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Linkages among Asian Stock Markets using a Vector Error Correction Model

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Abstract This paper analyses the degree of financial interdependence among Asia financial markets including Korea, Japan and China as well as ASEAN countries by dealing with the data through 2001 2013. The empirical results such as the cointegration and Vector Error Correction Model show that most countries respond significantly to shocks from other markets. In Asian Markets, China, Hong Kong, Japan, Korea, Singapore and Taiwan had appreciable impacts on other markets and those shocks were transmitted to other markets for 1 or 2 months. Variances Decomposition shows that Most Asian stock markets are appreciably influenced by each other at every six month ahead, especially by China. Korea has appreciable impacts of its own Korean innovations at every six month ahead. By contrast, the impulse responses of China and Japan to the other Asian markets were relatively small.

Keywords East Asia, Stock Market, Cointegration, Vector Error-Correction

JEL Classification F36, F33

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1. INTRODUCTION

Since the 1990s East Asia has benefited from WTO system which pursues globalization and open regionalism. World trade is tri-polarized in Europe, North America, and East Asia. Throughout the Asian economic crisis starting in July 1997, ASEAN+3 countries such as Korea, Japan and China have been involved in regional economic cooperation in 1990, so that East Asian region has developed economically and emerged as a major economic zone following the EU and NAFTA.

But after year 2008, global financial crisis and the severe recession exacerbated the Asian economy as well as the global economy. In global integration era, a crisis in one country may have the serious economic risk to affect the possibility of raising a crisis for other countries. These contagion effects of the financial crisis can get stronger as the financial markets are globally or locally more integrated as Glick and Rose (1999) pointed out. The openness with capital mobility across the region may raise not only economic efficiency but also contagion effects of the financial crisis. The East Asian countries have become more influential in global trade and open regionalism in 2000s. More importantly, the openness and the deepening of financial integration will foster the economic efficiency and lead to higher economic growth with stronger competition as Welfens and Kim (2009) argued.

Despite that, even though there have been many studies on regional economic integration in the real trade sector, there have been quite fewer studies in financial integration in Asia regions associated with global financial crisis. Based on this backdrop, this paper will focus on the degree of financial interdependence or integration in East Asia regions.

In this regards, it is very worthwhile to analyze the financial markets interdependence or financial integration using recent East Asian financial data. This paper highlights three key aspects.

Firstly, most previous studies such as Alexeis et al.(1997), Arshanapali and Dukes (1993), Angresano (2004) did not consider the recent financial crisis. They did not use the strict econometric methodologies, so that they did not give us the quantitatively informative analysis. Achsani and Siregar (2007, 2009) did not consider the cointegration in financial or stock markets. They adopted only a standard VAR model and conventional Granger causality tests. However, if we dont consider this cointegration when there are the stable relations among stock markets or cointegrated financial markets, it may lead inconsistent estimates and mislead the empirical interpretation and inferences.

Secondly, the cointegration analysis has been considered by Royfaizal, Lee

and Azali (2009), Leong and Felmingham (2003), Awokuse et al. (2009) and Majid et al.(2008). However, most previous studies did not consider post global financial crisis of 2008. This paper adopts the cointegration methodologies to examine the linkages among stock markets.

Thirdly, Click and Plummer (2005) analyzed the stock market integration in ASEAN using a cointegration approach after the Asian financial crisis of the end of 1990s. They just analyzed whether the stock markets in ASEAN 5 countries was cointegrated or not. But, they did not analyze the interdependences and transmission mechanism using an error correction model.

Thus, this paper will analyze the Asian stock market integration using the error correction cointegration approach, error correction causality test and the Vector Error Correction methodologies including global crisis period unlike most previous studies. This paper expands on the literature by applying several advanced econometric framework with the use of the latest data, which covers the period after the global financial crisis. The remainder of the paper is as follows. Section II introduces the previous literature. Section III explains the empirical specification. Section IV analyzes empirical results of correlation, cointegration tests, error correction causality test and the Vector Error Correction models. Section IV summarizes and concludes empirical findings..

2. LITERATURE REVIEW

After the global shock in year 1987, the international markets deepened integration and US had strong influence on all other markets as a dominant power. Panton et al. (1976) and Hilliard (1979) found strong interdependence among main European countries of Germany, UK, France and Switzerland. According to Glick and Rose (1999), a crisis in one country affects the possibility of raising a crisis for other countries. As Janakiramanan and Lamba (1998) pointed out, stock markets may have interdependence since one market reacts both directly and indirectly to the initial shock by the time difference. Common investor groups are composed by geographically close countries or similar backgrounds and the larger market effects on small markets. Kaminsky and Reinhart (2000), Van Rijckeghem and Weder (2001), Caramazza, Ricci, and Salgado (2004) analyzed international financial integration.

Strohe and Achsani (2004) studied the comparison of East and West European markets. They found clearly that West European Markets have strong integration but East European Markets are not such integrated. Welfens and Keim (2009), introduced the historical process of financial market integration in the

EU such as EMU, ESCB and ECB and well explained theories of the financial market integration and endogenous growth theories as well as the welfare effects of the financial market integration.

However, most previous studies above concerning financial market interdependence have focused on the developed markets in western advanced countries. Results from these studies didnt present a variety of direct analysis on the financial linkages in developing countries such as Asia. Achsani and Siregar (2007, 2009) began to analyze the financial and economic integration among 10 ASEAN members plus China, Japan and Korea using VAR or Fuzzy Clustering approach and the data 1992 through 2002.[1] Awokuse et al. (2009) investigated the structural change and international stock market interdependence among Asian emerging markets. Leong and Felmingham (2003) and Majid et al.(2008) examined the interdependence of East Asia stock markets and ASEAN-5 Stock Markets from the US and Japan, respectively.

In recent years, using the cointegration analysis, Click and Plummer (2005) analyzed 5 ASEAN stock market integration after the Asian financial crisis. Lim et al. (2008) analyzed the financial crisis and stock market efficiency using from Asian countries. They did not use VECM after financial crisis of 2008. Yi and Lim (2013) analyzed the EU financial market integration using VAR. Royfaizal, Lee and Azali (2009) examined the linkages between ASEAN-5+3 and US stock markets (Malaysia, Singapore, Philippines, Thailand, Indonesia, China, Japan and Korea). The data they used is weekly stock indices data, the total samples are separated into three sub-periods: pre-crisis period spanning from 1990 to 1997; crisis-period from 1997 to 1998; and post-crisis period from July 1998 to May 2007. They apply the Johansens cointegration test and VECM for each period before financial crisis of 2008.

Thao and Kevin (2012) investigated whether the relationship between Asian equity markets in Southeast Asian such as Thailand, Malaysia, Singapore and Philippine countries have changed or not as a result of the Global Financial Crisis. Most previous, however, did not use the recent data after financial crisis of 2008 and did not use error correction causality test to get more efficient estimates to analyze the stock markets interdependence in Asia region.

[1] See also Arshanapali et al. (1995), Chan et al. (1992) and Wong et al. (2004) for earlier studies.

