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Did Focusing on Asia Pacific Emerging Markets Provide Much Benefit to Portfolio Diversification during the Late 2000s Recession?

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Did Focusing on Asia Pacific Emerging Markets Provide Much Benefit to Portfolio Diversification during the Late 2000s Recession?

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This research studies the international co-movement among Asia Pacific emerging markets stock price indices during the late 2000s recession by using the monthly observations start from 1st October 2001 until 1st April 2011. The co-integration analysis and parsimonious Vector Error Correction Model employed in this research reveal a long-term relationship and interdependencies among seven Asia Pacific emerging market stock price indices. This research finds that the unique co-integation exists on the equations. Specifically, two indices from China and Taiwan having meteor shower potential while the rest indices from Thailand, Malaysia, and Indonesia are known to have heat waves effects or country specific factors on the equation. Finally, all the results are linked to the international diversification strategies.

Keywords: *Co-movement, co-integration, emerging market, heat waves, meteor shower, Asia Pacific, interdependencies, Vector Error Correction Model, international diversification*

Introduction

International openness to trade and capital flows have a potential to increase the vulnerability of a country to international shocks. The recent international shock happened during the late 2000s when most securities suffered large losses erupted by the US subprime mortgage collapse in August 2007. It has resulted in a sharp drop in international trade, rising unemployment and slumping commodity prices and investments amount around the world. It also included a global explosion in prices, focused especially in commodities and housing, marking an end to the commodities recession of 1980–2000. In 2008, the prices of many commodities, notably oil and food, rose so high as to cause economic damage, threatening stagflation and a reversal of globalization (Rubin, 2008). Some large financial institutions were collapsed and some national governments granted the bailout of the banks. The global recession also resulted in the downturns in stock markets around the world. On the international stock market, Standard & Poor in December 2009 reported that most countries in the S&P Indices experienced a serious negative impact on stock markets in 2008 as the effect of the global financial crisis took hold.

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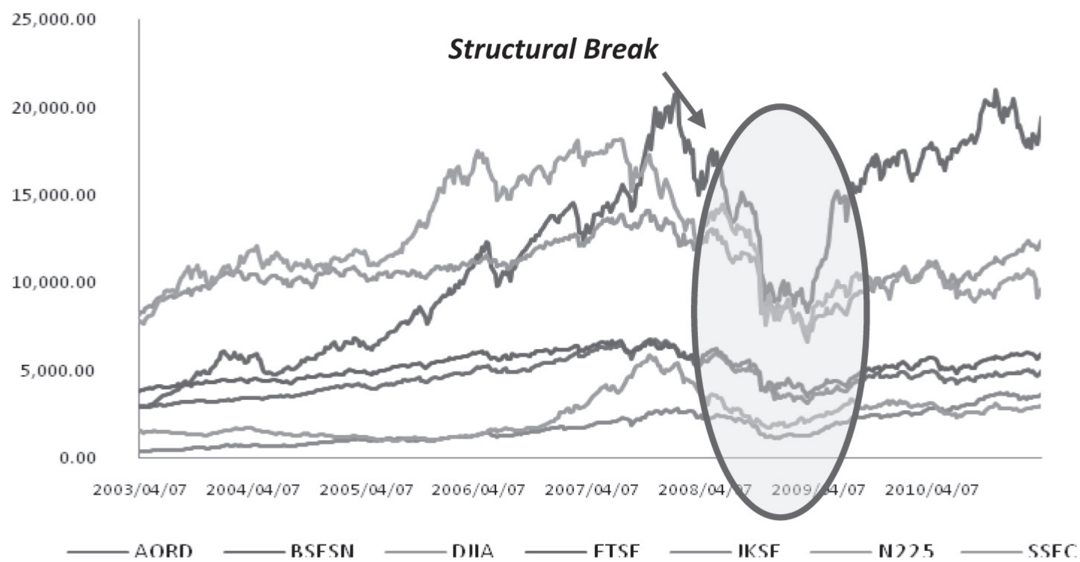

Figure 1. Global stock market indices during the 2008 financial crisis

Meanwhile, previous investigators found any interdependencies between some equity markets on crisis period since a high level of common short-run and long-run patterns of the market behavior tends to occur during the crisis. Forbes and Rigobon (2002) found any interdependencies during the 1997 Asian crisis, 1994 Mexican devaluation, and 1987 US market crash. They prefer to call it interdependencies since in their finding, co-movement does not increase significantly after the shocks. Baig and Goldfajn (1999) found a co-movement among financial markets of Thailand, Malaysia, Indonesia, Korea, and the Philippines. They found that correlations in currency increased significantly during the crisis period. Huyghebaert and Wang (2009) revealed that the relationships among East Asian stock markets were time varying. However, they revealed that there were integration and interdependencies among seven major East Asian stock exchanges before, during, and after the 1997–1998 Asian financial crises. Then, what about the latest 2000s recession? Figure 1 depicts a structural break on all equity indices especially after the mid of 2008. The indices seemed to move together, declining on the second semester of 2008, and then bouncing back one year after.

The typical co-movements and interdependencies on some crises suggest an unfavorable condition for creating some international portfolio diversifications. On the other side, previous investigators often stated that emerging markets are the best alternative solution for investing in global economic crisis. Dattels and Miyajima (2009) stated that emerging markets are too worthy to miss because they have been relatively resilient to global market turmoil since they are able to avoid the kind of turbulence experienced in mature credit and other risk markets, especially in Asia. Emerging market returns typically have a low correlation with developed market returns (Errunza, 1983). The diversification potential of the emerging markets is further supported by Harvey's (1995) findings that the correlation between developed and emerging markets is less than 0.10. That implies that emerging countries' equities may serve as attractive diversification vehicles for investors in developed countries.

This research seeks the internal relationship among Asia Pacific emerging market relationship during the late 2000s recession. The internal relationships may be revealed as co-movement or interdependencies. The investigation is advanced by detecting the characteristics behind the transmission of the shocks, if any, based on Engle et al. (1990) hypothesis, "heat waves" and "meteor showers". Finally, the implication of the interdependencies detected on this research is linked to the diversification policy, especially for any equity investors around the globe.

