-integrated markets (Meera et. al 2009). Next, we will find long run relationships among our variables with the long run structural model (LRSM).

5.4. Long Run Structural Modelling (LRSM)

Using the Long Run Structural Modelling (LRSM), we can quantify the theoretical information among variables through estimating theoretically the meaningful long-run relations by imposing on those long run relations and then testing both exact-identifying and over-identifying restrictions based on theories and a priori information of economies (Masih et. al 2010). First, we applied a normalising restriction of PSX at the exact-identifying stage, obtained the results as below (Panel A of table 6).

Table 5. Exact and over-identifying restrictions on the co-integrating vector

Variables	Panel A	Panel B	Panel C	Panel D
PSX	1.0000 (*NONE*)	1.0000 (*NONE*)	1.0000 (*NONE*)	1.0000 (*NONE*)
KLCI	-0.27610 (0.15413)	-0.0000 (*NONE*)	-0.44768 (0.14903)	-0.0000 (*NONE*)
IDX	0.65608 (0.30964)	0.83764 (0.43627)	0.69992 (0.38431)	0.83764 (0.43627)
SET	-0.14277 (0.093510)	-0.26785 (0.095888)	-0.0000 (*NONE*)	-0.0000 (*NONE*)
SGX	-0.93399 (0.32739)	-1.2536 (0.46284)	-0.95791 (0.40023)	-1.2536 (0.46284)
Trend	-0.0020734 (0 .8234E-3)	-0.0029785 (0.0011468)	-0.0020080 (0 .9720E-3)	-0.0029785 (0 .0011468)
Chi-Square	None	2.7930 [0.095]	2.1209 [.145]	3.024 [0.062]

Note: The output above shows the maximum likelihood estimates subject to exactly identifying (Panel A) and over-identifying (Panel B, C, D) restrictions.

By calculating the t-ratios manually, we found that only PSX, IDX and SGX were significant, while other variables such as KLCI and SET were insignificant. These results were surprising since we already found theoretical relationships in earlier stages. Therefore, we decided to verify the significance of these variables by doing over-identifying restrictions.

Table 6: Significance of variable at exact identification

Variable	T-ratio	Implication
PSX	-	-
KLCI	1.791345	Insignificant

IDX	-2.11885	Significant
SET	1.526789	Insignificant
SGX	2.852836	Significant

When we imposed the over-identifying restrictions of KLCI, the null hypothesis 'KLCI was insignificant' was rejected. It means that the restriction was incorrect, in other words, KLCI was significant (Panel B of table 5). On the contrary, when we made the over-identifying restrictions for SET, we were not able to reject the null hypothesis (Panel C of table 5), it means that SET was still insignificant.

Despite the fact that SET remained insignificant even after over-identifying them, we will still proceed with Panel A since by intuition, we strongly believe that SET cannot be economically ignored in this study as it will deter this study from achieving its main objective. Furthermore, the reason for proceeding with panel A is further strengthened by the findings of Lim (2007) showing that stock markets of Malaysia, Philippines, Indonesia, Thailand and Singapore are significant towards each other.

From the above analysis, we arrive at the following co-integrating equation (numbers in parentheses are standard errors).

$$\mathbf{PSX - \underset{(0.154)}{0.276}\,KLCI + \underset{(0.310)}{0.656}IDX - \underset{(0.094)}{0.143}SET - \underset{(0.327)}{0.934}SGX \longrightarrow I(0)}$$

5.5. Vector Error Correction Model (VECM)

Based on our analysis, we have established that our variables are co-integrated to a certain significant degree. However, the co-integration cannot tell us the direction of the causality, that is, which variables are exogenous and which are endogenous. For this, we employ the VECM model to examine the lead-lag relationships of the variables. It is essential for investors to know which indices are exogenous and endogenous as it enables them to come up with a better forecast on their investment decisions. For example, investors would keep an eye on the index which is the most exogenous since the exogenous index will influence the movement other indexes which is under the investor's portfolio. In addition to this, the vector error correction technique is able to differentiate between short run and long run causality. The main principle of this techniques is the Granger causality which examines whether the past changes in one variable helps to explain the current changes in another variable .

The error correction model tells us the differences between the short-term and long-term Granger causality. Granger-causality is a form of temporal causality among variables and long-term relations 'e_{t-1}'. The error correction term 'e_{t-1}' explains the long-term relations among the variables, and tells us how long it will take to get back to long term equilibrium if the variable is shocked.

