Stock Market Integration and Financial Crises: the Case of Asia

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Abstract
In this paper, the linkage between stock prices for Asian markets such as Japan, Singapore, South Korea, India, the Chinese mainland, and Hong Kong is analyzed, as are the influences of the Asian financial crisis and the global financial crisis on the Asian stock markets. The analyses demonstrate that the effects of the Japanese stock market and the Singapore stock market on the Asian markets are great, while the Chinese mainland market and the India market are little affected by the other markets. On the whole, it has been revealed that the interdependence in stock prices among the Asian markets has increased since the global financial crisis.

JEL Classification: E44, F65, G01, G15
Keywords: Linkage of Stock Prices, Asian Stock Markets, Asian Financial Crisis, Global Financial Crisis, VAR Model

Ⅰ Introduction

In recent years, the development of the Asian economy has attracted worldwide attention. Japan initially took the lead and achieved high economic growth in the 1960s. Japan was followed in the 1980s by South Korea, Singapore and Hong Kong, which are the Asian Newly Industrializing Economies (NIEs). In addition, China and India have developed remarkably since the 1990s and have been supporters of the current high level of growth in the Asian economy. However, the development of the Asian economy has been far from smooth. The Asian financial crisis of 1997 had various impacts, not only on the mentioned Asian countries, but also on the world economy through exchange rates, stock markets, and other elements. In addition, the global financial crisis that arose from the subprime loan problem in the United States in 2007 hit Asian economies through the global slowdown in demand.

The presence of the six stock markets, i.e., Japan, Singapore, South Korea, India, Hong Kong and the Chinese mainland, has risen significantly because of the development of their economies. The capital inflows and outflows of the six stock markets continue in expectation of high Asian economic growth. The interdependence of stock markets is expected to increase as economic development and economic exchanges among the Asian countries continue in the future. A consideration of the linkage between stock prices in the six Asian markets is thus indispensable if we are to plan ahead for the future of the Asian economy. This analysis is also important for ascertaining the ideal way for the Asian economy to proceed.

There has been much previous research on the linkage of stock prices (for instance, Eun and Shin 1989, Chan *et al.* 1997, Dekker *et al.* 2001, Ahlgren and Antell 2002, Forbes and Rigobon 2002, Wang *et al.* 2003, Boschi 2005, Fraser and Oyefeso 2005, Kang and Yoon 2014, and so on). Recent research on the linkage of stock prices in Asian markets includes the following: Chan *et al.* (1992) analyzed the relationships among the stock markets in Hong Kong, South Korea, Singapore, Taiwan, Japan, and the United States for 1983-1987. This paper used unit root tests and cointegration tests, and suggested that no evidence of cointegration was found. Hung and Cheung (1995) analyzed the interdependence of five major Asian emerging equity markets: Hong Kong, Korea, Malaysia, Singapore, and Taiwan, for 1981-1991. The paper used the Johansen multivariate cointegration approach, and suggested that the five Asian stock indices measured in local currency are not cointegrated, while the five Asian stock indices measured in terms of the US dollar are cointegrated. Corhay *et al.* (1995) analyzed the long run relationship among five major Pacific Basin stock markets, including Japan, Hong Kong, and Singapore, for 1972-1992. The paper used cointegration analysis, and found that there existed a rather integrated Pacific-Basin financial area. Sheng and Tu (2000) examined the linkages among the stock markets of 12 Asia-Pacific countries for the period from 1 July 1996 to 30 June 1998. This study used cointegration and variance decomposition analysis, and revealed the existence of cointegration relationships among these stock markets during the Asian financial crises. Yang *et al.* (2003) examined long-run cointegration relationships and short-run dynamic causal linkages among stock markets in the United States, Japan, and 10 Asian emerging stock markets, from 2 January 1995 to 15 May 2001. The paper employed a cointegrated vector autoregression (VAR) framework. The analyses showed that both long-run relationships and short-run linkages among these markets were strengthened during the Asian financial crisis, and that these markets have generally been more integrated after the crisis than before the crisis. Chen *et al.* (2007) analyzed the return and volatility interactions among Japan, Taiwan, South Korea and the US by employing a multivariate stochastic volatility (MSV) model. The data covered the period from January 1998 to December 2004. The analyses found no linkage of stock prices among these stock markets, although there was some linkage of stock prices between some markets. Huyghebaert and Wang (2010) examined the integration and causality of interdependencies among six major Asian stock markets (Japan, Singapore, Hong Kong, Taiwan, South Korea, and China) from 1 July 1992 to 30 June 2003. The study employed a Multivariate VAR model and showed that the integration of Asian stock markets was strengthened during as well as after the Asian financial crisis. Cheng and Glascock (2005) analyzed the linkages among three Greater China Economic Area (GCEA) stock markets, including the Chinese mainland, Hong Kong, and Taiwan, and two developed markets, Japan and the US, over a period from January 1993 to August 2004.The study employed a GARCH model, an ARIMA model, and cointegration tests, and found that there was no evidence of cointegration among the GCEA, the Japan, and the U.S. markets.

The main contribution of this paper is that it is the first to analyze the linkage of stock prices in major Asian markets including the Chinese mainland market and the India market, with the particular attention to both the 1997-1998 Asian financial crisis and the recent global financial crisis. The global financial crisis that occurred from the subprime loan problem of the United States had various impacts on not only the United States, but also Europe, Asia, and other areas, and caused the recent economic recession. Dooley and Hutchison (2009) analyzed transmission of the U.S. subprime crisis to emerging markets (Argentina, Brazil, Chile, Colombia, Mexico, China, South Korea, Malaysia, Czech Republic, Poland, Hungary, Russia, South Africa and Turkey) by focusing on 5-year Credit-default swap spreads on sovereign bonds. Zhang (2012) has analyzed the linkage between stock prices for Asian markets (Japan, Singapore, South Korea, the Chinese mainland, Hong Kong, and Taiwan) since the 1990s, however, the India market was not included. In this paper, the linkage between stock prices for Asian markets such as Japan, Singapore, South Korea, India, the Chinese mainland, and Hong Kong from 1991 to 2014 is analyzed, as are the influences of both the Asian financial crisis and the global financial crisis on the Asian stock markets.