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Literature Review

Optimum benefit of international diversification

The international portfolio activity will reach the optimum benefit when they are able to get the minimum risk. When the correlation coefficient between stock markets in one country of another are very low, it will imply that income portfolio that are balance-weighted greatly benefit from international diversification (Bodie et al., 2007). That is it, the basic technique for constructing the efficient international portfolio is still the efficient frontier. Markowitz (1952) has shown the main framework of the optimum mean-variance diversification in efficient frontiers concept. Portfolio risk depends on the correlation between the returns of the assets in the portfolio.

The variance of the portfolio is a sum of the contributions of the component security variances plus a term that involves the correlation coefficient between the returns on the component securities. Therefore, Markowitz stated that a well-diversified portfolio means the portfolio with minimum variance so that the dispersion of the expected returns will be minimized. For instance, once a portfolio is perfectly correlated, it has a standard deviation which is a weighted-average of the standard deviation for each asset based on the weight of each asset in the portfolio. Thus, in this scenario investors do not obtain the risk reduction benefit from the diversification.

Co-movement

Baur (2004) once stated that there is no clear and unambiguous definition of term co-movement and no unique measure associated with it. It is also difficult to analyze in a time-varying context if it is based on the correlation coefficient. However, Barberis et al. (2005) determined the explicit definition of co-movement as defined as a pattern of positive correlation. In general statistical usage, positive correlation means a correlation in which large values of one variable are associated with large values of the other and small with small. Cahyadi (2009) described co-movement as co-integration, co-trending, and co-breaking. This definition was supported by Dolado et al. (1999) who stated that co-integration signifies co-movements among trending variables which could be exploited to test for the existence of equilibrium relationships within a fully dynamic specification framework. Thus, this research concludes that the basic principle behind the term "co-movement" involves the common movements among any simultaneous variables during at certain time.

Furthermore, some common movement patterns have several distinctions when it comes to the characteristics affecting the movement. Engle et al. (1990) proposed two hypotheses this characteristics. The first one is called the "heat wave" effect or country specific effect, a meteorological analogy of a co-movement which is consistent with a view that major sources of disturbances are changes in country-specific fundamentals. In other words, it transmits the information internally within the same market on the previous *t*. The alternative hypothesis is "meteor shower" which rains down on the earth as it turns. The meteor shower effect transmits the information, as captured when they trade in different regions and time zones.

Previous empirical research

There are so many similar empirical researches that have been conducted to seek the interdependencies and international diversification among some stock market indices in any economic climate in the world. Azizan and Ahmad (2008) revisited at the relationship between the movements of capital markets in developed economies and their emerging market counterparts in the Asia Pacific region using market indices of the US, British, Malaysian, Singaporean, Chinese, Hong Kong, Indian, Japanese, and Australian markets for the periods 1997 to 2007. They found several empirical results. The first one is the fact that the Asian markets are very much influenced by the events in the United States rather than other developed markets. The second one is the fact that of all the markets being surveyed, the South East Asian markets are the most sensitive towards events in their own regions outside themselves. Their last finding is the fact that Mainland China in the long-run is not affected by events outside themselves.

Baig and Goldfajn (1999) tested for evidence of contagion between the financial markets of Thailand, Malaysia, Indonesia, Korea, and the Philippines. They found that correlations in currency and sovereign spreads increase significantly during the crisis period, whereas the equity market correlations offer mixed evidence. They showed that after controlling for own country news and other fundamentals, there is evidence of cross-border contagion in the currency and equity markets. Forbes and Rigobon (2002) showed that there is a high level of market comovement in all periods during the 1997 Asian crisis, 1994 Mexican devaluation, and 1987 US market crash, which is called interdependence. Huyghebaert and Wang (2009) examined the integration and causality of interdependencies among seven major East Asian stock exchanges before, during, and after the 1997–1998 Asian financial crisis by using daily stock market data from July 1st 1992 to June 30th 2003 in local currency as well as US dollar terms. They revealed that the relationships among East Asian stock markets were time varying. While stock market interactions were limited before the Asian financial crisis, they found that Hong Kong and Singapore responded significantly to shocks in most other East Asian markets, including Shanghai and Shenzhen, during this crisis. After the crisis, shocks in Hong Kong and Singapore largely affected other East Asian stock markets, except for those in China. On their final conclusion, they stated that considering the role of the US showed that it strongly influences stock returns in East Asia – except for China – in all periods, while the reverse did not hold true.

Dekker et al. (2001) found that there are strong relationships on Asia Pacific stock markets. All Asia Pacific stock markets, excluding Taiwan, have significant interdependencies with United States stock markets. Some significant relationships also exist on Australia and New Zealand, also among Malaysia, Singapore, and Hong Kong. While stock markets in Japan, the Philippines, and Taiwan tend to be segmented. Dunis and Shannon (2005) examined the relationships among developing countries' stock markets in Asia Pacific region versus US stock market. They revealed a co-integrating relation among developing countries' stock markets and US stock markets. However, in the short run, the correlations among those stock markets get declining compared with previous period.

Research Method

Data summary

This research uses seven countries as proxies which are listed as Asia Pacific emerging markets based on the S&P Global BMI (Broad Market Index) as of December 31st 2010 with significant market capitalizations of listed companies. It uses monthly adjusted close stock price indices returns of the proxies which are constructed by the market capitalization-weighted method[1], from October 1st 2001 as the re-opening of US stock market after the September 11th 2001 attacks, to April 1st 2011 obtained from Yahoo Finance. The choosing of the opening research period are also referred on Alan Greenspan's decisive reaction to September 11th attacks and the various corporate scandals which undermined the economy that led Federal Reserve initiated a series of interest cuts that brought down the Federal Funds Rate to 1% in 2004[2]. The proxies are listed in Table 1.