By noting the significance of the error correction coefficients (see table 8 and appendix 5), we found that there are three exogenous variables which are PSX, SET and SGX, and two variables KLCI and IDX are endogenous since their error correction terms are significant (p-value below 5% significance level), meaning they are dependent on the movement of other indices. PSX, SET and SGX on the other hand are exogenous, being independent of the movements of other indices, and expressed by the error correction terms that are insignificant (p-value above 5% significance level). This implies that the deviation of the exogenous variables (PSX, SET and SGX) have a significant feedback effect on the KLCI and IDX that bear the burden of adjusting themselves in the short run to bring about the long-term equilibrium. The consequence of the results revealing exogenous variables is that these indices would transmit the effects of the shock to other endogenous variables when they experience shocks from the market. Therefore, for instance, an investor whose investment portfolio includes IDX may want to monitor the fluctuations within PSX, SET and SGX as fluctuations in those indices are likely to influence the movements in IDX.

Table 7. Vector error correction model

Variables	ECM(-1) t-ratio [p-value]	Implications
LNKLCI	-3.7379 [0.000]	Endogenous
LNPSX	-1.7066 [0.088]	Exogenous
LNIDX	-3.8861 [0.000]	Endogenous
LNSET	-.13288 [0.894]	Exogenous
LNSGX	-.29158 [0.771]	Exogenous

However, the fact that KLCI and IDX are endogenous variable seems to be somewhat surprising (particularly KLCI) but will be analyzed closer under variance decomposition analysis. The diagnostics of all equations of the error correction model tends to show positive results except for normality (Masih et. al 2010). Therefore, the equations of the error correction model may be experiencing problems of non-normality which may in turn affect the reliability of the results obtained under the VECM technique. This would be used subsequently for comparison if the VECM and the variance decomposition (VDC) results happen to be conflicting with each other.

On a side note, the p-value of the DUM variable which represents a dummy variable for the 2013 Typhoon Haiyan was significant (at less than 5% significance level). The dummy variable was significant not only in the Philippines Stock Exchange (PSX), but also all ASEAN 5 stock markets.

Table 8 : Vector Error Correction Model

Dependent Variables	***dLNKLCI***	***dLNPSX***	***dLNIDX***	***dLNSET***	***dLNSGX***
dLNKLCI(1)	-0.062194 (0.049826)	0.080717 (0.045579)	0.087199 (0.085649)	-0.027101 (0.087953)	0.094297 (0.071672)
dLNPSX (1)	-0.087843 (0.037007)	0.13166 (0.067579)	-0.14415 (0.063613)	0.12377 (0.065325)	0.025118 (0.053232)
dLNIDX (1)	-0.0018083 (0.030250)	-0.20650 (0.050192)	-0.15124 (0.051997)	-0.093705 (0.053397)	-0.15306 (0.043512)
dLNSET (1)	0.029180 (0.029344)	-0.019503 (0.041027)	0.059357 (0.050440)	-0.13965 (0.051798)	0.018652 (0.042209)
dLNSGX (1)	0.11540 (0.039732)	-0.042789 (0.039799)	0.14346 (0.068296)	0.19789 (0.070134)	0.043240 (0.057151)
ECM(-1)	0.040960 (0.010958)	0.15809 (0.053887)	-0.073200 (0.018836)	-0.0025704 (0.019343)	-0.0045960 (0.015763)
DUM	-0.0086904 (0.010142)	-0.025364 (0.014862)	-0.026986 (0.017433)	-0.020726 (0.017902)	-0.0040953 (0.014588)
Chi-sq SC(1)	0.001723 [0.967]	0.099979 [0.752]	0.55722 [0.455]	0.1044 [0.747]	0.13711 [0.711]
Chi-sq FF(1)	0.38039 [0.537]	5.1284 [0.024]	0.78329 [0.376]	0.09421 [0.759]	0.02387 [0.877]
Chi-sq N(2)	1771.6 [0.000]	868.2546 [0.000]	912.8828 [0.000]	773.667 [0.000]	1141.1 [0.000]
Chi-sq Het (1)	9.7859 [0.002]	2.7871[0.095]	9.1663 [0.002]	2.239 [0.134]	4.5886 [0.032]

Note : Standard errors are given in parenthesis.*indicates significance at 5% level. The diagnostics are chi-squared statistics for: serial correlation (SC), functional form (FF), normality(N) and heteroscedasticity (Het) and indicate that the equations suffer from the problem of non-normality.