The previous studies have analyzed long-run relationships and short-run dynamic causal linkages in the Asian stock markets. Some studies employed cointegration in order to investigate long-run relationships of the Asian stock markets (Chan *et al.* 1992, Corhay *et al.* 1995, Hung and Cheung 1995). Some studies have estimated short-run dynamic causal linkage (Sheng and Tu 2000). Some studies analyzed both long run relationships and short-run dynamic causal linkages, by employing vector autoregression (VAR) techniques, such as cointegration, impulse response analysis, and forecast error variance decomposition (Yang *et al.* 2003, Huyghebaert and Wang 2010), a GARCH model and an ARIMA model (Cheng and Glascock 2005), and a multivariate stochastic volatility model (MSV) (Chen *et al.* 2007).

In this paper, in order to analyze the linkage of stock prices in major Asian markets, vector autoregressive (VAR) techniques are used. According to Brooks (2008), VAR models have several advantages compared with univariate time series models or simultaneous equations structural models: (1) I do not need to specify which variables are endogenous or exogenous because all variables are endogenous; (2) VAR models allow the value of a variable to depend on more than just its own lags or combinations of white noise terms, so VAR models are more flexible than univariate AR models, and therefore can capture more features of the data; (3) The forecasts generated by VAR models are often better than ‘traditional structural’ models (Sims 1980).

Unlike Sheng and Tu (2000), Yang *et al.* (2003), and Huyghebaert and Wang (2010), I cannot observe clearly that the linkage of stock prices in the Asian markets had increased during the 1997-1998 Asian financial crisis in this paper. However, I can find that the linkage had increased just after the period of the Asian financial crisis by using cointegration tests. Furthermore, according to all analyses results, my paper demonstrates that the linkage of stock prices in the Asian markets has increased since the global financial crisis. Unlike Huyghebaert and Wang (2010), who points out that the Singapore and Hong Kong stock markets are two interactive and influential markets in the region during and after the Asian financial crisis, and unlike Dekker *et al.* (2001), who indicates that Hong Kong is the leading market, my finding indicates that the effects of the Japan market and the Singapore market on the Asian markets are great.

However, I can get the conclusion that Hong Kong market is affected by the Singapore market greatly, and the Singapore market is affected by the Hong Kong market greatly. In line with Huyghebaert and Wang (2010), my analyses further demonstrate that the Chinese mainland market is little affected by other markets. Furthermore, unlike Zhang (2012), my paper indicates that not only the Chinese mainland market, but also the India market is also little affected by other Asian markets.

The paper is organized as follows. First, the data are presented; a time series transition and the summary statistics are examined. Then, the methodology is introduced. Next, the empirical results of the unit root tests, cointegration tests, impulse response, and forecast error variance decomposition are reported. Finally, the summary and the concluding remarks are provided.

Ⅱ Data

The data consist of day-end stock market index observations. This paper uses the Nikkei 225 Index (Japan), the Straits Times Index (Singapore), the Korea Composite Stock Price Index (South Korea), the Bombay Stock Exchange Sensitive Index (India), the Shanghai stock exchange composite index (Chinese mainland), and the Hang Seng Index (Hong Kong) to analyze the linkage among stock prices in major Asian markets. The indices are taken from the Yahoo Finance database and are corrected in logs. The sample period is from 1 January 1991 to 31 December 2014. The number of observations is 6262. The data are from Mondays to Fridays. If a value is missing, data of the previous day are used.

To examine the influence of the Asian financial crisis and the global financial crisis on the linkage of stock prices among the Asian markets, five periods are analyzed: before the Asian financial crisis, the period from 1 January 1991 to 30 June 1997; during the Asian financial crisis, the period from 1 July 1997 to 31 December 1998; after the Asian financial crisis and before the global financial crisis, the period from 1 January 1999 to 14 August 2007;[1] during the global financial crisis, the period from 15 August 2007 to 31 December 2009; and after the global financial crisis, the period from 1 January 2010 to 31 December 2014.

2.1 *A Time Series Transition of Stock Prices*

First, the movement of stock prices in each market is analyzed. Figure 1 shows a time series transition of stock prices in each market.

[1] BNP Paribas, a bank major company in France, froze the subsidiary fund due to the US subprime loan problem on 15 August 2007, so the subprime loan problem came up.

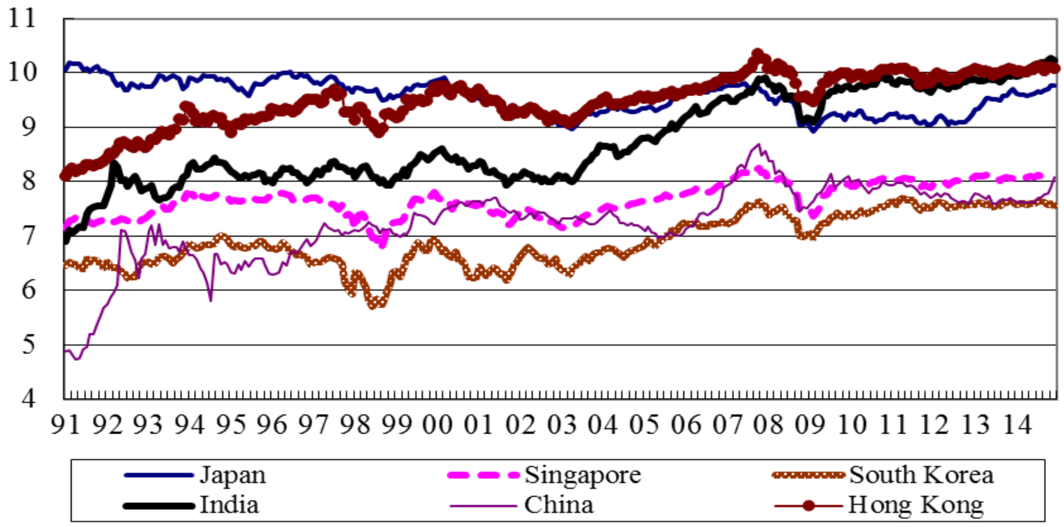

Figure 1. Stock Prices of Each Market

Figure 1 shows that, in general, stock prices in Japan have fallen. Although stock prices in Singapore and South Korea have risen gradually in the long term, stock prices fell sharply in 1998. Stock prices in India, China and Hong Kong have risen greatly over time. In addition, stock prices in all markets fell sharply from October 2007 to February 2009.