[1] Market capitalization-weighted method is computed by the following formula:

$$Index_t = \frac{\Sigma P_t Q_t}{\Sigma P_b Q_b} x \text{ Beginning Index Value}$$

[2] On October 15th 2008, Anthony Faiola, Ellen Nakashima, and Jill Drew wrote a lengthy article in The Washington Post titled, "What Went Wrong", claiming that Alan Greenspan's controversy as Chairman of the Federal Reserve in lowering of Federal funds rate at only 1% for more than a year triggering the subprime mortgage crisis 2007.

Table 1. List of major indices on Asia Pacific emerging markets

Index	Ticker	Country	Index	Ticker	Country
Jakarta Composite Index	JKSE	Indonesia	Kuala Lumpur Composite Index	KLSE	Malaysia
Shanghai Stock Exchange Composite Index	SSEC	China	Philippines Stock Exchange Index	PSEI	Philippines
Bombay Stock Exchange Sensex	BSESN	India	Taiwan Stock Exchange Index	TWII	Taiwan
Stock Exchange of Thailand Index	SETI	Thailand			

Source: S&P Global BMI (Broad Market Index) as of December 31st 2010

Table 2. Descriptive statistic of Asia Pacific emerging market stock price indices

	BSESN	JKSE	KLSE	PSEI	SETI	SSEC	TWII
Mean	10541.4	1565.6	1016.1	2305.9	651.44	2241.9	6610.3
Std. Dev.	5711.20	964.90	267.93	920.5	186.52	1077.9	1413.1
Skewness	0.1408	0.5547	0.3776	0.3339	-0.1272	1.2957	0.1313
Kurtosis	1.5941	2.2173	1.9177	1.9868	2.551	4.3384	2.1629
Obs.	115	115	115	115	115	115	115

Source: Author's own calculation

Table 3. Pairwise correlation matrix of Asia Pacific emerging market stock price indices

Correlation	BSESN	PSEI	SSEC	TWII	SETI	KLSE	JKSE
BSESN	1.000000						
PSEI	0.963047	1.000000					
SSEC	0.771458	0.751814	1.000000				
TWII	0.866697	0.900711	0.766250	1.000000			
SETI	0.798446	0.843705	0.505131	0.863948	1.000000		
KLSE	0.961676	0.980311	0.783464	0.915473	0.851562	1.000000	
JKSE	0.971072	0.959831	0.713310	0.840366	0.814037	0.971260	1.000000

Source: Author's own calculation

Table 2 shows the descriptive statistic among the proxies, compared with some developed countries' major indices relevant statistics. There are two important aspects informed by the table above. The first aspect is volatility. BSESN was the most volatile index among the group members and KLSE was the least volatile one during 2001 until 2010. The high monthly volatility, as a quadratic function of standard deviation, in BSESN, TWII, SSEC, JKSE, and PSEI implies that Asia Pacific emerging market is fairly volatile. The second aspect is the data distribution. The excess kurtosis in Asia Pacific emerging markets is significantly greater from zero. It indicates a fat-tailed distribution. The absolute skewness statistics are a bit greater than zero, revealing that the distributions are somewhat asymmetric.

The existance of the co-movement on Asia Pacific emerging markets indices can be roughly withdrawn by analyzing the pairwise correlation matrix on Table 3 above since most of the indices are strongly correlated to each other. The highest correlation coefficient implies to the relationship between PSEI and KLSE in 0.9803. The lowest correlation coefficient implies to the relationship between SSEC and SETI in 0.051. The strong positive correlation coeficients indicates that most of variables are strongly co-moving on this decade. In other words, it can be said that the variables are strongly interdependent on each other. From this phenomenon, at glance investors do not obtain the risk reduction benefit from the diversification. However, correlation matrix does not show the dynamic and simultaneous relationship among the variables since it can not ensure the integration and interdependencies among the variables (Cahyadi, 2009).

Co-integration analysis

This research describes co-integration as a set of variables with a stationary linear combination of them (Engle and Granger, 1987). The co-integration test shall be conducted to seek if there is any long-term relationship or equilibrium among the Asia Pacific emerging markets' stock price indices. The test of co-integration is conducted by the Johansen's test as the using of multivariate system, begins with defining a vector Z_t of n potentially endogenous variables following Johansen (1988) and Harris (2003). Z_t is assumed as an unrestricted VAR system in k-lags:

$$Z_t = A_1 Z_{t-1} + A_2 Z_{t-2} \dots \dots \dots + A_k Z_{t-k} + \Phi D_t + \mu + \varepsilon_t \qquad 1)$$

where Z_t is $n \times 1$ and A_1 is $n \times n$ matrix of parameters, μ is a constant, D_t is a dummy variable that is orthogonal with μ constant, and error ε_t is assumed to be independent. This way estimates dynamic relationships among jointly endogenous variables without imposing strong a priori restrictions (Harris, 2003). The equation (1) can be reformulated into Vector Error Correction Model (VECM) by subtracting Z_{t-1} of the both equation sides:

$$\Delta Z_t = \Gamma_1 \Delta Z_{t-1} + \dots + \Gamma_{k-1} \Delta_{Zt-k+1} + \Pi Z_{t-k} + \Phi D_t + \mu + u_t \qquad 2)$$

where $\Gamma i = -(I - A1 - \dots - Ai)$, $(i = 1, \dots, k-1)$, and $\Pi = -(I - A1 - \dots - Ak)$.

Equation (2) contains some information on both short term and long term error correction models to ΔZ_t, via the estimates of Γ and Π respectively. As will be seen, $\Pi = \alpha\beta'$, where α represents the speed of adjustment to disequilibrium and β is a matrix of long-run coefficients such that the term $\beta' Z_{t-k}$ embedded in equation (2) represents up to (n - 1) co-integration relationships in the multivariate model which ensure that the Z_t converge to their long-run steady-state solutions.