Besides determining the absolute exogeneity and endogeneity of variables, the vector error correction technique is able to tell how long does it take for the variable to go back to long-term equilibrium if the variable experiences a shock (Masih 2013). In the case of PSX, the coefficient is 0.15809 which implies that when a shock is applied to PSX, it would take average about of (1/0.15809) or 6.33 weeks to get back into equilibrium with the other indices, which happens to be the fastest time needed. The slowest to return from the data is SET at (1/0.0025704) or 389 weeks.

5.6. Variance Decomposition (VDC)

Although the error correction model tends to indicate the exogeneity and endogeneity, the variance decomposition technique had to be applied in this study in order to determine the relative exogeneity or endogeneity of the indices. The relative exogeneity or endogeneity of a variable can be determined by the proportion of the variance explained by its own past. If a variable is mostly explained by itself, it is the most exogenous variable. Whereas, the most endogenous variable is mostly explained by others. The relative endogeneity and exogeneity of the variables are important for policy makers. For example, if the causality runs from economic variables to stock markets, the appropriate policies for developing financial markets will be controlling the economic factors. On the other hand, if the causality runs from changes in stock market indices to other macroeconomic variables, then policy makers may need to keep their stock market stable in order to control the economic volatility. The variance decomposition technique is further broken down into the orthogonalized and generalized type.

Table 9 : Orthogonalized Variance Decomposition

Weeks	ΔKLCI	ΔPSX	ΔIDX	ΔSET	ΔSGX
Relative Variance in ΔKLCI					
26	80.68%	2.22%	2.56%	2.48%	12.05%
52	71.32%	3.71%	4.43%	3.33%	17.19%
78	67.26%	4.39%	5.28%	3.69%	19.38%
104	65.16%	4.73%	5.72%	3.87%	20.52%
Relative Variance in ΔPSX					
26	27.02%	67.18%	0.874%	0.219%	4.71%
52	24.11%	67.96%	1.39%	0.345%	6.19%
78	22.90%	68.25%	1.63%	0.402%	6.82%
104	22.27%	68.40%	1.75%	0.431%	7.15%
Relative Variance in ΔIDX					
26	22.11%	20.20%	41.58%	3.02%	13.09%
52	18.00%	25.22%	32.97%	4.17%	19.64%
78	16.22%	27.31%	29.30%	4.66%	22.50%
104	15.30%	28.38%	27.40%	4.92%	23.99%
Relative Variance in ΔSET					
26	28.85%	14.89%	5.03%	50.30%	0.927%
52	29.07%	14.86%	5.04%	50.12%	0.906%
78	29.16%	14.85%	5.049%	50.05%	0.895%
104	29.20%	14.84%	5.05%	50.02%	0.889%
Relative Variance in ΔSGX					
26	38.74%	9.15%	2.25%	3.75%	46.10%

52	38.99%	9.09%	2.22%	3.73%	45.96%
78	39.11%	9.06%	2.22%	3.73%	45.90%
104	39.16%	9.04%	2.21%	3.72%	45.86%

Note : The output of the generalized VDC show the relative exogeneity and endogeneity of the variables. The elements along the principal diagonal tend to indicate that KLCI is the most exogenous variable.

We applied both orthogonalised and generalised VDCs, and compared the exogeneity / endogeneity of variables for 26 weeks, 52 weeks, 78 weeks and 104 weeks. The table 10 below is the results of orthogonalised VDCs by ranking of most exogenous variable.

Table 10. Orthogonalised VDC Ranking (Leadership)

No.	Time Horizon			
	26 weeks	52 weeks	78 weeks	104 weeks
1	KLCI	KLCI	PSX	PSX
2	PSX	PSX	KLCI	KLCI
3	SET	SET	SET	SET
4	SGX	SGX	SGX	SGX
5	IDX	IDX	IDX	IDX

The results gave us some confusion initially. According to VECM analysis, PSX, SET and SGX were exogenous, while KLCI and IDX were endogenous. However, in VDCs, KLCI was not only exogenous, it is the most exogenous variable for 26 weeks, 52 weeks and second for 78 weeks and 104 weeks. SGX which was previously exogenous (in VECM) is now endogenous, being ranked fourth through all four horizons. Upon further analysis, we began to understand about the limitations of orthogonalised VDCs. Firstly, it assumes that when a particular variable is shocked, all other variables are switched off. Secondly, it is dependent on a particular ordering of variables thus, the first variable would report as the highest percentage.