2.2 *Summary Statistics of Stock Prices*

Table 1 displays the basic statistics describing stock prices.

Table 1. Summary Statistics of Stock Prices

Table 1-1. Summary Statistics: sample: 1 January 1991 to 31 December 2014

	Mean	Std. Dev.	Maximum	Minimum	Skewness	Kurtosis
Japan	9.5563	0.3052	10.2090	8.8615	-0.1639	1.9332
Singapore	7.6694	0.3027	8.2625	6.6909	-0.2103	2.2912
South Korea	6.9071	0.4812	7.7093	5.6348	0.0076	2.0410
India	8.7552	0.8110	10.2644	6.8629	0.2069	1.7934
China	7.2461	0.7066	8.7147	4.6613	-1.2336	5.3209
Hong Kong	9.4774	0.4784	10.3621	8.0010	-0.7330	3.1776

Table 1-2. Summary Statistics: sample: 1 January 1991 to 30 June 1997

	Mean	Std. Dev.	Maximum	Minimum	Skewness	Kurtosis
Japan	9.8907	0.1279	10.2090	9.5687	0.1734	2.8066
Singapore	7.5385	0.2014	7.8215	7.0467	-0.5201	1.7513
South Korea	6.6381	0.1909	7.0377	6.1292	-0.1105	2.1254
India	7.9620	0.3537	8.4404	6.8629	-1.2803	3.9855
China	6.3750	0.6580	7.3375	4.6613	-1.1940	3.5460
Hong Kong	8.9373	0.4077	9.6288	8.0010	-0.4863	2.1425

Table 1-3. Summary Statistics: sample: 1 July 1997 to 31 December 1998

	Mean	Std. Dev.	Maximum	Minimum	Skewness	Kurtosis
Japan	9.6850	0.1064	9.9318	9.4634	0.3415	2.6637
Singapore	7.2457	0.2441	7.6045	6.6909	-0.3669	2.0752
South Korea	6.1195	0.2937	6.6615	5.6348	0.2264	1.8893
India	8.1628	0.1348	8.4224	7.9245	-0.0568	1.7618
China	7.1115	0.0620	7.2584	6.9489	0.4115	2.6104
Hong Kong	9.2552	0.2250	9.7216	8.8039	0.3758	2.4095

Table 1-4. Summary Statistics: sample: 1 January 1999 to 14 August 2007

	Mean	Std. Dev.	Maximum	Minimum	Skewness	Kurtosis	Rate of Change※
Japan	9.4782	0.2473	9.9443	8.9369	-0.1158	1.8550	-4.2
Singapore	7.5832	0.2418	8.2066	7.1015	0.3867	2.9290	0.6
South Korea	6.7519	0.3262	7.6030	6.1501	0.4211	2.3646	1.7
India	8.5851	0.4858	9.6674	7.8633	0.7208	2.3335	7.8
China	7.3938	0.2854	8.4914	6.9192	1.3247	5.3904	16.0
Hong Kong	9.5080	0.2254	10.0636	9.0371	0.0934	2.4160	6.4

Note: This rate of change represents the rate of change compared with the mean from 1 January 1991 to 30 June 1997 (before the Asian financial crisis).

Table 1-5. Summary Statistics: sample: 15 August 2007 to 31 December 2009

	Mean	Std. Dev.	Maximum	Minimum	Skewness	Kurtosis
Japan	9.3295	0.2413	9.7676	8.8615	0.0459	1.7671
Singapore	7.8509	0.2532	8.2625	7.2841	-0.5101	2.1418
South Korea	7.3294	0.1856	7.6328	6.8445	-0.6043	2.4511
India	9.5631	0.2484	9.9462	9.0070	-0.7235	2.3593

China	8.0390	0.3385	8.7147	7.4423	0.3071	2.0897
Hong Kong	9.9077	0.2458	10.3621	9.3071	-0.4846	2.2375

Table 1-6. Summary Statistics: sample: 1 January 2010 to 31 December 2014

	Mean	Std. Dev.	Maximum	Minimum	Skewness	Kurtosis	Rate of Change※
Japan	9.3258	0.2255	9.7945	9.0070	0.4569	1.6933	-1.6
Singapore	8.0290	0.0620	8.1474	7.8355	-0.5729	2.5183	5.9
South Korea	7.5602	0.0671	7.7093	7.3478	-0.8242	3.3942	12.0
India	9.8727	0.1434	10.2644	9.6274	1.0616	3.4908	15.0
China	7.7860	0.1349	8.0963	7.5756	0.4621	2.0276	5.3
Hong Kong	9.9884	0.0788	10.1393	9.6959	-0.6395	2.7891	5.1

Note: This rate of change represents the rate of change compared with the mean from 1 January 1999 to 14 August 2007 (after the Asian financial crisis and before the global financial crisis).

The rate of change of average stock prices from 1 January 1999 to 14 August 2007, was significantly higher compared with those from 1 January 1991 to 30 June 1997: with a difference of 16.0% in China, 7.8% in India, and 6.4% in Hong Kong. The rate of change of average stock prices rose slightly: with a slight rise of 0.6% in Singapore and 1.7% in South Korea. The rate of change of the average stock price in Japan fell by 4.2%.

In addition, the rate of change of average stock prices from 1 January 2010 to 31 December 2014 was higher compared with those from 1 January 1999 to 14 August 2007, although to different degrees: a difference of 5.9% in Singapore, 12.0% in South Korea, 15.0% in India, 5.3% in China, and 5.1% in Hong Kong. The rate of change of the average stock price in Japan fell by 1.6%.

Ⅲ Methodology

In this section, I describe the methodology utilized to conduct the empirical analyses of this paper. I start with describing the augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) tests for unit roots. Next, I introduce Johansen test for cointegration. Furthermore, I describe the impulse response functions and forecast error variance decomposition, two applications of the VAR model.