Assuming Z_t is a vector non-stationary I(1) variables, then the term (2) which involve ΔZ_t are I(0) while ΠZ_{t-k} must also be stationary for $u_t \sim I(0)$ to be white noise. There are three instances when this requirement $\Pi Z_{t-k} \sim I(0)$ is met:

1. If Π has full rank or there are $r = n$ linearly independent columns, then all variables will be stationary on level. It implies that there is no problem of spurious regression and the appropriate modeling strategy is to estimate the standard VAR in levels.
2. If the rank of Π is zero, then it will imply that there are no linear combinations of the Z_t that are I(0), and consequently Π is an (n x n) matrix of zeros. In this case the appropriate model is a VAR in first differences involving no long-run elements.
3. The third instance is when Π has reduced rank, then there will exist up to (n – 1) co-integration relationships: $\beta' Z_{t-k} \sim I(0)$. In this instance $r \leq (n - 1)$ co-integration vector exists in β, together with (n - r) non-stationary vectors. Only the co-integration vectors in β enter (equation 3), otherwise ΠZ_{t-k} would not be I(0), which implies that the last (n – r) columns of α are insignificantly small. In this case the appropriate model is a VECM.

To test the null hypothesis that there are at most r co-integration vectors can be used what has become known as trace statistic:

$$\lambda_{trace} = -2\log(Q) = -T \sum_{i=r+1}^{n} \log(1-\hat{\lambda}) \qquad 3)$$

$r = 0,1,2, \dots, (-2), (-1)$

where Q is the ratio between restricted maximized likelihood between unrestricted maximized likelihood. Besides that, another test of the significant of the largest λ is the so-called maximal Eigenvalue or λ_{max} statistic, formulated as follows:

$$\lambda_{max} = -T \log(1-\widehat{\lambda_{t+1}}) \qquad 4)$$

$r = 0,1,2, \dots, (n-2), (n-1)$

The maximum-Eigenvalue tests that there are r co-integration vectors againts the alternative that (r + 1) exist.

Vector Autoregression (VAR)

In a Vector Autoregression (VAR) model the current value of each variable is a linear function of the past values of all variables plus random disturbances. All the variables in a VAR are treated symmetrically by including for each variable an equation explaining its evolution based on its own lags and the lags of all the other variables in the model. Suppose that each

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equation contains k lag values of Y and X. In this case, one can estimate each of the following equations by OLS:

$$Y_t = a + \sum_{j=1}^{k} b_j Y_{t-j} + \sum_{j=1}^{k} c_j X_{t-j} + u_{1t} \quad 5)$$

$$X_t = d + \sum_{j=1}^{k} e_j Y_{t-j} + \sum_{j=1}^{k} f_j X_{t-j} + u_{2t} \quad 6)$$

where the u is the stochastic error term, called impulse or innovation or shock or white noise disturbance term.

Unrestricted VAR

This type of VAR illustrates the value of VAR as a linear function of its value on the past. The value on the past of other variables is the serially uncorrelated error term. This type of VAR can be divided into VAR on level and VAR on first difference. The unrestricted VAR on level is used for stationary data or if Π has full rank or there are $r = n$ linearly independent columns. Whereas, the unrestricted VAR on first difference shall be used if the rank of Π is zero or if there are no linear combinations of the Z_t that are I(0)

Vector Error Correction Model

The model becomes a Vector Error Correction Model (VECM) which can be seen as a restricted VAR. This type of VAR restricts the long-term relationship of the endogenous variables so that there are convergent co-integrations but still tolerance the short-term dynamics. This type of VAR is used for data that has reduced rank on its Π or there exist up to $(n – 1)$ co-integration relationships. When the variables are co-integrated, the error correction term has to be included in the VAR. The co-integration term is also known as an "error" since the deviation of the long-term equilibrium is corrected gradually through the partial series of short term adjustments. Recalling the bivariate version of VAR equations (5) and (6), Z_t value on VAR(2) can be decomposed as follows:

$$Z_t = \begin{bmatrix} Y_t \\ X_t \end{bmatrix} = \begin{bmatrix} \phi_1 \\ \phi_2 \end{bmatrix} \begin{bmatrix} Y_{t-1} \\ X_{t-1} \end{bmatrix} = \begin{bmatrix} \phi_{21} \\ \phi_{22} \end{bmatrix} \begin{bmatrix} Y_{t-2} \\ X_{t-2} \end{bmatrix} + u_t \quad 7)$$

where can be reformulated into Vector Error Correction Model (VECM) by subtracting Z_{t-1} of the both equation sides:

$$\Delta Z_t = \begin{bmatrix} \Delta Y_t \\ \Delta X_t \end{bmatrix} = \Pi Z_{t-1} + \begin{bmatrix} \Gamma_{11} \\ \Gamma_{12} \end{bmatrix} \begin{bmatrix} \Delta Y_{t-1} \\ \Delta X_{t-1} \end{bmatrix} \cdots$$
$$\cdots + \begin{bmatrix} \Gamma_{21} \\ \Gamma_{22} \end{bmatrix} \begin{bmatrix} \Delta Y_{t-2} \\ \Delta X_{t-2} \end{bmatrix} + u_t \quad 8)$$

where: $\Pi = -(I\text{-}\Phi_1\text{-}\Phi_2) = -\Phi(1)$ and
$\Gamma = -(\Phi_1+\Phi_2) = -(I\text{-}\Phi_1)$

From the decomposition above, the VECM model can be reformulated as detail estimation:

$$\begin{bmatrix} \Delta Y_t \\ \Delta X_t \end{bmatrix} = \begin{bmatrix} \alpha_{11}\ \alpha_{12} \\ \alpha_{21}\ \alpha_{22} \end{bmatrix} \begin{bmatrix} \beta_{11}\ \beta_{12} \\ \beta_{21}\ \beta_{22} \end{bmatrix} \begin{bmatrix} Y_{t-1} \\ X_{t-1} \end{bmatrix} \cdots$$
$$\cdots + \begin{bmatrix} \varphi_{11}\ \varphi_{12} \\ \varphi_{21}\ \varphi_{22} \end{bmatrix} \begin{bmatrix} \Delta Y_{t-1} \\ \Delta X_{t-1} \end{bmatrix} \cdots$$
$$\cdots + \begin{bmatrix} \theta_{11}\ \theta_{12} \\ \theta_{21}\ \theta_{22} \end{bmatrix} \begin{bmatrix} \Delta Y_{t-1} \\ \Delta X_{t-1} \end{bmatrix} + u_t \quad 9)$$