3. EMPIRICAL FRAMEWORK

This paper uses 10 Asia + Oceania countries(hereafter East Asia) stock markets(Japan(JP), South Korea(KR), China(CH), Singapore(SG), Malaysia(MA), Indonesia(IN), Taiwan(TW), Australia(AU), Hong Kong(HK) and India(ID)). Thus, this paper adopts total 10 nations monthly stock data from February 2001 through January 2011. The starting point is 2001 because data on monthly data since 2001 can be accessible to more common sources of information for many countries. The data were compiled from IMF, Yahoo Finance and Bloomberg. The stock indices are obtained by each local currency and then converted into the monthly return rates in logarithm as usual.

In this section, the VAR model is similarly adopted to analyze the dynamic co-movements and interactions among the stock markets following Yi and Lim (2013). As Sims (1980) pointed out, VAR model can analyze multiple variables which affect the dynamics of interaction between the variables. VAR has characteristics to interpret the error term structurally and be placed the covariance matrix of error terms by identified constraints.

When Cholesky decomposition is employed, theoretical or empirical support should be given to rationalize the order of variables. The variable ordering of Sims orthogonalization would be justified.[2] The impulse response can be very sensitive to the order of variables especially when the number of variables is big such as ten in the case of this paper. The opening-closing time or relative size of stock market can be used to determine the order of variables.

Due to time differences among countries, there is a definite order of market closings. Specifically, the Taiwan Stock Exchange closes earliest among the countries analyzed in this paper (05:30 GMT), then the Tokyo, Korea, and Australian Exchanges close at the same time (06:00 GMT), next the Shanghai Stock Exchange closes at 07:00 GMT, HK closes at 08:00 GMT, Singapore closes at 09:00 GMT and India closes at 09:00 GMT etc.

Thus, there would be a one-way influence from the earlier closing market to later closing markets. However, the reverse influence, say, from Shanghai to Tokyo, would be contaminated by news emanating from intervening countries in South Asia, the Middle East, Europe, the Americas, and the like. Consequently, this paper considers both the opening-closing time and relative size of stock market to determine the order.

In order to solve residual autocorrelation and trade-offs, we have to select the appropriate lagged values of variables. To do this, the unit root test by the Aug-

[2]See Tsutsui and Hirayama (2004).

mented Dickey-Fuller Test (ADF) is conducted and the order, p, can be selected using Akaike Information Criteria (AIC) or Schwarz Bayesian Criteria(SBC) in this paper. Furthermore, using impulse response, we will analyze the effect how shocks are transmitted to all other countrys markets using the following Impulse response of the VAR.[3] The objective is the reaction of the system to a shock as follows with a shock(a_t).

$$Y_t = c + \Phi_1 Y_{t-1} + \Phi_2 Y_{t-2} + \cdots + \Phi_p Y_{t-p} + a_t \tag{1}$$

If the system is covariance-stationary and we assume that $\Phi(L)$ and $\Psi(L)$ denote the functions of lag operators(L) as usual, then we have equation (2).

$$\begin{aligned} Y_t &= \mu + \Psi_L a_t = \mu + a_t + \Psi_1 a_{t-1} + \Psi_2 a_{t-2} + \cdots, \\ &\text{where } \Psi(L) = [\Phi(L)]^{-1}. \end{aligned} \tag{2}$$

Redating at time t+s, we can have the following equation

$$\begin{aligned} Y_{t+s} &= \mu + a_{t+s} + \Psi_1 a_{t+s-1} + \Psi_2 a_{t+s-2} + \cdots + \Psi_s a_t + \Psi_{s+1} a_{t+1} + \ldots, \\ &\text{where } \frac{\partial Y_{t+s}}{\partial a_{t+s-i}} = \Psi_i. \end{aligned} \tag{3}$$

The relative importance of each market in the VAR systems could be analyzed by using the decomposition of forecasting error variance.[4] The results will show that countries have a significant influence each other or could be the dominate market in explaining the error variance in the other market. Contribution of the j-th orthogonalized innovation to the MSE (Mean Squares Error) of the s-period ahead forecast.

$$MSE(\hat{Y}_t(S)) = E(Y_{t+s} - \hat{Y}_t(S))(Y_{t+s} - \hat{Y}_t(S)) \tag{4}$$

If we set $e_t = Y_{t+s} - \hat{Y}_t(S) = a_{t+s} + \Psi_t a_{t+s-1} + \cdots + \Psi_{s-1} a_{t+1}$, then we have $E e_t(S) e_t(S)'$=$\Sigma_a + \Psi_1 \Sigma_a \Psi_1' + \cdots + \Psi_{s-1} \Sigma_a \Psi_{s-1}'$. Thus the MSE[5] can be written as follows in this paper.

[3] See Yi and Lim (2013).

[4] Hamilton (1994), pp.304-305.

[5] Recall that $M_1 = \Psi_1 P^{-1}$, $M_0 = P^{-1}$, and $\Psi_0 = I$.

$$MSE = P^{-1}P\Sigma_a P'(P^{-1})' + \Psi_1 P^{-1}P\Sigma_a P'(P^{-1})'\Psi_1' + \cdots \tag{5}$$
$$+\Psi_{s-1}P^{-1}P\Sigma_a P'(P^{-1})'\Psi_{s-1}' = M_0M_0' + M_1M_1' + \cdots + M_{s-1}M_{s-1}'$$

.

Now if we have cointegrating vectors, we can represent and analyze the Error-Correction VAR model. To do this Error-Correction VAR model, we can rearrange equation (3) to equation (6) for $s = 1, 2, \cdots, p-1$.

$$Y_t = \zeta_1\Delta Y_{t-1} + \zeta_2\Delta Y_{t-2} + \cdots + \zeta_{p-1}\Delta Y_{t-p+1} + \alpha + \rho Y_{t-1} + a_t, \tag{6}$$
$$\text{where } \rho \equiv \sum_{r=1}^{p}\Phi_r \text{ and } \zeta_s \equiv -\sum_{r=s+1}^{p}\Phi_r. \tag{7}$$

Subtracting Y_t from both sides of (6) produces

$$\Delta Y_t = \zeta_1\Delta Y_{t-1} + \zeta_2\Delta Y_{t-2} + \cdots + \zeta_{p-1}\Delta Y_{t-p+1} + \alpha + \zeta_0 Y_{t-1} + a_t, \tag{8}$$
$$\text{where } \zeta_0 = \rho - I_n = -\Phi(1).$$

Note that if Y_t has h cointegrating vectors, then we have

$$\Delta Y_t = \zeta_1\Delta Y_{t-1} + \zeta_2\Delta Y_{t-2} + \cdots + \zeta_{p-1}\Delta Y_{t-p+1} + \alpha - \zeta_0 A' Z_{t-1} + a_t. \tag{9}$$

Now we assume $Z_{t-1} = A'Y_t$ and A is the appropriate vector, and then Z_t has a stationary $(h \times 1)$ vector if we have h numbers of cointegrating vectors. That is, Z_t is the stationary Error Correction element. Then we have the Vector Error Correction Model (VECM) which is a restricted VAR designed for use with non-stationary series. The VECM has cointegration relations so that it restricts the long-run behavior of the endogenous variables to converge to their cointegrating relationships while allowing for short-run adjustment dynamics.