3.1 *Unit Root Tests*

To test whether the data series used is stationary, unit root tests are conducted. Here the unit root tests are carried out using the augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) tests.[2]

The two forms of the ADF test by Dickey and Fuller (1979, 1981) are given by the following equations:

$$\Delta X_t = a_0 + \gamma X_{t-1} + \sum_{i=1}^{P} \beta_i \Delta X_{t-i} + u_t \quad (1)$$

$$\Delta X_t = a_0 + \gamma X_{t-1} + a_2 t + \sum_{i=1}^{P} \beta_i \Delta X_{t-i} + u_t \quad (2)$$

where a_0 is the drift term and a_2 is the time trend. γ is the coefficient of the lagged dependent variable X_{t-1}. The ADF tests for stationarity are the 't' tests on the coefficient γ.The critical values for the ADF tests are given in MacKinnon (1991). The null hypothesis is $H_0 : \gamma = 0$. If this is true, X_t has a unit root. The lag length on these extra terms is either determined by the Akaike Information Criterion (AIC) or Schwartz Bayesian Criterion (SBC).

Phillips and Perron (1988) developed a generalization of the ADF test procedure that allows for fairly mild assumptions concerning the distribution of errors. The test regression for the Phillips-Perron (PP) test is as follows:

$$\Delta X_{t-1} = a_0 + \gamma X_{t-1} + e_t \quad (3)$$

The PP statistics are just modifications of the ADF t statistics that take into account the less restrictive nature of the error process. The asymptotic distribution of the PP t statistic is the same as the ADF t statistic, therefore the critical values for the PP test is also given in MacKinnon (1991).

3.2 *Cointegration Tests*

To examine the long-term equilibrium relationships among the variables, cointegration tests are performed. Johansen (1988) derived the maximum likelihood estimator, which can estimate and test for the presence of multiple cointegrating vectors.[3]

Following Johansen (1988) procedure, the augmented vector autoregressive (VAR) model can be written as follows:

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[2] The unit root test approach refers to Asteriou and Hall (2007).

[3] The Johansen test approach refers to Brooks (2008).

$$X_t = a_1 X_{t-1} + a_2 X_{t-2} + ... + a_k X_{t-k} + \varepsilon_t \quad (4)$$

This can be rewritten as

$$\Delta X_t = \Pi X_{t-k} + \Gamma_1 \Delta X_{t-1} + \Gamma_2 \Delta X_{t-2} + ... + \Gamma_{k-1} \Delta X_{t-(k-1)} + \varepsilon_t \quad (5)$$

where $\Pi = (\sum_{i=1}^{k} a_i) - I_g$ and $\Gamma_i = (\sum_{j=1}^{i} a_j) - I_g$

The Johansen (1988) test focuses on an examination of the Π matrix. In equilibrium, all the ΔX_{t-i} will be zero, and setting the error terms, ε_t, to their expected value of zero will leave $\Pi X_{t-k} = 0$, so Π can be interpreted as a long-run coefficient matrix.

There are two test statistics for cointegration under the Johansen approach, which are written as

$$\lambda_{trace}(r) = -T \sum_{i=r+1}^{g} In(1-\hat{\lambda}_i)$$

and

$$\lambda_{\max}(r, r+1) = -TIn(1-\hat{\lambda}_{r+1})$$

where r is the number of cointegrating vectors under the null hypothesis and $\hat{\lambda}_i$ is the estimated value for the *i*th ordered eigenvalue from the Π matrix.

3.3 *Generalized Impulse Response Functions*

To analyze the influence among variables according to the VAR model, the impulse response is analyzed. An impulse response function traces the effect of a one-time shock to one of the innovations on current and future values of the endogenous variables. As with the impulse responses, the variance decomposition based on the Cholesky factor can change dramatically if the ordering of the variables is altered in the VAR, so the generalized impulse responses, not depending on the variable turns, are analyzed. Generalized Impulses as described in Pesaran and Shin (1998) constructs an orthogonal set of innovations that is unaffected by ordering of variables.

The VAR model is constructed as follows:

$$x_t = \sum_{i=1}^{p} \Phi_i x_{t-i} + \psi w_t + \varepsilon_t, \quad t = 1,2,\dots,T, \quad (6)$$

where $x_t = (x_{1t}, x_{2t}, ..., x_{mt})'$ is an $m \times 1$ vector of jointly determined dependent variables, w_t is an $q \times 1$ vector of deterministic and/or exogenous variables, and $\{\Phi_i, i = 1,2,..., p\}$ and ψ are $m \times m$ and $m \times q$ coefficient matrices.

Under the assumption that all the roots of $\left| I_m - \sum_{i=1}^{p} \Phi_i z^i \right| = 0$ fall outside the unit circle, x_t would be covariance-stationary, and (6) can be rewritten as the infinite moving average representation,

$$x_t = \sum_{i=0}^{\infty} A_i \varepsilon_{t-i} + \sum_{i=0}^{\infty} G_i w_{t-i}, \quad t = 1,2,\ldots,T, \quad E(\varepsilon_t) = 0, E(\varepsilon_t \varepsilon_t^{'}) = \Sigma \quad (7)$$

where the $m \times m$ coefficient matrices A_i can be obtained using the following recursive relations:

$$A_i = \Phi_1 A_{i-1} + \Phi_2 A_{i-2} + \ldots + \Phi_p A_{i-p}, \quad i = 1,2,\ldots, \quad (8)$$

with $A_0 = I_m$ and $A_i = 0$ for $i < 0$, and $G_i = A_i \psi$ **.**

An impulse response function measures the time profile of the effect of shocks at a given point in time on the (expected) future values of variables in a dynamical system. The best way to describe an impulse response is to view it as the outcome of a conceptual experiment in which the time profile of the effect of a hypothetical $m \times 1$ vector of shocks of size $\delta = (\delta_1, \ldots, \delta_m)'$, say, hitting the economy at time t is compared with a base-line profile at time $t + n$, given the economy's history.