As described previously, the rank Π equals to $\alpha\beta$', where α represents the speed of adjustment to disequilibrium and β is a matrix of long-run coefficients. If the rank Π is k, then α can be decomposed as $k \ x \ 2$ matrix while β is decomposed as $2 \ x \ k$ matrix on the bivariate VECM. Therefore, the error correction term of the equation (9) is determined follow:

$$\Pi Z_{t-1} = \begin{bmatrix} \alpha_{11}\ \alpha_{12} \\ \alpha_{21}\ \alpha_{22} \end{bmatrix} \begin{bmatrix} \beta_{11}\ \beta_{12} \\ \beta_{21}\ \beta_{22} \end{bmatrix} \begin{bmatrix} Y_{t-1} \\ X_{t-1} \end{bmatrix} \quad 10)$$

Granger Causality test

The causality testing can figure out whether an endogenous variables can be treated as an exogenous one. The causality relationship can be tested by Granger Causality test with assumption that the information relevant to the prediction of the respective variables. The Granger Causality test is a statistical hypothesis test for determining whether one time series is useful in forecasting another (Granger, 1969). However, bivariate Granger Causality is not sufficient to imply true causality in multivariate system. A similar test involving more variables can be applied with Vector Autoregression (VAR). On an examination process of VAR model, it needs to conduct simultaneously so that there will be a combined significances on the equation (Hamilton, 1994; Patterson, 2000). All VAR estimations shall be tested on Wald Chi-squares distribution (χ^2-Wald). The statistical results of χ^2-Wald shall show the joint significance of the endogenous variables on VAR estimation.

Is this test always valid for every measurement? Toda and Phillips (1993) stated that the empirical use of Granger Causality tests in levels VAR is not to be encouraged in general when there are stochastic trends and the possibility of co-integration[3]. That is, causality tests are valid asymptotically as χ^2-Wald criteria only when there is sufficient co-integration with respect to the variables whose causal effects are being tested. Since the estimates of such matrices in levels VAR suffers from simultaneous equations bias there is no valid statistical basis for determining whether the required sufficient condition applies.

Impulse Response Function

In structural analysis, certain assumptions about the causal structure of the data under investigation are imposed, and the resulting causal impacts of unexpected shocks or innovations to the specific variables on the variables in the model are summarized. These causal impacts are usually summarized with impulse response functions and forecast error variance decompositions.

This research emphasizes on Impulse Response Function (IRF) as a tool on VAR analysis to see the response and the future effects to the shocks or changes in other variables in the VAR system. An impulse response function traces out the response of a variable of interest to an exogenous shock. The shocks and innovations of each variable are correlated each other so that those variables have the same component but are unable to be specifically attributed to a certain variable. This problem can be overcome by creating the orthogonal error using Cholesky decomposition method. The mathematical approach of the IRF is conducted by manipulating the VAR equations on (5) and (6) into the matrices below:

$$\begin{bmatrix} y_t \\ x_t \end{bmatrix} = \begin{bmatrix} a_{10} \\ a_{20} \end{bmatrix} + \begin{bmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{bmatrix} \begin{bmatrix} y_{t-1} \\ x_{t-1} \end{bmatrix} + \begin{bmatrix} \varepsilon_{1t} \\ \varepsilon_{2t} \end{bmatrix} \quad 11)$$

From the equation above, it is obvious that the value of *Y* and *X* depend on their respective lag and residual values. By focusing the derivation into the influence of residual shock changing ε_{1t} and ε_{2t} on the value of *Y* and *X*, the equation (11) can be denoted as follows:

$$\begin{bmatrix} y_t \\ x_t \end{bmatrix} = \begin{bmatrix} \overline{y_t} \\ \overline{z_t} \end{bmatrix} + \sum_{i=0}^{\infty} \begin{bmatrix} \varphi_{11}(i) & \varphi_{12}(i) \\ \varphi_{21}(i) & \varphi_{22}(i) \end{bmatrix}^i + \begin{bmatrix} \varepsilon y_{t-1} \\ \varepsilon x_{t-1} \end{bmatrix} \quad 12)$$

Those φ11, φ21, φ12, and φ22 are the impulse response function coefficient.

Result and Discussion

Co-integration analysis

This research has found that all indices are stationary in first difference I(1). Thus, if there is no co-integration found on the system, the first difference VAR will be able to be conducted. This research conducts the optimum lag based on the least result of Final Prediction Error, which is lag 1. The optimum lag length declaration must be done before estimating the models since the simultaneous equation process such as VAR and co-integration test is very sensitive to the lag length (Enders 2004). Based on the optimum lag declared, the Johansen's co-integration test is conducted.

To determine the appropriate assumption of the Johansen's co-integration test, five sets of assumptions that stated that the co-integration test should be conducted with intercept and trend assumption on CE with linear deterministic trend in data. Dummy variable is set for

[3] They developed a limit theory for Wald tests of Granger Causality in levels Vector Autoregressions (VAR) and Johansen-type error correction models (ECM), allowing for the presence of stochastic trends and co-integration. For further explanation, see Toda and Phillips (1993).