The cointegration term Z_t is known as the error correction term since the deviation from long-run equilibrium is corrected gradually through a series of partial short-run adjustments. In long run equilibrium, this term is zero. However, if each variable deviates from the long run equilibrium, then the error correction term will be nonzero and each variable adjusts to partially restore the equilibrium relation. The coefficient measures the speed of adjustment of the endogenous variable towards the equilibrium.

Most previous papers adopted the Granger causality test which is a technique for determining whether one time series variable is caused in forecasting another.

The conventional causality in the sense defined by Granger (1969) and Sims (1972) is inferred when lagged values of a variable y_t and x_t have explanatory powers in a regression of a variable y_t. A particular regressive model of lagged value p with error term(v_t) can be written as follows:

$$\Delta y_t = \alpha_1 y_{t-1} + \cdots + \alpha_p y_{t-p} + \beta_1 x_{t-1} + \cdots + \beta_p x_{t-p} + v_t. \tag{10}$$

By OLS method, F-test of the null hypothesis $H_0 : \beta_1 = \cdots = \beta_p = 0$ (x does not Granger-cause) can be conducted and the sum of square residuals to univariate autoregression for y_t.

However, this paper did not use this conventional Granger causality test unlike previous papers such as Achsani and Siregar (2007, 2009) and Awokuse et al. (2009). This conventional Granger causality test is not valid because two integrated series cannot cause each other in the long run unless they are cointegrated. In such a case, we have to use VECM representations for the cointegrated variables to test the error correction causality in this paper as follows:

$$\Delta y_t = \sum_i^p \alpha_i \Delta y_{t-i} + \sum_i^p \beta_p \Delta x_{t-p} + \gamma z_{t-1} + u_t. \tag{11}$$

Then we can estimate it by OLS and obtain S statistics for the causality test

$$S = \frac{(RSS_2 - RSS_1)/p}{RSS_1/(T-2p-1)}, \tag{12}$$

where unrestricted sum of squared residuals (RSS_1) = $\sum_{\forall t} \hat{u}_t^2$ and restricted sum of squared residuals (RSS_2) = $\sum_{\forall t} \tilde{u}_t^2$ with the null hypothesis $H_0 : \beta_1 = \cdots = \beta_p = \gamma = 0$. We can reject the null hypothesis if $S > F_{\alpha,(p,T-2p-1)}$ at a significance level α. That is, if S is greater than the critical value that it S rejects the null hypothesis that x does not Granger-cause y.

4. EMPIRICAL RESULTS

4.1. CORRELATION AMONG ASIAN STOCK MARKETS

This paper begins with the analysis of the Asian situations and their features. This analysis will observe whether one market is correlated with other markets or uncorrelated. The result could be indicated that the correlation coefficients are positive and large. Table 1 indicates the correlation coefficients between market returns among the Asia regions from February 2001 to January 2011. Comparison analysis was divided into before and after the global financial crisis in 2008. In particular, stock markets tend to have strong correlations among Singapore, Indonesia and Malaysia as members of ASEAN.

The results show that all markets are correlated significantly as the correlation coefficients are positively recorded, because these markets are closed geographically and economically. ASEAN tend to keep highly integrated with ASEAN nations but lowly integrated with non-ASEAN member. The results also show that correlations coefficients after the crisis are slightly and relatively lower than those before the crisis. The correlations coefficients between China and other countries are relatively lower than those of the other countries due to somewhat more controlled China stock market compared to other market economy countries.

To choose the appropriate lags(p) of the VAR models in this paper and to have the unbiased and efficient estimators, we obtain the appropriate lagged number (=2) by AIC (Akaike Information Criteria) and SBC (Schwarz Bayesian Criteria) in 10 Asian countries(Japan, South Korea, China, Singapore, Malaysia, Indonesia, Taiwan, Australia, Hong Kong, India) as shown in Table 2.

4.2. UNIT ROOT AND COINTEGRATION TEST

We employ the ADF (augmented Dickey-Fuller Test) unit root tests with the constant terms to test whether the time series are stationary or not. The results of unit root test on variables of each nation are as follows: As we can see in the (Table 3), all stock variables of Asia regions can accept the null hypothesis that the unit root exists at 1% or 5% significance level. Thus, the level variables of Asian stock market are not stationary. On contrast, all log differenced stock variables reject the null hypothesis at 1%, 5% and 10% significance levels.

Table 1: Correlation coefficients in Asia Regions

	AU	CH	HK	IN	ID	JP	KR	MA	SG	TW
A. Before global financial crisis(before year 2008)										
AU	1.00	0.74	0.94	0.97	0.95	0.88	0.97	0.95	0.99	0.92
CH		1.00	0.85	0.78	0.79	0.55	0.74	0.79	0.78	0.77
HK			1.00	0.97	0.97	0.76	0.94	0.94	0.96	0.93
IN				1.00	0.98	0.80	0.97	0.96	0.96	0.92
ID					1.00	0.73	0.96	0.97	0.95	0.91
JP						1.00	0.81	0.74	0.86	0.79
KR							1.00	0.95	0.96	0.94
MA								1.00	0.97	0.94
SG									1.00	0.95
TQ										1.00
B. After global financial crisis(after year 2008)										
AU	1.00	0.76	0.90	0.54	0.64	0.90	0.72	0.65	0.84	0.79
CH		1.00	0.77	0.43	0.59	0.68	0.56	0.58	0.66	0.70
HK			1.00	0.78	0.87	0.72	0.90	0.86	0.97	0.95
IN				1.00	0.96	0.22	0.94	0.98	0.88	0.86
ID					1.00	0.33	0.95	0.97	0.93	0.93
JP						1.00	0.45	0.34	0.61	0.55
KR							1.00	0.95	0.96	0.95
MA								1.00	0.93	0.91
SG									1.00	0.96
TQ										1.00
C. Entire periods										
AU	1.00	0.73	0.89	0.74	0.82	0.76	0.87	0.83	0.95	0.87
CH		1.00	0.85	0.71	0.75	0.37	0.74	0.76	0.77	0.75
HK			1.00	0.91	0.95	0.48	0.94	0.93	0.96	0.92
IN				1.00	0.98	0.20	0.95	0.97	0.87	0.83
ID					1.00	0.33	0.97	0.96	0.91	0.86
JP						1.00	0.42	0.33	0.62	0.56
KR							1.00	0.96	0.94	0.90
MA								1.00	0.94	0.91
SG									1.00	0.95
TQ										1.00

Table 2: Lag order selection by the criterion

Region	Period	Log L	AIC	SBC	VAR(p)
Asia	Before Financial Crisis	-5473.789	127.7256	133.5977	VAR(2)
	After Financial Crisis	-1966.205	124.3545	133.6866	VAR(2)
	Entire Period	-7215.002	129.7414	137.1001	VAR(3)

* Table 2 shows a short summary of the results to select lag order by the criterion.