Denoting the known history of the economy up to time $t-1$ by the non-decreasing information set Ω_{t-1}, Pesaran and Shin (1998) proposed the generalized impulse response function (*GI*) of x_t at horizon n as follows:

$$GI_x(n, \delta, \Omega_{t-1}) = E(x_{t+n} | \varepsilon_t = \delta, \Omega_{t-1}) - E(x_{t+n} | \Omega_{t-1}) \quad (9)$$

Using (9) in (7), we have $GI_x(n, \delta, \Omega_{t-1}) = A_n \delta$, which is independent of Ω_{t-1}, but depends on the composition of shocks defined by δ.

The Cholesky decomposition of Σ is as follows:

$$PP' = \Sigma, \quad (10)$$

where ***P*** is an $m \times m$ lower triangular matrix. Then, (7) can be rewritten as

$$x_t = \sum_{i=0}^{\infty} (A_i P)(P^{-1} \varepsilon_{t-i}) + \sum_{i=0}^{\infty} G_i w_{t-i} = \sum_{i=0}^{\infty} (A_i P) \xi_{t-i} + \sum_{i=0}^{\infty} G_i w_{t-i}, \quad t = 1,2,\ldots,T, \quad (11)$$

such that $\xi_t = P^{-1} \varepsilon_t$ are orthogonalized; namely, $E(\xi_t \xi_t^{'}) = I_m$. Hence, the $m \times 1$ vector of the orthogonalized impulse response function of a unit shock to the j th equation on x_{t+n} is given by

$$\psi_j^0(n) = A_n P e_{j,} \; n = 0,1,2,\ldots, \quad (12)$$

where e_j is an $m \times 1$ selection vector with unity as its j th element and zeros elsewhere.

GI is defined as follows:

$$GI_x(n, \delta_j, \Omega_{t-1}) = E(x_{t+n} | \varepsilon_{jt} = \delta_j, \Omega_{t-1}) - E(x_{t+n} | \Omega_{t-1}) \tag{13}$$

Assuming that ε_t has a multivariate normal distribution, it is now easily seen that

$$E(\varepsilon_t | \varepsilon_{jt} = \delta_j) = (\sigma_{1j}, \sigma_{2j}, \ldots, \sigma_{mj})' \sigma_{jj}^{-1} \delta_j = \sum e_j \sigma_{jj}^{-1} \delta_j \tag{14}$$

Hence, the $m \times 1$ vector of the (unscaled) generalized impulse response of the effect of a shock in the j th equation at time t on x_{t+n} is given by

$$\left(\frac{A_n \sum e_j}{\sqrt{\sigma_{jj}}}\right)\left(\frac{\delta_j}{\sqrt{\sigma_{jj}}}\right), \quad n = 0,1,2,\ldots, \tag{15}$$

By setting $\delta_j = \sqrt{\sigma_{jj}}$, the scaled generalized impulse response function is given by

$$\psi_j^g(n) = \sigma_{jj}^{-\frac{1}{2}} A_n \sum e_j, \quad n = 0,1,2,\ldots, \tag{16}$$

which measures the effect of one standard error shock to the j th equation at time t on expected values of $\boldsymbol{x}$ at time $t + n$.

3.4 *Variance Decomposition*

Variance decomposition separates the variation in an endogenous variable into the component shocks to the VAR. Thus, variance decomposition provides information about the relative importance of each random innovation in affecting the variables in the VAR.

The above generalized impulses can be used in the derivation of the forecast error variance decompositions, defined as the proportion of the *n*-step ahead forecast error variance of variable *i* which is accounted for by the innovations in variable *j* in the VAR. Denoting the orthogonalized and the generalized forecast error variance decompositions by $\theta_{ij}^o(n)$ and $\theta_{ij}^g(n)$, respectively, then for $n = 0,1,2,\ldots,$ forecast error decomposition is as follows:

$$\theta_{ij}^o(n) = \frac{\sum_{l=0}^{n} (e_i' A_l P e_j)^2}{\sum_{l=0}^{n} (e_i' A_l \sum A_l' e_i)}, \quad \theta_{ij}^g(n) = \frac{\sigma_{ii}^{-1} \sum_{l=0}^{n} (e_i' A_l \sum e_j)^2}{\sum_{l=0}^{n} (e_i' A_l \sum A_l' e_i)}, \quad i, j = 1,\ldots,m$$

Notice that $\sum_{j=1}^{m}\theta_{ij}^{o}(n)=1$, and $\sum_{j=1}^{m}\theta_{ij}^{g}(n)\neq 1$ due to the non-zero covariance between the original (non-orthogonalized) shocks.[4]

Ⅳ Empirical Results

4.1 *Unit Root Tests*

Here the unit root tests are carried out using the ADF tests and the PP tests for the two cases, with both a trend and a constant, and with a constant only. The unit root test results are presented in Table 2.

Table 2. Unit Root Tests: sample: 1 January 1991 to 31 December 2014

	ADF test		PP test	
	With trend and constant	With constant	With trend and constant	With constant
Japan	-2.0290	-2.2341	-1.8423	-2.1376
Lag	0	0	8	9
⊿Japan	-81.4292***	-81.4198***	-81.5978***	-81.5833***
Lag	0	0	9	9
Singapore	-2.5198	-2.0172	-2.5365	-2.0224
Lag	1	1	11	10
⊿Singapore	-73.0773***	-73.0822***	-73.1504***	-73.1554***
Lag	0	0	7	7
South Korea	-2.5098	-1.2294	-2.5008	-1.2366
Lag	0	0	4	1
⊿South Korea	-78.4462***	-78.4508***	-78.4453***	-78.4499***
Lag	0	0	2	2
India	-2.6222	-1.4288	-2.6027	-1.3501
Lag	1	1	21	20
⊿india	-73.0940***	-73.0970***	-73.2014***	-73.2066***
Lag	0	0	20	20
China	-3.4880**	-3.1679**	-3.5259**	-3.2101**
Lag	3	3	15	14
⊿China	-42.1110***	-42.0887***	-76.7376***	-76.7556***
Lag	2	2	13	14

[4] If the variables in a VAR model are cointegrated, then Vector Error Correction Model (VECM) should be used to estimate the impulse response and variance decomposition.

Hong Kong Lag	-3.5934** 0	-2.8017* 0	-3.5800** 6	-2.8048* 9
⊿Hong Kong Lag	-79.0077*** 0	-78.9969*** 0	-79.0218*** 9	-79.0080*** 8

Notes: 1. ***, **, and * show that the null hypothesis proposing that unit roots exist at 1 %, 5 %, and 10 % is rejected.