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Table 4. Johansen's co-integration rank test on trace statistic method

Hypothesized No. of CE(s)	Eigenvalue	Trace statistic	0.05 Critical value	Prob.
None *	0.493370	217.3668	187.4701	0.0006
At most 1	0.304812	140.5298	150.5585	0.1597
At most 2	0.262914	99.44595	117.7082	0.3955
At most 3	0.209881	64.97524	88.80380	0.7001
At most 4	0.127063	38.35568	63.87610	0.8965
At most 5	0.114081	22.99992	42.91525	0.8779
At most 6	0.057398	9.312216	25.87211	0.9509
At most 7	0.023029	2.632700	12.51798	0.9170

Trace test indicates 1 co-integrating eqn(s) at the 0.05 level

Source: Author's own calculation

Table 5. Johansen's co-integration rank test on maximum Eigenvalue method

Hypothesized no. of CE(s)	Eigenvalue	Max-Eigen statistic	0.05 critical value	Prob.
None *	0.493370	76.83705	56.70519	0.0002
At most 1	0.304812	41.08381	50.59985	0.3400
At most 2	0.262914	34.47071	44.49720	0.3965
At most 3	0.209881	26.61956	38.33101	0.5540
At most 4	0.127063	15.35577	32.11832	0.9364
At most 5	0.114081	13.68770	25.82321	0.7488
At most 6	0.057398	6.679516	19.38704	0.9212
At most 7	0.023029	2.632700	12.51798	0.9170

Max-Eigenvalue test indicates 1 co-integrating eqn(s) at the 0.05 level

Source: Author's own calculation

Table 6. Adjustment coefficients on unique co-integration equation (standard error in parentheses)

D(TWII)	*D(SSEC)*	*D(SETI)*	*D(PSEI)*	*D(KLSE)*	*D(JKSE)*	*D(D)*	*D(BSESN)*
-0.27961	-0.25382	-0.00329	-0.03672	0.007807	-0.01247	-1.55E-05	-0.2
(-0.08306)	(-0.04778)	(-0.00853)	(-0.03037)	(-0.00833)	(-0.02498)	(-1.90E-05)	(-0.1837)

Source: Author's own calculation

identifying the crisis period and non-crisis period. Crisis period (July 2007 – present) is represented by 1 dummy value and non-crisis period is represented by 0 dummy value. The Johansen Co-integration test shows that there is 1 co-integration rank on both trace statistics and maximum Eigenvalue test type. Co-integration analysis variable ordering is *JKSE-SSEC-BSESN-KLSE-SETI-PSEI-TWII-DUMMY*. Table 4 and 5 comprehend the co-integration testing results from both methods above.

Both maximum Eigenvalue and trace statistic indicate one co-integration equation in 5% levels. That means there is only one long-term equilibrium possibility among the markets or Π has reduced rank. Furthermore, it is called a unique co-integration. In this instance one co-integration vector exists in β, together with seven non-stationary vectors. The speed of adjustment to disequilibrium α is decomposed as (1x8) matrix while matrix of long-run coefficients β is decomposed as (8x1) matrix. Table 6 reveals the adjustment coefficients of the variables. *TWII* and *SSEC*, with highest adjustment coefficients, at glimpse, tend to follow variables with smaller adjustment coefficients or in other words, it is called interdependency. The comprehensive explanation of the movement interdependency is described after analyzing the results in Vector Error Correction Models.

Vector Error Correction Model

Since there is one linear combinations of the variables proof by the results of Johansen co-integration test on previous subsection, the appropriate model to estimate is a Vector Error Correction Models (Harris, 1995). The optimum lag is 1, declared by the VAR lag order selection criteria for first difference data on

Table 7. Vector Error Correction Model estimates

Error Correction:	D(JKSE)	D(SSEC)	D(BSESN)	D(KLSE)	D(SETI)	D(PSEI)	D(TWII)	D(D)
CointEq1	-0.0187	-0.3802	-0.2996	0.01169	-0.0049	-0.0550	-0.4188	-2.3E-05
	[-0.4992]	**[-5.3123]**	[-1.0887]	[0.9369]	[-0.3857]	[-1.2092]	**[-3.3665]**	[-0.8036]
D(JKSE(-1))	0.19238	0.72303	1.935604	0.13864	0.12521	0.114708	0.767379	9.44E-05
	[1.1310]	**[2.2228]**	[1.5476]	[2.4440]	[2.1557]	[0.5548]	[1.3571]	[0.7177]
D(SSEC(-1))	-0.04004	-0.13183	-0.41211	-0.00779	-0.00154	-0.07617	-0.09229	1.20E-05
	[-0.7668]	[-1.3202]	[-1.0734]	[-0.4473]	[-0.0865]	[-1.2002]	[-0.5317]	[0.2984]
D(BSES(-1))	-0.04111	-0.18189	-0.39013	-0.01231	-0.01451	-0.04341	-0.28373	-2.7E-05
	[-1.6663]	**[-3.8546]**	[-2.1503]	[-1.4962]	[-1.7229]	[-1.4472]	**[-3.4589]**	[-1.4033]
D(KLSE(-1))	0.495301	-0.47180	3.328057	0.09186	0.03936	0.858592	0.329165	-0.00013
	[1.1358]	[-0.5657]	[1.0380]	[0.6316]	[0.2643]	[1.6199]	[0.2271]	[-0.3974]
D(SETI(-1))	0.114274	-0.50190	1.523858	-0.03109	-0.02413	0.343491	1.513761	-6.2E-05
	[0.2823]	[-0.6485]	[0.5121]	[-0.2303]	[-0.1746]	[0.6983]	[1.1252]	[-0.1985]
D(PSEI(-1))	0.13918	0.761293	1.206895	0.02353	0.01177	-0.02985	0.6473	6.39E-05
	[1.2120]	**[3.4666]**	[1.4293]	[0.6143]	[0.3002]	[-0.2138]	[1.6956]	[0.7191]
D(TWII(-1))	0.00095	0.103464	-0.05415	0.00197	0.01037	0.042958	0.180185	1.68E-05
	[0.0244]	[1.3919]	[-0.1895]	[0.1524]	[0.7818]	[0.9092]	[1.3945]	[0.5596]
D(D (-1))	-99.8649	-347.771	-932.312	-66.7648	-21.9059	-126.797	-414.296	-0.03997
	[-0.7618]	[-1.3873]	[-0.9673]	[-1.5272]	[-0.4894]	[-0.7958]	[-0.9507]	[-0.3943]
C	-20.3597	2.791016	-72.8366	-4.30451	-4.18908	-19.4120	-20.2838	0.009098
	[-1.6596]	[0.1190]	[-0.8075]	[-1.0521]	[-1.0000]	[-1.3018]	[-0.4974]	[0.9591]
R-squared	0.091441	0.294196	0.121806	0.14602	0.08478	0.09706	0.171817	0.023102
F-statistic	1.151818	**4.770323**	1.587349	1.95686	1.06025	1.230195	**2.374302**	0.270639