Because of above reasons, we decided to rely on generalised VDCs. Generalised VDCs is more reliable than orthogonalised VDCs, since it does not make such a restrictive assumption and independent on a particular ordering of variables. However, when interpret the numbers generated by the Generalised VDCs, we need to be careful and perform additional computations to make the numbers add up to 100% for a specified horizon (the numbers add up to 100% in the case of orthogonalised VDCs). Based on generalised VDCs, the forecast error variance of each variable are as below.

Table 11 : Generalized Variance Decomposition

Weeks	ΔKLCI	ΔPSX	ΔIDX	ΔSET	ΔSGX
Relative Variance in ΔKLCI					
26	35.92%	15.10%	6.90%	14.11%	27.97%
52	33.21%	16.44%	5.30%	14.39%	30.66%
78	32.02%	17.03%	4.63%	14.50%	31.83%
104	31.38%	17.34%	4.28%	14.55%	32.45%
Relative Variance in ΔPSX					
26	12.42%	43.22%	9.06%	13.22%	22.09%
52	11.55%	44.04%	8.03%	13.24%	23.13%
78	11.18%	44.40%	7.60%	13.25%	23.57%
104	10.97%	44.59%	7.37%	13.26%	23.81%
Relative Variance in ΔIDX					
26	8.57%	15.03%	30.65%	18.11%	27.63%
52	7.19%	16.54%	27.10%	18.55%	30.62%
78	6.59%	17.20%	25.55%	18.73%	31.93%
104	6.28%	17.55%	24.73%	18.82%	32.62%
Relative Variance in ΔSET					
26	11.79%	15.18%	13.32%	40.06%	19.65%
52	11.85%	15.18%	13.35%	39.97%	19.65%
78	11.87%	15.18%	13.36%	39.94%	19.65%
104	11.88%	15.18%	13.37%	39.92%	19.65%
Relative Variance in ΔSGX					
26	16.49%	14.47%	11.94%	15.14%	41.96%
52	16.58%	14.45%	11.94%	15.13%	41.90%
78	16.61%	14.44%	11.95%	15.13%	41.87%
104	16.63%	14.44%	11.95%	15.13%	41.86%

Note : The output of the generalized VDC show the relative exogeneity and endogeneity of the variables. The elements along the principal diagonal tend to indicate that SGX is the most exogenous variable.

The results from the generalised VDCs clearly indicates a consistent exogeneity and endogeneity of the variables with the results obtained from VECM, but different from the orthogonal VDC test (confirming the latter's limitations). The table 12 below ranks the results of generalized VDCs where PSX was found to be the most exogenous variable, while IDX was the most endogenous, throughout all four time horizons. The generalized VDC test showed the relative exogeneity / endogeneity of the variables which the VECM test could not.

Table 12. Generalized VDC Ranking (Leadership)

No.	Time Horizon			
	26 weeks	52 weeks	78 weeks	104 weeks
1	PSX	PSX	PSX	PSX
2	SGX	SGX	SGX	SGX
3	SET	SET	SET	SET
4	KLCI	KLCI	KLCI	KLCI
5	IDX	IDX	IDX	IDX

While SGX was found to be endogenous in the orthogonal VDC test, it was found to be exogenous in the generalized VDC test, giving similar results to the VECM test. Looking at the time horizons from 26 weeks to 104 weeks, the rankings for relative exogeneity has not changed indicating stability of the rankings. Other information that can be obtained through the generalized VDC is that the difference in exogeneity between the indices is quite substantial. For instance in the horizon of 52 weeks, the difference between the most exogenous and the most endogenous variable 14.80%, and in the horizon of 104 weeks, the difference between the most exogenous and the most endogenous variable 17.13%.