2. The lags are based on the Schwarz info criterion in the ADF tests and on the Newey–West bandwidth in the PP tests.

The results indicate that the null hypotheses, namely, unit roots are present, are rejected at the 5% and 10% significance level for the China and Hong Kong variables, respectively. The null hypotheses are not rejected at the 10% significance level for any of the other variables in any case. Moreover, the null hypotheses proposing that unit roots are present are all rejected at the 1% significance level in the first differences of the variables represented by ⊿. That is, the first differences of the variables are all stationary, and all the variables are considered as I (1) processes. In the following analyses, the first differences are used to establish the stationarity of the data.[5]

4.2 *Cointegration Tests*

Next, to establish whether cointegration exists between the stock prices, the Johansen tests are employed. Table 3 presents the results.

Table 3. Cointegration Tests (Johansen's likelihood ratio tests)

Table 3-1. Cointegration Tests: sample: 1 January 1991 to 31 December 2014

Null hypothesis	Alternative hypothesis	Trace test	Max-eigenvalue test
r=0	r>=1	146.8 (95.8)	71.4 (40.1)
r<=1	r>=2	75.4 (69.8)	26.9 (33.9)
r<=2	r>=3	48.5 (47.9)	23.2 (27.6)
r<=3	r>=4	25.2 (29.8)	13.0 (21.1)
r<=4	r>=5	12.2 (15.5)	9.8 (14.3)
r<=5	r>=6	2.5 (3.8)	2.5 (3.8)

Note: The figures in the parentheses represent 5% significance points.

[5] The first difference of the stock prices that takes a natural logarithm becomes approximately the rate of stock returns.

Table 3-2. Cointegration Tests: sample: 1 January 1991 to 30 June 1997

Null hypothesis	Alternative hypothesis	Trace test	Max-eigenvalue test
r=0	r>=1	76.2 (95.8)	31.5 (40.1)
r<=1	r>=2	44.7 (69.8)	15.5 (33.9)
r<=2	r>=3	29.2 (47.9)	13.6 (27.6)
r<=3	r>=4	15.6 (29.8)	11.0 (21.1)
r<=4	r>=5	4.6 (15.5)	4.6 (14.3)
r<=5	r>=6	0.0 (3.8)	0.0 (3.8)

Table 3-3. Cointegration Tests: sample: 1 July 1997 to 31 December 1998

Null hypothesis	Alternative hypothesis	Trace test	Max-eigenvalue test
r=0	r>=1	76.5 (95.8)	23.1 (40.1)
r<=1	r>=2	53.4 (69.8)	18.8 (33.9)
r<=2	r>=3	34.6 (47.9)	15.1 (27.6)
r<=3	r>=4	19.5 (29.8)	10.8 (21.1)
r<=4	r>=5	8.7 (15.5)	6.1 (14.3)
r<=5	r>=6	2.6 (3.8)	2.6 (3.8)

Table 3-4. Cointegration Tests: sample: 1 January 1999 to 14 August 2007

Null hypothesis	Alternative hypothesis	Trace test	Max-eigenvalue test
r=0	r>=1	103.8 (95.8)	40.4 (40.1)
r<=1	r>=2	63.4 (69.8)	28.6 (33.9)
r<=2	r>=3	34.8 (47.9)	15.2 (27.6)
r<=3	r>=4	19.5 (29.8)	12.2 (21.1)
r<=4	r>=5	7.4 (15.5)	7.1 (14.3)
r<=5	r>=6	0.3 (3.8)	0.3 (3.8)

Table 3-5. Cointegration Tests: sample: 15 August 2007 to 31 December 2009

Null hypothesis	Alternative hypothesis	Trace test	Max-eigenvalue test
r=0	r>=1	101.0 (95.8)	36.5 (40.1)
r<=1	r>=2	64.5 (69.8)	27.8 (33.9)
r<=2	r>=3	36.7 (47.9)	20.2 (27.6)
r<=3	r>=4	16.5 (29.8)	8.7 (21.1)
r<=4	r>=5	7.8 (15.5)	5.9 (14.3)
r<=5	r>=6	1.9 (3.8)	1.9 (3.8)

Table 3-6. Cointegration Tests: sample: 1 January 2010 to 31 December 2014

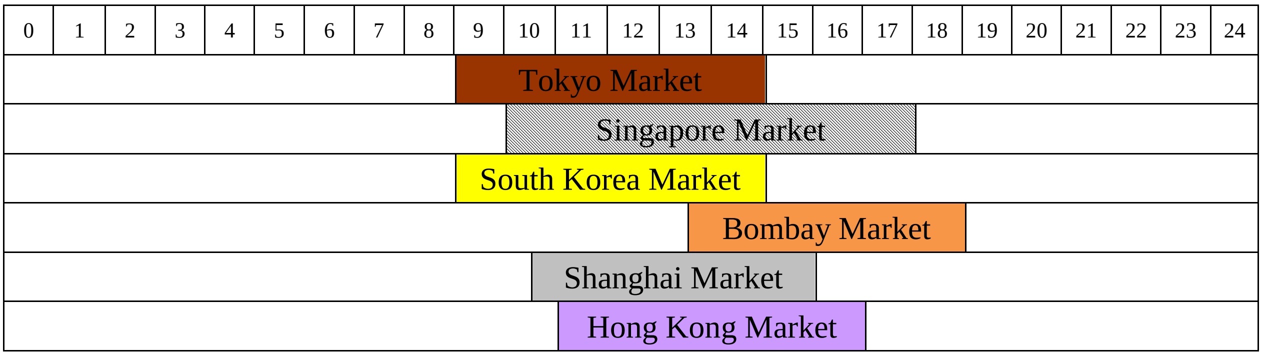
Null hypothesis	Alternative hypothesis	Trace test	Max-eigenvalue test
r=0	r>=1	78.3 (95.8)	26.2 (40.1)
r<=1	r>=2	52.1 (69.8)	19.0 (33.9)
r<=2	r>=3	33.1 (47.9)	13.4 (27.6)
r<=3	r>=4	19.7 (29.8)	10.9 (21.1)
r<=4	r>=5	8.7 (15.5)	6.4 (14.3)
r<=5	r>=6	2.3 (3.8)	2.3 (3.8)