Source: Author's own calculation

Table 8. Parsimonious VECM with DSSEC as dependent variable

Variable	Coefficient	Std. error	*t*-Statistic	Prob.
DJKSE	-1.415195	0.304771	-4.643464	0.0000
DPSEI	0.360639	0.257165	5.402362	0.1636
DBSESN	0.400682	0.066115	6.060332	0.0000
C	-1024.478	392.3037	-2.611441	0.0103
R-squared	0.674763	*F*-statistic		57.05365

Source: Author's own calculation

previous subsection. The equation is conducted with intercept and trend assumption on CE with linear deterministic trend in data.

The comprehensive VECM estimates for seven Asia Pacific emerging market indices are listed in table 7. The numbers within the parentheses describes the *t*-statistics value. The *F* tests given in that table are to test the hypothesis that collectively the various lagged coefficients are zero. The high *F*-stat value on *SSEC* and *TWII* equations reveals the "meteor shower" potential on those variables. However, the statistically least significant lag variables are sequentially eliminated so that parsimonious specification is obtained following Ndako (2008). The parsimonious VECM is used to examine the existence of significant interdependencies among variables.

The VECM equations suggest that there exists an interdependence pattern in response to *SSEC*. The significant influences come from the response of *JKSE*, *BSESN*, and *PSEI* so that the parsimonious equation is built using those variables as independent ones. The estimation is conducted on first difference data. Table 8 shows the results of parsimonious VECM with *SSEC* as dependent variable.

The "meteor shower" effect apparently exists on the internal relationship effects on SSEC. With *R*-squared 0.675 and *F*-stat coefficient 57.056, the parsimonious VECM suggests that *SSEC* is significantly influenced by *JKSE* on the previous lag, *BSESN* on the previous lag, and *PSEI* on the previous lag. It can be said that the main factors that influenced the *SSEC* movement pattern are *BSESN*, *JKSE*, and

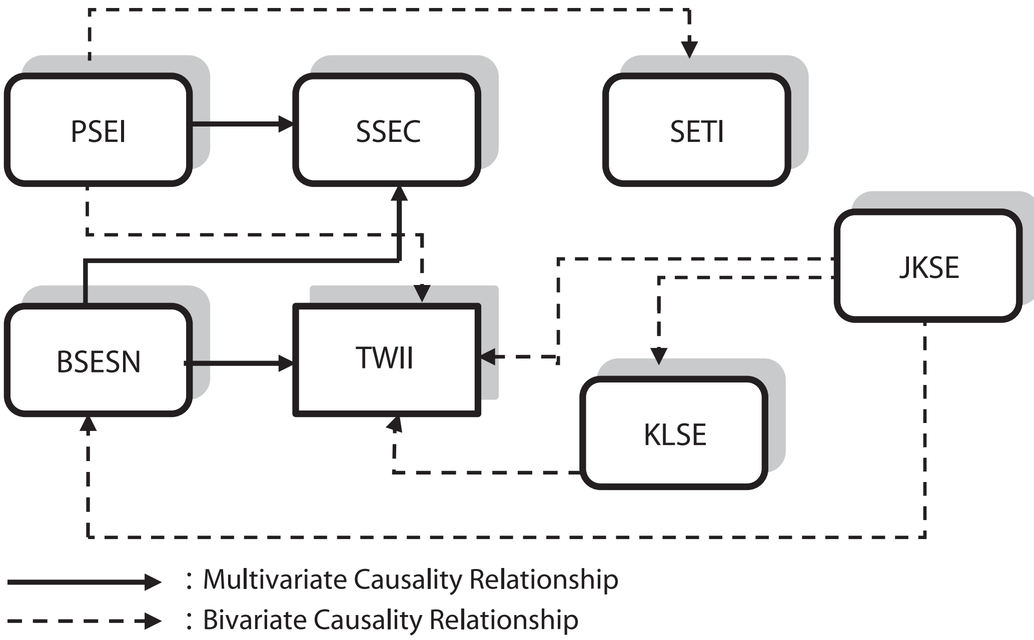

Figure 2. The causality relationship on Asia Pacific emerging market stock price indices

Table 9. Parsimonious VECM with DTWII as dependent variable

Variable	Coefficient	Std. Error	*t*-Statistic	Prob.
DBSESN	0.214449	0.011611	18.46923	0.0000
C	4349.748	139.0694	31.27753	0.0000
R-squared	0.751163	*F*-statistic		341.1123

Source: Author's own calculation

PSEI. However, to say that it consists of meteor shower effects, the exogeneity test should be conducted since that effect examines the causality relationship among variables.

The VECM equations also suggest that an interdependence pattern exists in response to *TWII*. Only that the significant influences come only from the response of *BSESN*. The parsimonious VECM again prove that the relationship between *TWII* and *BSESN* significantly exists. At last, the VECM equation suggests that *JKSE* and *PSEI* are not significantly influenced by other proxies. The tendency of the *heat waves* effect seems existing on these situations though the situations on *JKSE* and *PSEI* are inconclusive. The causality relationship to examine the direction of causality is tested by Multivariate Granger Causality test based on the output of parsimonious VECM test.

Granger Causality test

Toda and Phillips (1993) stated that the causality tests are valid asymptotically as χ^2-Wald criteria only when there is sufficient co-integration with respect to the variables whose causal effects are being tested. Since the data have one co-integration relationship, the Granger Causality test can be used to detect the specific causality relationship among variables. The greater χ^2-Wald value suggests the endogenous variable significantly cause the exogenous variable.