Table 3: Unit root test

Difference		AU	CH	HK	IN	ID	JP	KR	MA	SG	TW
Level	Statistic	-1.40	-1.85	-1.39	-0.39	0.45	-1.72	-0.70	-0.71	-1.43	-1.89
	1 % level	-3.49	-3.49	-3.49	-3.49	-3.49	-3.49	-3.49	-3.49	-3.49	-3.49
	5 % level	-2.89	-2.89	-2.89	-2.89	-2.89	-2.89	-2.89	-2.89	-2.89	-2.89
	p-value	0.58	0.35	0.59	0.91	0.98	0.42	0.84	0.84	0.56	0.33
1st Difference	Statistic	-4.87	-4.76	-5.82	-5.48	-4.26	-5.07	-4.98	-4.96	-5.28	-5.30
	1 % level	-3.49	-3.49	-3.49	-3.49	-3.49	-3.49	-3.49	-3.49	-3.49	-3.49
	5 % level	-2.89	-2.89	-2.89	-2.89	-2.89	-2.89	-2.89	-2.89	-2.89	-2.89
	p-value	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Now to check the cointegration, in this paper we adopted Johansens Cointegration Tests on the null hypothesis $r = 0$, $r \leq 1$, $r \leq 2$ or $r \leq 3$ in Table 4, Table 5 and Table 6. r is the number of cointegrating vectors.

Table 4: Cointegration Rank Test before global financial crisis

Unrestricted Cointegration Rank Test (Trace)- before global financial crisis				
Hypothesized No. of coitegrating vectors	Eigenvalue	Trace Statistic	0.05 Critical Value	*Prob.***
$r = 0$*	0.633102	426.4611	273.1889	0.0000
$r \leq 1$*	0.570048	338.2259	228.2979	0.0001
$r \leq 2$*	0.518248	263.9467	187.4701	0.0000
$r \leq 3$*	0.48556	199.6781	150.5585	0.0000

* denotes rejection of the hypothesis at the 0.05 level.
** MacKinnon-Haug-Michelis (1999) p-values.

Table 5: Cointegration Rank Test after global financial crisis

Unrestricted Cointegration Rank Test (Trace)- after global financial crisis				
Hypothesized No. of coitegrating vectors	Eigenvalue	Trace Statistic	0.05 Critical Value	*Prob.***
$r = 0$*	0.975993	512.1431	239.2354	0.0000
$r \leq 1$*	0.943645	381.6136	197.3709	0.0000
$r \leq 2$*	0.922105	280.9508	159.5297	0.0000
$r \leq 3$*	0.861057	191.6171	125.6154	0.0000

* denotes rejection of the hypothesis at the 0.05 level.
** MacKinnon-Haug-Michelis (1999) p-values.

Table 6: Cointegration Rank Test for entire periods

Unrestricted Cointegration Rank Test (Trace)- entire periods				
Hypothesized No. of coitegrating vectors	Eigenvalue	Trace Statistic	0.05 Critical Value	*Prob.***
$r \leq 0$*	0.488149	378.1636	273.1889	0.0000
$r \leq 1$*	0.469934	300.4759	228.2979	0.0000
$r \leq 2$*	0.365073	226.8445	187.4701	0.0001
$r \leq 3$*	0.319259	174.152	150.5585	0.0012

* denotes rejection of the hypothesis at the 0.05 level.
** MacKinnon-Haug-Michelis (1999) p-values.

As we can see in three tables, we divide into two periods whether there is a difference between pre the financial crisis of 2008, after the financial crisis in Asia nations and Australia. Both periods of the pre and the post financial crisis of 2008 and entire period can reject the null hypothesis at the 5 % significant level. The Asian financial stock market is cointegrated with at least 3 cointegrating vectors at the 5 % significance level.[6] While the global financial crisis of 2008 exacerbated the Asian economy as well as the global economy, Asian stock markets have a long-run equilibrium relationship. There has been the stable interdependence among Asian financial markets due to long historic and economic backgrounds as ASEAN member countries regardless of financial crisis of year 2008.

[6]The hypotheses that there exist more than 4 cointegrating vectors were rejected.

4.3. ERROR CORRECTION CAUSALITY TEST

As we mentioned before, this paper did not use this conventional Granger causality test since if the conventional Granger causality test is not valid because when Asian financial or stock markets are cointegrated. Thus, this paper uses the error correction causality approach. The results of Error Correction Granger-Causality tests are described in Table 7. In Table 7, while the first row countries are independent countries, the first column countries are dependent countries. The Error Correction Granger-Causality test investigates the importance of one market in influencing another market. Table 7 shows that Australia, China, Hong Kong, Korea, Singapore and Taiwan Granger-cause other markets. In particular, China and Hong Kong stock markets are the most dominant markets. The China stock market Grange-causes Australia, Hong Kong, India, Malaysia and Singapore stock markets. Hong Kong stock market Grangecauses Australia, India, Indonesia, Korea, Malaysia, Singapore and Taiwan stock market. Hong Kong stock market is Grange-caused by China and Korea stock market.

While India and Indonesia stock markets Grange-cause Malaysia stock market, Malaysia stock market also Granger-causes India stock market. Japan stock market Granger-causes India, Malaysia and Singapore stock markets and Japan stock market is influenced by Korea and Taiwan stock markets. Korea stock market Grange-causes Hong Kong, Japan, Malaysia and Taiwan stock markets. Korea stock market is influenced by Australia, Hong Kong and Taiwan stock markets. While Malaysia stock market Grange-causes India stock market, Malaysia stock market is influenced by Australia, China, Hong Kong, India, Indonesia, Japan, Korea, Singapore and Taiwan stock market. Singapore stock market Grangecauses Australia, India and Malaysia stock markets. Singapore market is affected by China, Hong Kong and Taiwan.

These results could be derived from differences of the opening-closing time among countries and relative size of stock market. Japan, Korea, and Australian Exchanges close at the same time (06:00 GMT), next China Shanghai Stock Exchange closes at 07:00 GMT. Thus these stock markets would affect the other stock markets. Hong Kong closes at 08:00 GMT and it affects Singapore stock market which closes at 09:00 GMT and India which closes at 09:00 GMT and other south Asian countries. Taiwan stock market closes at 05:30 GMT and it Grangecauses Japan, Korea, Indonesia, Singapore and Malaysia stock markets.

Thus, as a whole, the stock markets in East Asia seem to have a close interdependence since one stock market reacts to the initial shock. There is a tendency to influence Asia stock markets from the earlier closing market to later closing markets. However, the reverse influence from Hong Kong to Shanghai,

Tokyo, Korea and Australia and mutual influences occurred. This reverse influence would be contaminated by news emanating from intervening countries in South Asia, the Middle East, Europe, the Americas, and the like.

Furthermore, the larger market may affect smaller markets. Most of these markets except China and Japan have been very significantly influenced by other markets such as China and Hong Kong, Japan stock markets. China and Japan are 2 big enough countries which can be significantly influenced not only by East Asian countries but also by other big countries in the world. China stock market was also somewhat relatively more managed by China government than other stock markets.