It was not surprising to find that. KLCI is found to be endogenous to SGX which means KLCI is influenced by the movements of SGX. This is in conformity with previous literatures such as Karim and Majid (2010) and Karim and Karim (2008) which found that SGX to be exogenous towards KLCI. Right after the 2008 Global Financial Crisis, Malaysia suffered capital flight since the second quarter of 2008 where banks from other countries including Singapore reduced their investments in Malaysia and focused on their home market causing a big drop in funds flowing into Malaysia (Khoon and Lim 2010) and it is from here it is evident that Singapore was exogenous towards Malaysia after the 2008 global financial crisis despite the condition that investment commitment in Singapore's manufacturing and services sectors fell for the first time four years.

5.7. Impulse Response Functions (IRF)

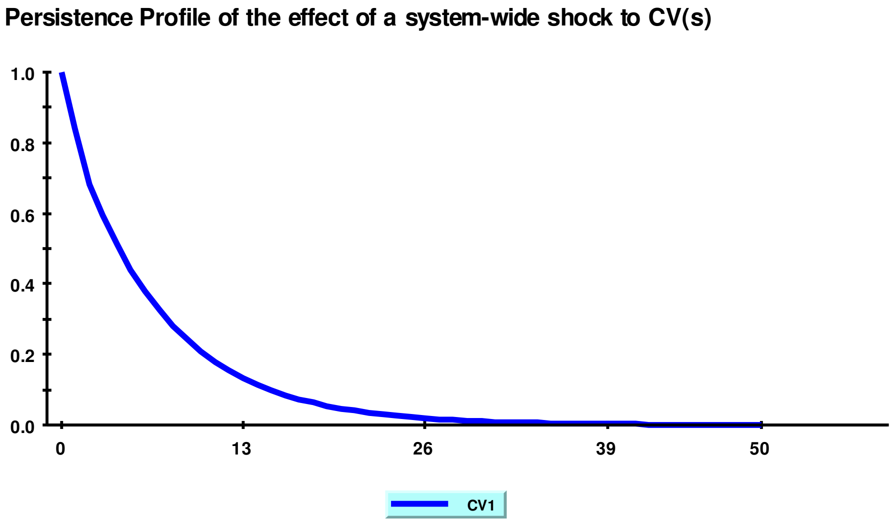
The IRFs presents the same information as the VDCs but in graphical format. We applied both the orthogonalised IRFs and generalised IRFs developed by Pesaran and Shin (1998), found similar results from both. This approach is shown to be invariant to the ordering of variables and is useful for the study of stock markets which are in general, categorized by quick price transmission and adjustments (Ewing et. al 2003). Plus, it also enables us to examine whether more complex transmission mechanisms are involved (Hutson et. al 2008). Referring to appendix 7, it shows that when the most exogenous variable which is the Philippine Stock Exchange (PSX) was shocked, the other variables responded fairly drastically while on the other hand, when the endogenous Indonesian Stock Exchange (IDX) was shocked, other markets did not react that much by observing at the scale of the magnitude of the shocks in each variable. Therefore, the results of the impulse response functions essentially produce the same information as the ones in variance decomposition analysis, see appendix 7.

5.8. Persistence Profile

While VDCs and IRFs indicate variable-specific shocks, the persistence profile estimates the speed with which the economy or the markets return to equilibrium owing to a system-wide shock on the co-integrating relations. It differs from the IRF in terms of having a system wide shock on the long run relationship rather than having variable specific shocks (Masih 2013). The chart below shows the persistence profile for the co-integrating equation of this study.

The chart below illustrates that the persistence profile for the co-integrating equation of this study. According to our result as Figure 1 below, it will take about 33 weeks for the co-integrating relationship to get back to equilibrium.

Figure 1. Persistence Profile



6. Conclusions and Suggestions for Future Research

This study examines the co-integration among five selected ASEAN emerging stock markets (i.e., Malaysia, Indonesia, the Philippines, Thailand and Singapore) based on time series testing approach. 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 2008 global financial crisis. According to Pretorius (2002), that the crisis put pressure on emerging markets and has contributed to virulent contagion and volatility in international markets. In addition, Kearney and Lucey (2004) note that the world's economic and financial systems are becoming increasingly integrated because of the rapid expansion of international trade in commodities, services and financial assets. Reduction of common trends among ASEAN-5 markets in the post-crisis period suggests a partial convergence of the indices. Overall, there is some evidence of an increase in the level of integration and interdependence between the ASEAN-5 markets after the financial crisis (Lim, 2000).