The empirical of the Pairwise Granger Causality suggests that *BSESN* Granger causes *SSEC* (χ^2 = 14.85839), *PSEI* Granger causes *SSEC* (χ^2 = 12.01752), and *BSESN* Granger causes *TWII* (χ^2 = 11.96404). Eight bivariate causality relationships that are found on those variables strengthen the co-integration pattern among the variables.

From those types of Granger Causality test, the results can be summarized into the causality relationship Figure 2. It depicts that in the system, the major sources of disturbances are changes in country-specific fundamentals, especially in *PSEI*, *BSESN*, *SETI*, *KLSE*, and *JKSE*. In other words, it transmits the information internally within the same market and tend to suffer from heat waves effect. A shock transmission in different regions and time zones can be found on causal relationship within two stock market indices from East Asia. *SSEC* tends to follow what has happened on *PSEI* and *BSESN* on the previous *t.* While TWII tends to follow what has happened on BSESN on the previous *t.* The interesting fact is when China, as the largest market capitalization on Asia, is apparently influenced by the Philippines, the much smaller market capitalization.

Impulse Response Functions

On IRF model, the response of the shock in variables to the new information is measured by 1 standard deviation (SD) innovations. The impulse response similarities will be found on *SSEC* and *TWII* responses. In response to *SSEC*, the negative responses on early periods will be found on the responses of all variables in the second period. Except the response of *KLSE*, those variables will bounce back on the next period significantly. Meanwhile, *KLSE* will significantly respond on the second period, and then get less significant response on the third period. Meanwhile in response to *TWII*, both *TWII* and *SSEC* will respond to *TWII*'s shocks negatively until period 5, and then reach the long term equilibrium on the next period. It is consistent with the responses of those indices to all indices but *SETI*. *KLSE* will emerge the same response like its responses to *PSEI* and *SETI*, which will give a monotonic response since it will just positively respond until period 5 and then reach the steady state condition or long-term equilibrium.

The shock of *JKSE* will be responded positively by all variables on the first four periods. The positive response to *JKSE* simply means that the shock of *JKSE* will cause the rise on the responding variables, vice versa. The negative response to *JKSE* will be continued to the fifth period, except the response of *KLSE*. The responses tend to be less significant to converge to the long-term equilibrium. Meanwhile in response to *PSEI*; *SSEC*, *TWII*, and *SETI* will make a positive response in period 2 and turn down in period 3. Only that *SETI* will still have significant positive responses until period 8. The responses to *BSESN* shock also tend to be less significant to reach the long-term equilibrium. The significant negative responses to the shock of *BSESN* on period two will obviously happen on all variables. At last, the responses of all variables to *KLSE* on early period are homogenous. They will positively respond until period 3.

Particularly, the empirical result of the Impulse Response Function test simulates that the country specific factor is the main reason that the signal will be transmitted through the shock of the variable in the future. Most significant response will happen on the early period, especially in period two, since the responses tend to be less significant to reach the long-term equilibrium in the indefinite period. The similar functions looks like happen on certain indices, like in China and Taiwan as countries of Eastern Asia emerging market. Similarity also happens in response to Indonesia and China in one SD innovations. All indices will positively respond to both *JKSE* and *KLSE* on early period, and then will converge into steady state shock.

Conclusion

The observed high correlations across Asia Pacific emerging markets brings into question the wisdom of large diversification benefits from international investing on the region. A long term relationship among seven Asia Pacific emerging market stock price indices during October 2001 until April 2011 suggests that investors did not obtain the risk reduction benefit from the diversification since the indices do not offset the risk of other indices. That means all tested variables in the short term were integrated each other to reach their long term equilibrium. The co-integration is unique since there is no flexibility to achieve equilibrium in equation. This situation can be associated as a common movement among any simultaneous variables during the research period since there exists some influences on the series which imply that the markets are bound by some relationship in the long run or integrated, in other words. So, since the market integration across Asia Pacific emerging market exists, it can be said that focusing on Asia Pacific emerging markets did not provide much benefit to international diversification during the late-2000s recession. Focusing the portfolio on the Asia Pacific emerging market only is not encouraged considering the final result of the research. Equity investors, need to hedge the risk of the portfolio by diversifying their assets on may be different emerging market region on the globe, such as Midwest, Africa, Europe, or South America.

Several interdependencies on the multivariate systems are revealed by parsimonious Vector Error Correction Model. The estimations of *SSEC* and *TWII*, which belong to East Asian hemisphere, are the most significant estimates among the others. They tend to follow certain variables from the previous time ($t - 1$). The multivariate Granger Causality tests strengthen the phenomenon that *SSEC* and *TWII* have meteor shower potential. Meanwhile, the rest variables such as *KLSE*, *SETI*, and *JKSE* tend to have heat waves effects since they are not significantly influenced by other variables in multivariate system. The result is consistent with Engle et al. (1990) statement that the "meteor showers" and "heat waves" effects are not mutually exclusive and, hence, during any period of time both of them can co-exist, even though one may dominate. The Impulse Response Function simulates that the country specific factor is the main reason that the signal will be transmitted through the shock of the variable in the future. Most significant response will happen on the early period then the responses tend to be less significant to reach the long-term equilibrium in the indefinite period.

For the next research, the analysis and finding of volatility spillovers during the crisis is encouraged since the stock movement may vary over time. The volatility analysis provides more information of the variables' interdependencies and information transmissions and is very useful in detecting the existence of time-varying variance and volatility clustering on the observed data. When return distribution data shows asymmetric pattern, and the associated variances are non constant, the resulting model can be used to predict (Febrian and Herwany, 2009). Since this research employs only 114 monthly data during the global financial crisis 2008, the detail estimations on the pre -crisis and on-crisis period are not possible to estimate. The monthly data is al so not encouraged to estimate the variance process since the standard deviations of the data will be so high (Engle et al., 1990). That is the reason that this research does not touch the variance process estimation to determine the volatility spillovers.

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