In particular, some South East Asian stock markets seem to have considerable 2-way Granger-causality due to geographical proximity and close political relationships. South East Asian countries also have the long-rooted historic and economic backgrounds as ASEAN member countries. For example, South East ASEAN-5 countries agreed to form the Federation of ASEAN Stock Exchanges in 1978. The Singapore and Malaysian stock markets were fairly well linked at that time[7], as many Malaysian registered companies traded on the Stock Exchange of Singapore (SES) before financial crises in Singapore during 19851986. Singapore Declaration of 1992 was done to draw the stronger capital market cooperation as part of an effort to direct South East ASEAN economic cooperation. Their stock exchanges in the region tried to cooperate to facilitate cross-border trading and to promote intra- South East ASEAN markets.

Table 7: Error Correction Causality in East Asia

F-value	AU	CH	HK	IN	ID	JP	KR	MA	SG	TW
AU		3.91*	2.79**	0.07	0.01	0.38	0.74	0.01	2.61**	0.78
CH	0.23		0.03	0.34	0.27	0.23	0.35	0.25	0.15	0.89
HK	0.56	3.90*		1.36	2.16	0.53	2.39**	0.90	1.63	1.04
IN	4.76*	2.71**	5.46*		0.80	3.76*	2.21	2.46**	2.91**	3.98*
ID	0.79	1.85	6.52*	1.65		0.84	0.67	1.05	2.26	2.02
JP	0.18	1.25	1.89	1.15	0.00		2.40*	1.32	1.82	3.07*
KR	3.02**	0.66	3.19*	0.85	0.03	0.49		0.88	0.29	2.67**
MA	4.87*	2.43**	6.53*	8.51*	5.74*	2.85**	7.80*		7.84**	2.44**
SG	2.23	2.73**	7.60*	1.14	0.19	4.25**	1.12	1.81		3.16*
TW	0.10	0.21	2.82**	0.87	0.85	0,01	2.71**	1.72	0.39	

*(**): statistically significant at 5(10)% significance level.

[7]See Click and Plummer (2005).

4.4. VECTOR ERROR CORRECTION RESULTS

The results of the VEC model are shown in the Table 8 and Table 9. Table 8 shows the estimated cointegrating vector. In Table 9 we applied the VEC model in 10 countries. Among 10 countries, 6 countries such as Australia, China, Japan, Korea, Singapore and Taiwan have the long-run links with 10 countries. The VEC model has both short-run and long-run information. The significant error correction terms in these countries indicate that there are some adjustment processes which prevent the errors in the long-run relationships becoming larger and larger.

From the results of the VEC model, Australia, China, Japan, Korea, Singapore and Taiwan have the significant error correction terms which mean that these countries are affected and caused by the other countries in the long-run. We can infer that these countries have relatively large open stock market systems so that these stock markets may have the long-run interdependence. Australia itself has the significant long-run adjustment parameter and the significant short-run parameters of China in t-2, Hong Kong in t-1, India in t-2 and Singapore in t-2. This indicates that the stock market indices in China, Hong Kong, India and Singapore influence the stock market of Austria.

China also has its own significant long-run adjustment parameter of error correction in the long-run but in the short-run China stock market is positively affected only by its own China stock index in t-2 and Taiwan stock market index in t-2. Hong Kong does not have the long-run link with other markets but has the short-run positive links with China and Korea in t-2 and the negative link with Malaysia in t-2. Korea and China positively affected Hong Kong in the short-run unlike Malaysia.

Table 8: Cointegration Equation

AU(-1)	CH(-1)	HK(-1)	ID(-1)	IN(-1)	JP(-1)	KR(-1)	MA(-1)	SG(-1)	TW(-1)
1.00000	-0.217387	0.105226	0.105226	-0.722936	-0.556158	1.683120	-12.18627	1.017650	1.198381
	(0.16819)	(0.10087)	(0.10087)	(0.87590)	(0.08197)	(0.98316)	(2.33110)	(0.80124)	(0.19291)
	[-1.29248]	[1.04317]	[1.04317]	[-0.82537]	[-6.78500]	[1.71195]	[-5.22768]	[1.27010]	[6.21210]

* Values in ( ) and [ ] are standard errors and t-statics of estimators, respectively.