Table 3-1 shows that trace tests find three cointegrating vectors and max-eigenvalue tests find one cointegrating vector. Table 3-4 show that both trace tests and max-eigenvalue tests find one cointegrating vector. Table 3-5 shows that trace tests find one cointegrating vector. Table 3-2, Table 3-3 and Table 3-6 show that both trace tests and max-eigenvalue tests find no cointegrating vectors. In other words, generally speaking, for the period before the Asian financial crisis, the period of the Asian financial crisis, and the period after the global financial crisis, no cointegration relationship exists among the markets. For the whole sample period, the period after the Asian financial crisis and before the global financial crisis, and the period of the global financial crisis, cointegration relationships exist among the markets, and long-term equilibrium relationships could be found among the stock prices of these markets. The reason of the results for the cointegration tests can be thought as follows: learning a lesson from the Asian financial crisis in 1997, many Asian countries had have accumulated foreign reserves, enhanced their financial systems and adopted closer collaborative measures in the field of finance to respond jointly to financial risk.

4.3 ***Impulse Response***

First, I consider the trading time of each market before implementing the impulse response analysis. Figure 2 shows the stock trading opening and closing times in Japan standard time. The Tokyo market in Japan and the South Korea market open at 9 a.m., the Singapore market opens at 10 a.m., the Shanghai market in China opens at 10:30 a.m., the Hong Kong market opens at 11 a.m., and the Bombay market in India opens at 1:25 p.m. In addition, the Tokyo market and the South Korea market close at 3 p.m., the Shanghai market closes at 4 p.m., the Hong Kong market closes at 5 p.m., the Singapore market closes at 6 p.m., and the Bombay market closes at 7 p.m.

Figure 2. Stock trading opening and closing times (Japan standard time)



Here, the generalized impulse response, not depending on the variable turns, indicates the mechanism by which innovations in one stock market are transmitted to other markets over time. Figures 3-1 to 3-6 show the impulse responses of each market to a shock of one standard deviation. The vertical axes represent deviations from the trend, and the horizontal axes represent time, shown daily. Twenty days are represented.[6] According to the results of the Johansen cointegration tests, cointegration relationships exist among the markets during the whole sample period of 1 January 1991 to 31 December 2014, so Vector Error Correction Models (VECM) are used here.

Figure 3. Impulse Responses

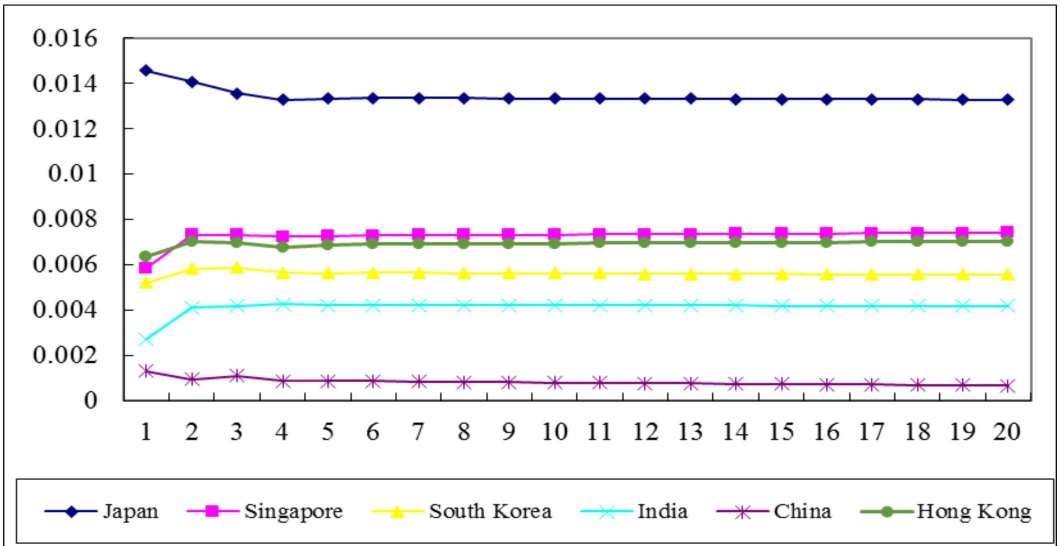


Figure 3-1. Impulse Responses of Japan:
sample: 1 January 1991 – 31 December 2014

[6] According to the Akaike information criterion, the VAR order lag is two period lags.

Figure 3-1 indicates the impulse responses for Japan. It is as follows, in order of size. To a one standard deviation shock in its own value, the impulse response of Japan is 0.015 on the first day and 0.014 on the second day, settling at about 0.013 beginning on the third day. To a one standard deviation shock in Hong Kong, the impulse response of Japan is 0.006 on the first day, and settles at about 0.007 beginning on the second day. To a one standard deviation shock in Singapore, it is 0.006 on the first day and settles at about 0.007 beginning on the second day, exceeding the impulse response to a one standard deviation shock in Hong Kong on the second day. To a one standard deviation shock in South Korea, it is 0.005 on the first day, and settles at about 0.006 beginning on the second day. To a one standard deviation shock in India, it is 0.003 on the first day and settles at about 0.004 beginning on the second day. To a one standard deviation shock in China, the impulse response of Japan is about 0.001 over time.