As far as the efficient market hypothesis is concerned, this study finds that the co-integration between the Singaporean stock market with its major Asian trading partners suggests that each stock price has information on the common stochastic trends and therefore the predictability of one's country stock price can be enhanced drastically by utilising the information on other countries' stock prices (Ansari 2009).

7. Policy Implications

For the purpose of policy making, any shocks in the major ASEAN trading partners should be taken into consideration by the ASEAN policy-makers in order to formulate macro stabilisation policies that pertain to its stock market as ignorance to do so may result in a unwanted consequences. The extent of effectiveness of the independent macroeconomic policies in dealing with its stock market imbalances will rely heavily on the extent of financial integration of each of its ASEAN partners. Since the ASEAN market is interconnected with the markets of its major trading partners, then ASEAN cannot be isolated or insulated from foreign shocks and thus, reduces the scope for independent monetary policy. Furthermore, the advantage of effective diversification among ASEAN markets can no longer be achieved and the ASEAN market is perceived as one market set by investors intending to invest in the long run period (Meera et. al 2009).

Now it is evident that the co-integration of the ASEAN stock market reflects the limitation attributed to the pursuit of interdependent policy especially the financial policy. This limitation then brings about the need for policy coordination in ASEAN to mitigate the impact of financial fluctuations. If ASEAN intends to exploit the advantages of greater economic interdependence, trade and investment barriers would need to be lifted in addition to better policy coordination, which AEC2015 is trying to achieve albeit at a slower pace than desired. Given this stock market co-integration of ASEAN partners, policy makers may want to use this issue as a solid reason to expedite the establishment of early warning system for natural disasters. With a sound early warning system, for instance, one member state with the backing of satellite technology can tell another member state that a typhoon or tsunami is impending on its territory. Asia Pacific, which covers the entire ASEAN region, is an area subjected to frequent natural disasters. Hazards like floods, droughts, typhoons, earthquakes and tsunamis pose a grave threat to human lives and economic activities. Reducing the risk of such natural disasters cannot be more important for regional stability and sustainable economic and social development. This dialogue should now move beyond frameworks and blueprints and into funding and implementation of actual technical and information-sharing systems.

Accordingly, the implication of our findings on integrated 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 (2005), Azman-Saini et al. (2002), and Daly (2003) and Majid et al. (2008). It is important to note that the existence of integration 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 & Wallace, 1992; Yang & Siregar, 2001). Thus, because of varying degrees of business and financial risks of different securities and various security cash flows co-varying 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.

As for Efficient Market Hypothesis (EMH), the finding that the five markets are integrated suggests that each stock price series contains information on the common stochastic trends, thus the predictability of one country's stock prices can be enhanced considerably through utilising information on the other countries' stock prices. However, Granger (1986) argues that integration between two prices reflects an inefficient market. Masih and Masih (2002) suggest that predictability from integration implies nothing necessarily about inefficiency. A market is inefficient only if by using the predictability, investors can earn risk-adjusted excess return, but if returns are generated it is unclear whether they are just compensation for risks incurred or are truly excess and risk-adjusted.

8. Limitations and Suggestions for Future Research

One of the limitations of this study is that more indices from other regions such as stock markets in the US, Europe and the Middle East (GCC particularly) could have been included in this study in order to provide a larger view about diversification benefits to assist global investors optimize their portfolios and hedge against the many forms of risks. Also, the period selected for this study could be extended further to include significant past events such as the 1987 crisis, the 1997 Asian financial crisis as well as the 2000 dot-com bubble for the study and hence, allow us to observe the long run trend of various stock markets under different types of shocks, besides natural disasters, which gives us a clearer picture when we are looking from the lens of a multi-factoral approach. It would have been important to also study the effects of political instability such as the continual Bangkok protests (2010, 2012, 2013, 2014) to its effects on the Stock Exchange of Thailand itself, and the effects to the regional ASEAN stock exchanges.

Potential areas that can be used for further research is attempting to quantify and compare the diversification benefits that can be gained by the diversification of securities across the ASEAN and possibly the GCC markets that cover a larger and more diverse group of nations. Other than that, a more developed way of testing is needed to discover the existence of non-linear co-integration among the ASEAN stock markets and its major as well as new trading partners to give a more accurate and realistic way of assessment in a climate where multi-factoral events affect stock markets and economic stability. International investors have to comprehend the driving forces behind the market integration in order to grasp the potential risks and returns of diversification.

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