Table 9: Vector Error Correction VAR

	D(AU)	D(CH)	D(HK)	D(ID)	D(IN)	D(JP)	D(KR)	D(MA)	D(SG)	D(TW)
Error	-0.056161	-0.095962	-0.133340	-0.156724	-0.017251	0.184505	-0.033494	0.002959	-0.035236	-0.182636
Correction	(0.02329)	(0.03732)	(0.15566)	(0.10928)	(0.01489)	(0.10308)	(0.01023)	(0.00620)	(0.01857)	(0.06520)
Term	2.41153]	[-2.57120]	[-0.85663]	[-1.43412]	[-1.15866]	[1.78995]	[-3.27395]	[0.47722]	[-1.89719]	[-2.80104]
D(AU(-1))	0.124071	0.235065	0.352034	0.164400	0.092551	0.024604	0.133610	0.077368	0.132957	-0.033583
	(0.15691)	(0.25146)	(1.04874)	(0.73630)	(0.10031)	(0.69449)	(0.06893)	(0.04178)	(0.12513)	(0.43930)
	[0.79073]	[0.93482]	[0.33567]	[0.22328]	[0.92261]	[0.03543]	[1.93842]	[1.85183]	[1.06253]	[-0.07645]
D(AU(-2))	-0.149659	-0.227707	-0.606953	-0.681725	-0.196882	-0.826158	-0.221440	-0.066309	-0.122860	-0.745322
	(0.15389)	(0.24663)	(1.02860)	(0.72215)	(0.09839)	(0.68116)	(0.06760)	(0.04098)	(0.12273)	(0.43087)
	[-0.97249]	[-0.92329]	[-0.59008]	[-0.94402]	[-2.00108]	[-1.21288]	[-3.27557]	[-1.61821]	[-1.00107]	[-1.72982]
D(CH(-1))	0.028590	-0.019535	-0.237303	-0.543826	-0.041512	0.252890	-0.063117	-0.011675	-0.005346	-0.316988
	(0.07161)	(0.11476)	(0.47864)	(0.33604)	(0.04578)	(0.31697)	(0.03146)	(0.01907)	(0.05711)	(0.20050)
	[0.39924] [-0.17022]	[-0.49578]	[-1.61832]	[-0.90671]	[0.79785]	[-2.00638]	[-0.61229]	[-0.09361]	[-1.58101]	
D(CH(-2))	0.208929	0.219784	2.260940	1.429914	0.165481	0.752177	0.133562	0.038954	0.152126	0.546220
	(0.07450)	(0.11939)	(0.49793)	(0.34959)	(0.04763)	(0.32974)	(0.03273)	(0.01984)	(0.05941)	(0.20858)
	[2.80449]	[1.84091]	[4.54064]	[4.09030]	[3.47442]	[2.28112]	[4.08122]	[1.96375]	[2.56054]	[2.61878]
D(HK(-1))	0.057915	-0.001676	0.226559	0.276322	0.022416	-0.062874	0.009042	0.008272	0.040953	0.076651
	(0.02605)	(0.04175)	(0.17413)	(0.12225)	(0.01666)	(0.11531)	(0.01144)	(0.00694)	(0.02078)	(0.07294)
	[2.22302]	[-0.04014]	[1.30108]	[2.26023]	[1.34580]	[-0.54524]	[0.79006]	[1.19244]	[1.97111]	[1.05085]
D(HK(-2))	-0.017349	-0.007083	-0.426429	0.006775	-0.019283	-0.245794	-0.026912	-0.012047	-0.018250	-0.172412
	(0.02528)	(0.04052)	(0.16898)	(0.11864)	(0.01616)	(0.11190)	(0.01111)	(0.00673)	(0.02016)	(0.07079)
	[-0.68623]	[-0.17482]	[-2.52349]	[0.05711]	[-1.19298]	[-2.19648]	[-2.42315]	[-1.78960]	[-0.90513]	[-2.43572]
D(ID(-1))	-0.004677	0.024126	-0.120686	-0.052990	0.010481	-0.000590	0.004011	-0.004854	-0.043406	0.051419
	(0.03188)	(0.05110)	(0.21311)	(0.14962)	(0.02038)	(0.14113)	(0.01401)	(0.00849)	(0.02543)	(0.08927)
	[-0.14670]	[0.47216]	[-0.56631]	[-0.35416]	[0.51414]	[-0.00418]	[0.28635]	[-0.57178]	[-1.70705]	[0.57600]
D(ID(-2))	-0.078354	-0.009027	-0.150538	-0.445918	-0.016365	-0.264445	-0.013365	0.002688	-0.034961	-0.017702
	(0.03220)	(0.05161)	(0.21525)	(0.15112)	(0.02059)	(0.14254)	(0.01415)	(0.00858)	(0.02568)	(0.09017)
	[-2.43299]	[-0.17490]	[-0.69935]	[-2.95067]	[-0.79481]	[-1.85517]	[-0.94469]	[0.31346]	[-1.36124]	[-0.19632]
D(IN(-1))	0.007002	0.072384	2.111941	0.461995	0.120223	-0.177434	-0.029282	0.027897	0.206330	-0.278887
	(0.21854)	(0.35023)	(1.46069)	(1.02551)	(0.13972)	(0.96729)	(0.09600)	(0.05819)	(0.17428)	(0.61186)
	[0.03204]	[0.20668]	[1.44585]	[0.45050]	[0.86047]	[-0.18343]	[-0.30502]	[0.47940]	[1.18387]	[-0.45580]
D(IN(-2))	0.076895	-0.237559	1.254220	2.546780	-0.106584	0.665133	0.048423	0.003728	0.047347	0.333884
	(0.20750)	(0.33254)	(1.38694)	(0.97373)	(0.13266)	(0.91845)	(0.09115)	(0.05525)	(0.16548)	(0.58097)
	[0.37057]	[-0.71437]	[0.90431]	[2.61548]	[-0.80341]	[0.72419]	[0.53122]	[0.06748]	[0.28611]	[0.57470]
D(JP(-1))	0.001492	-0.046953	-0.089704	0.006985	0.013025	0.123437	-0.007975	-0.004907	0.032321	-0.028960
	(0.02781)	(0.04457)	(0.18587)	(0.13050)	(0.01778)	(0.12309)	(0.01222)	(0.00740)	(0.02218)	(0.07786)
	[0.05365]	[-1.05357]	[-0.48261]	[0.05352]	[0.73263]	[1.00284]	[-0.65279]	[-0.66274]	[1.45740]	[-0.37195]
D(JP(-2))	-0.020260	-0.011033	-0.219994	-0.227275	-0.037749	0.005629	-0.003712	-0.001184	-0.027743	0.075409
	(0.02784)	(0.04462)	(0.18611)	(0.13066)	(0.01780)	(0.12324)	(0.01223)	(0.00741)	(0.02221)	(0.07796)
	[-0.72762]	[-0.24726]	[-1.18207]	[-1.73941]	[-2.12051]	[0.04567]	[-0.30350]	[-0.15972]	[-1.24936]	[0.96729]
D(KR(-1))	-0.336048	-0.680544	-1.728942	-1.113786	-0.280496	-0.938493	-0.186629	-0.128629	-0.372818	-0.224836
	(0.32951)	(0.52807)	(2.20241)	(1.54626)	(0.21067)	(1.45848)	(0.14475)	(0.08774)	(0.26278)	(0.92256)
	[-1.01984]	[-1.28874]	[-0.78502]	[-0.72031]	[-1.33147]	[-0.64347]	[-1.28931]	[-1.46605]	[-1.41872]	[-0.24371]
D(KR(-2))	0.277915	0.521457	3.850653	1.975720	0.450910	2.703917	0.150138	0.171143	0.436545	1.364647
	(0.31007)	(0.49691)	(2.07247)	(1.45503)	(0.19824)	(1.37243)	(0.13621)	(0.08256)	(0.24728)	(0.86813)
	[0.89630]	[1.04939]	[1.85800]	[1.35785]	[2.27460]	[1.97017]	[1.10225]	[2.07290]	[1.76538]	[1.57193]
D(MA(-1))	-0.425440	-0.689832	-5.908087	0.719202	0.576820	3.852851	0.019659	0.050331	-0.168891	0.956863
	(0.51462)	(0.82473)	(3.43967)	(2.41491)	(0.32901)	(2.27781)	(0.22607)	(0.13703)	(0.41041)	(1.44083)
	[-0.82670]	[-0.83644]	[-1.71763]	[0.29782]	[1.75319]	[1.69147]	[0.08696]	[0.36730]	[-0.41152]	[0.66410]
D(MA(-2))	-0.723644	-1.124835	-8.883675	-5.158390	-0.039687	-2.894762	-0.463989	-0.015601	-0.718576	-2.118268
	(0.51382)	(0.82344)	(3.43431)	(2.41114)	(0.32850)	(2.27426)	(0.22572)	(0.13681)	(0.40977)	(1.43859)
	[-1.40836]	[-1.36602]	[-2.58674]	[-2.13940]	[-0.12081]	[-1.27284]	[-2.05563]	[-0.11403]	[-1.75361]	[-1.47246]
D(SG(-1))	-0.082372	-0.023911	-0.022435	-0.837066	-0.076251	-0.494422	-0.036873	0.072297	-0.226396	-0.047798
	(0.22426)	(0.35940)	(1.49894)	(1.05237)	(0.14338)	(0.99263)	(0.09852)	(0.05971)	(0.17885)	(0.62789)
	[-0.36730]	[-0.06653]	[-0.01497]	[-0.79541]	[-0.53182]	[-0.49810]	[-0.37428]	[1.21072]	[-1.26585]	[-0.07612]
D(SG(-2))	0.592537	0.182146	2.117940	1.256009	0.321465	2.524941	0.322084	0.067975	0.370322	0.214130
	(0.20913)	(0.33515)	(1.39782)	(0.98137)	(0.13370)	(0.92566)	(0.09187)	(0.05569)	(0.16678)	(0.58553)
	[2.83331]	[0.54347]	[1.51518]	[1.27985]	[2.40430]	[2.72773]	[3.50588]	[1.22069]	[2.22039]	[0.36570]
D(TW(-1))	0.034092	0.132921	0.517610	0.063368	-0.009806	0.205863	0.050557	-0.010340	0.079637	0.140983
	(0.05099)	(0.08171)	(0.34079)	(0.23926)	(0.03260)	(0.22568)	(0.02240)	(0.01358)	(0.04066)	(0.14275)
	[0.66865]	[1.62673]	[1.51886]	[0.26485]	[-0.30083]	[0.91221]	[2.25724]	[-0.76167]	[1.95853]	[0.98761]
D(TW(-2))	0.089950	0.221885	0.619881	0.423562	0.009484	0.057327	0.052767	0.003876	0.036635	0.442936
	(0.05100)	(0.08174)	(0.34089)	(0.23933)	(0.03261)	(0.22574)	(0.02240)	(0.01358)	(0.04067)	(0.14280)
	[1.76365]	[2.71467]	[1.81840]	[1.76976]	[0.29086]	[0.25395]	[2.35518]	[0.28539]	[0.90069]	[3.10188]
R^2	0.352959	0.216645	0.357882	0.389383	0.369692	0.281753	0.419886	0.283889	0.333455	0.287236
$Adj.R^2$	0.233136	0.071580	0.238972	0.276306	0.252968	0.148745	0.312457	0.151276	0.210020	0.155242

* Values in ( ) and [ ] are standard errors and t-statics of estimators, respectively.

4.5. RESPONSES OF THE UNEXPECTED SHOCK IN ASIAN MARKET

Figure 1 represents the impulse responses for one country associated with an unexpected shock to the other 9 markets in Asia. While a total of 100 impulse responses could be calculated since there are 10 variables in the system, this paper adopts the impulse responses of 5 countries to 10 counties Cholesky one standard deviation of an unexpected shock. Figure 1 shows the impulse responses for one country with the confidence bands of 2 standard errors for 10 periods.

The impulse responses of China to the shocks of other 8 countries except Australia show no significant responses. Australia has a positive impact on China for 1 period. It is inferred that since China has controlled or managed the stock or financial market, Chinese stock market seems to be independent from Asian Stock markets except Australia. The impulse responses of Hong Kong to the shocks of other 9 countries show that while China and Australia have some positive effects on Hong Kong for 1 or 2 periods, the effects of shock died down even after 4 or 5 months.

The impulse responses of India show that Australia, China and Hong Kong have significant impacts on the India. The effects of shock of China seem to have a positive effect, then a negative effect, finally a positive effect. But those effects are not significant after 2 periods since the effects are within the confidence bands of 2 standard errors. Even those effects died out after 7 or 8 months. Hong Kong has the considerable positive effects on India until 2 months but those effects died down after 52 months since the effects are within the confidence bands of 2 standard errors.

Korea, Singapore, Taiwan and China, other Asian countries except Australia seem to have little effect on the Japan for the first 5-6 periods, but they are not significant. Beyond that, the shocks appear to have worked the way out. Only Australia has some positive effects on Japan for 1 or 2 periods, the effects of shock died down even after 4 or 5 months. Japan has been thought to be affected by other developed countries such as U.S. and the EU instead of Asian countries.

The impulse responses of Korea represent that Australia, Hong Kong and India seem to have very little effects on the Korea stock market for the first 1-2 periods. While Hong Kong seem to have the positive effects on the Korea stock market for the first 2 months, and then negative effects for 2 months, finally those effects died down after 4 months and they are not significant except 1 period.

Singapore shows that Australia, China and Hong Kong have some positive effects on the Singapore stock market for the first 6 periods. Especially, Hong Kong has the considerable positive effects for the first 1-2 months and then those effects are not significant after 1 or 2 months and finally died down af-

ter 6 months. China and Taiwan seem have the positive effects on the Singapore stock market in 3 months.

Thus Australia, China, Hong Kong, Japan, Korea, Singapore and Taiwan had some impacts on other markets. Shocks from these countries transmitted to other markets for 1 or 2 months. Most countries respond to the shocks from other markets in short run. But the impulse responses of China and Japan to the shocks of other markets were relatively small since China and Japan are 2 big enough countries compared to other East Asian countries.

4.6. INNOVATION AND DECOMPOSITION OF FORECASTING ERRORS

Table 10 represents the proportions of the h-step ahead forecasting error variance of the first row countries that are attributable to each orthogonalized innovation in column countries in the VAR system. It represents the decomposition of forecasting error variance how one market explains other markets in VAR system and how much one market contributes to other markets at 6,12 and 18 months ahead.

In the Asia regions, Australia is influenced by China, Japan, Korea as well as Australias own innovation. In particular, India has more than 26% at 6, 12 and 18 months ahead, respectively. China has more than 80.0%, 70.7% and 55.3% of its own innovations at 6, 12 and 18 months ahead, respectively. Japan and Hong Kong appear to contribute to China but they have less than 10% at 6, 12 and 18 months ahead, respectively.

Hong Kong is appreciably influenced by India, China, Taiwan, Japan as well as Hong Kongs own innovation. India and Indonesia are influenced about 38-40% at 6, 12 and 18 months ahead by Indias innovations. While, China, Australia and Taiwan have more than 10% on the fluctuations in Indias stock market at 6 through 18 month ahead, and Australia, China and Taiwan contribute appreciably(more than 5.8-16.7%) to the fluctuations in Indonesias stock market.

Japan has more than 69.6% at 6 months ahead and decreases to 38.7% and 39.2% of its own Japanese innovations at 12 and 18 months ahead. India appears to significantly contribute to Japan by more than 13.1% at 6 months ahead but China contributes to Japan by 1.2%, 1.6%, 8.6% at 6, 12 and 18 months ahead, respectively. Korea has more than 20.7%, 17.17% and 31.37% of its own Korean innovations at 6, 12 and 18 months ahead but Korea is relatively much(more than 9.8%) influenced by Japan, China, India and Taiwan.

Table 10: Decomposition of forecasting errors in Asian Region Countries

	h	AU	CH	HK	ID	IN	JP	KR	MA	SG	TW
	6	17.33253	10.8165	3.419674	26.92864	0.453426	22.32883	1.167751	3.767111	1.640069	12.14547
AU	12	7.976785	9.162827	1.709301	36.16599	2.896503	11.54829	9.781194	3.989871	1.65429	15.11496
	18	7.176887	8.709398	2.031519	30.92842	5.210455	16.66629	6.581703	5.627309	1.594712	15.47331
	6	2.859356	79.98509	2.234172	0.494465	4.038118	4.660628	0.565273	2.703214	1.619959	0.83973
CH	12	1.656798	70.73953	4.685729	0.813926	11.43812	2.511161	3.334507	2.60683	1.26962	0.943783
	18	1.515789	55.25004	4.005979	2.117494	15.68067	8.092105	2.942448	6.341809	1.468939	2.584728
	6	7.06158	18.27467	14.96957	39.28941	1.355967	5.545365	1.613267	5.926492	0.594618	5.369068
HK	12	5.439406	29.15871	7.871648	30.35285	5.702117	2.849066	6.343127	4.76701	1.017647	6.498418
	18	4.200501	23.84255	6.477038	27.59473	10.345	7.089145	5.05351	6.191883	1.125515	8.080133
	6	9.465682	14.59314	2.485511	49.1088	1.922776	8.381614	1.274874	0.658761	0.91329	11.19555
ID	12	11.46732	21.79753	2.966693	39.87359	2.903919	4.273522	2.568379	1.394526	0.903977	11.85054
	18	10.02997	18.07879	2.956105	40.50621	3.176051	6.356348	2.073592	2.463828	1.17274	13.18637
	6	9.104137	5.890119	0.470075	48.2993	21.33398	3.306608	0.485243	3.441781	0.447339	7.221415
IN	12	14.10783	13.13465	4.891411	38.68589	10.31578	2.312198	5.672172	3.062518	0.572896	7.244652
	18	16.78104	10.74219	6.562903	39.22801	7.843466	2.704357	4.457544	2.918586	0.646009	8.115898
	6	0.986033	1.237084	5.587021	13.08491	0.583309	69.55102	2.877111	2.80759	2.087692	1.198228
JP	12	1.000396	1.610728	8.543247	29.8617	2.52107	39.10152	4.294104	5.984513	2.977521	4.105203
	18	4.286972	8.553524	8.801472	23.38093	3.942167	32.89723	2.834689	6.755206	2.896246	5.651564
	6	3.82295	12.16351	0.843527	23.2223	1.579343	15.99367	20.74829	10.64131	1.211648	9.773447
KR	12	2.972946	16.6058	1.268069	31.45223	1.827537	8.476825	17.088	8.48726	1.110388	10.71095
	18	2.547483	13.2461	1.621818	34.97748	1.402869	9.630129	13.68319	7.528591	1.199389	14.16294
	6	3.079436	17.54272	1.664043	42.39353	6.022215	0.868132	2.332434	21.72384	1.376769	2.996883
MA	12	2.696552	17.81546	3.717656	40.77065	5.886898	1.194226	10.27158	12.15441	1.743136	3.749442
	18	3.356341	14.3119	5.015597	35.51071	8.897534	4.11303	8.716021	11.72316	1.445403	6.910295
	6	2.576755	13.66022	3.154934	39.28975	4.424333	14.96918	2.004857	7.104762	6.729343	6.08586
SG	12	1.576336	11.17946	1.532233	44.33744	5.849137	6.192195	12.37735	7.111185	3.79612	6.048545
	18	1.172122	9.101954	1.66277	37.91636	8.938155	11.45439	9.345151	8.225406	3.20471	8.978981
	6	2.915281	2.150159	2.311963	34.72064	3.223998	9.001621	6.360279	16.11032	2.690979	20.51476
TW	12	2.118569	11.11224	2.738172	32.1835	6.963732	5.274173	11.62407	13.05666	2.064564	12.86433
	18	2.091611	9.255474	2.667852	27.04396	11.83874	8.593544	9.733683	13.02881	1.859375	13.88696

Malaysia is influenced by China, India, Japan as well as its own innovation of Malaysia. Singapore is influenced by China, India, Japan and Malaysia as well as its own innovation. Taiwan is also appreciably influenced by China, India, Japan, Korea and Malaysia as well as its own innovation at 6, 12 and 18 months ahead.

Thus, there are overall stock market interdependences in East Asian countries. The larger stock markets such as China and Japan seem to affect smaller stock markets. Most Asian stock markets except so big countries such as China and Japan have been significantly influenced by other markets.

In particular, stock markets in South East Asia show very high interdependences due to geographical proximity and similar political and economic backgrounds as ASEAN member countries. South East ASEAN-5 countries agreed to form the Federation of ASEAN Stock Exchanges in 1978. After financial crises in Singapore during 19851986, Singapore Declaration of 1992 was done

to enhance capital market cooperation to direct South East ASEAN economic cooperation. The overseas ethnic Chinese network has also served as an impetus to help the South East Asia countries to connect the very close stock market interdependences in ASEAN countries.

These stock market interdependences might be driven not only by market-driven financial integration but also by the increased intra-regional FDI and trade flows which were strengthened through vertical and horizontal trade within East Asian countries since 2000s.

5. CONCLUSION

While there have been a lot of studies on Asian economic integration mainly in the real or commodity trade sectors, there have been relatively quiet fewer studies on Asian financial integration. This paper investigates the degree of financial interdependence and transmission process of stock markets among Asia regions using 10 Asian stock markets.

We analyzed the effect how shocks are transmitted to all other markets and which country could be the dominant country among Asia in explaining the error variances in the other financial markets. The cointegration, Error Correction causality, and VEC models are used to analyze the dynamic co-movements and interactions among the financial markets.

The findings of this paper suggest that all Asian markets are positively and significantly correlated. Some Asian countries have significant influences each other. The overall correlations coefficients are relatively high. As a whole, stock markets in Asia have been cointegrated and long-term equilibrium relationships, so that there are the stable interdependences among Asian financial markets. Australia, China, Hong Kong, Korea, Singapore and Taiwan stock markets Granger-cause other markets. In particular, stock markets among Singapore, Indonesia and Malaysia have had strong positive correlations as member countries of ASEAN.

According to impulse responses of VEC model, in Asian Markets, Australia, China, Hong Kong, Japan, Korea, Singapore and Taiwan stock markets had appreciable impacts on other stock markets. Those shocks were transmitted to other markets for 1 or 2 months. While most countries respond significantly to shocks from other stock markets, the impulse responses of China and Japan stock markets to the other markets were relatively small.

The Variance Decomposition shows that Australia and most of Asian stock markets are appreciably influenced by each other at every six months ahead, es-

pecially by China. By contrast, China has its own innovations at six and twelve months ahead Japan has more than 69.6% at 6 months ahead and decreases to 38.7% of its own Japanese innovations at 12 months ahead. While Korea stock market has considerable impacts of its own Korean innovations at every six month ahead, Korea is relatively much influenced by Japan, China, India and Taiwan stock markets.

These empirical results of relatively deepened financial integration might help give the insightful rationale in the future Asia economic integration. As Asian countries become more influential in the regional and global regionalism, the stock market interdependences in East Asia will be more deepened as the intra-regional trade and investment will expand in the future due to establishment of regional FTAs such as ASEAN, China-ASEAN FTA, ASEAN- Korea, etc. The interdependences and transmission of the stock and financial markets should be considered to achieve the most efficient economic integration in East Asian region.

As a difference, this paper adopts the cointegration approach, error correction causality, VEC model to obtain the consistent estimates, and then analyzes the interdependences between recent stock markets using recent data in Asia region. This paper, however, has the limitation to the analysis. If we can collect the longer period data and divide the crisis period of 2007-2009 and the post-crisis period and then do the structural break test, it may provide more interpretations of the results.

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Figure 1: Responses of the Unexpected Shock