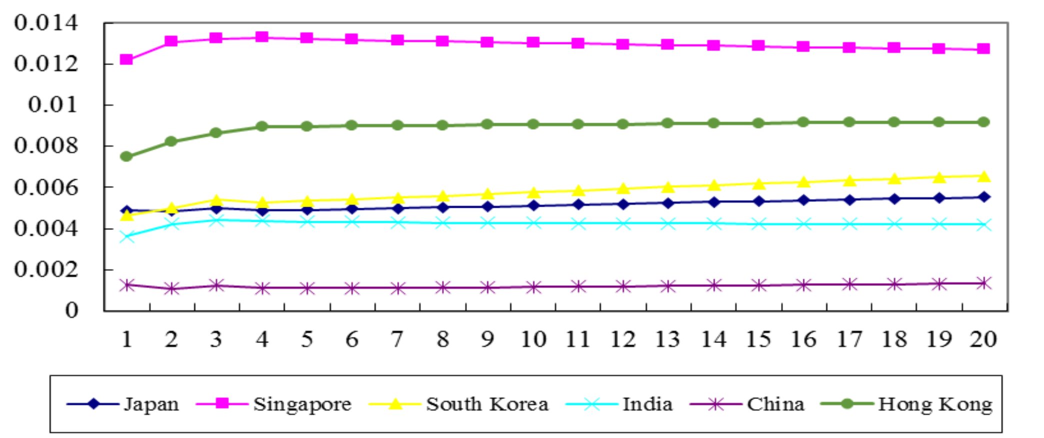


Figure 3-2. Impulse Responses of Singapore: sample: 1 January 1991 – 31 December 2014

Figure 3-2 indicates the impulse responses for Singapore. It is as follows, in order of size. To a one standard deviation shock in its own value, the impulse response of Singapore is 0.012 on the first day, settling at about 0.013 beginning on the second day. To a one standard deviation shock in Hong Kong, the impulse response of Singapore is 0.007 on the first day, 0.008 on the second day, and settles at 0.009 beginning on the third day. To a one standard deviation shock in Japan, it is about 0.005 over time. To a one standard deviation shock in South Korea, the impulse response of Singapore is 0.005 on the first day, and then becomes larger little by little until settles at 0.007 on the 20th day. To a one standard deviation shock in India and China, it is about 0.004 and 0.001 over time, respectively.

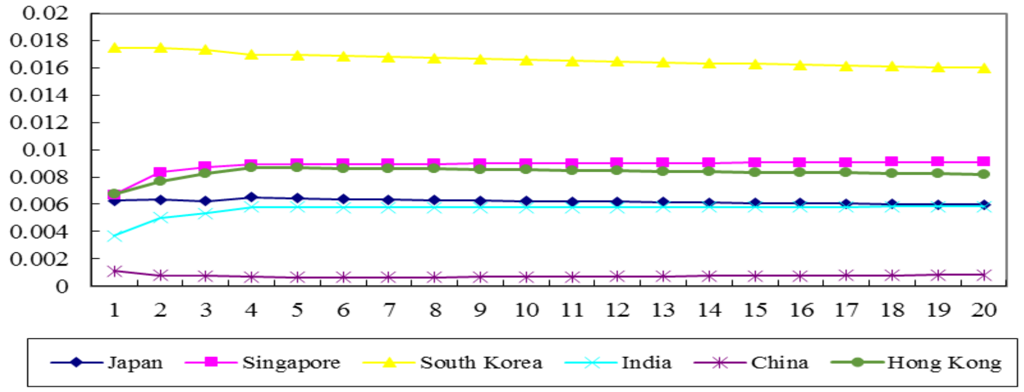


Figure 3-3. Impulse Responses of South Korea:
sample: 1 January 1991 – 31 December 2014

Figure 3-3 indicates the impulse responses for South Korea. It is as follows, in order of size. To a one standard deviation shock in its own value, the impulse response of South Korea is 0.017 on the first day, and then becomes smaller little by little until settles at 0.016 on the 20th day. To a one standard deviation shock in Singapore, it is 0.007 on the first day, and then becomes larger little by little until settles at 0.009 on the 20th day. To a one standard deviation shock in Hong Kong, it is 0.007 on the first day, and settles at about 0.008 beginning on the second day. To a one standard deviation shock in Japan, it is about 0.006 over time. To a one standard deviation shock in India, the impulse response of South Korea is 0.004 on the first day, 0.005 on the second and third day, and settles at 0.006 beginning on the fourth day. To a one standard deviation shock in China, it is about 0.001 over time.

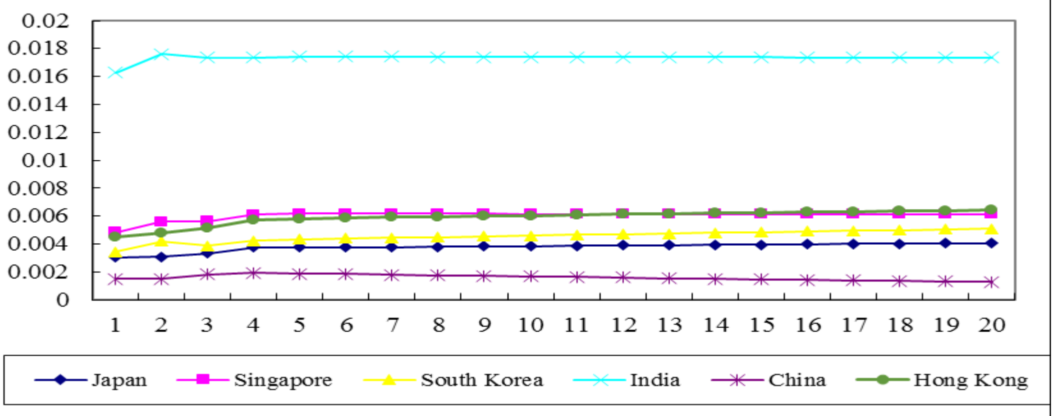


Figure 3-4. Impulse Responses of India:
sample: 1 January 1991 – 31 December 2014

Figure 3-4 indicates the impulse responses for India. It is as follows, in order of size. To a one standard deviation shock in its own value, the impulse response of India is 0.016 on the first day, 0.018 on the second day, and settles at 0.017 on the third day. To one standard deviation shocks in other markets, the impulse responses of India are very small: concretely, to a one standard deviation shock in Singapore, it is 0.005 on the first day, and settles at 0.006 on the second day; to a one standard deviation shock in Hong Kong, it is 0.004 on the first day, 0.005 on the second and third day, and settles at 0.006 on the fourth day; to a one standard deviation shock in South Korea, it is 0.003 on the first day, then becomes larger little by little until settles at 0.005 on the 20th day; to a one standard deviation shock in Japan, it is 0.003 on the first three days, and settles at 0.004 on the fourth day; and to a one standard deviation shock in China, it is about 0.001 over time.

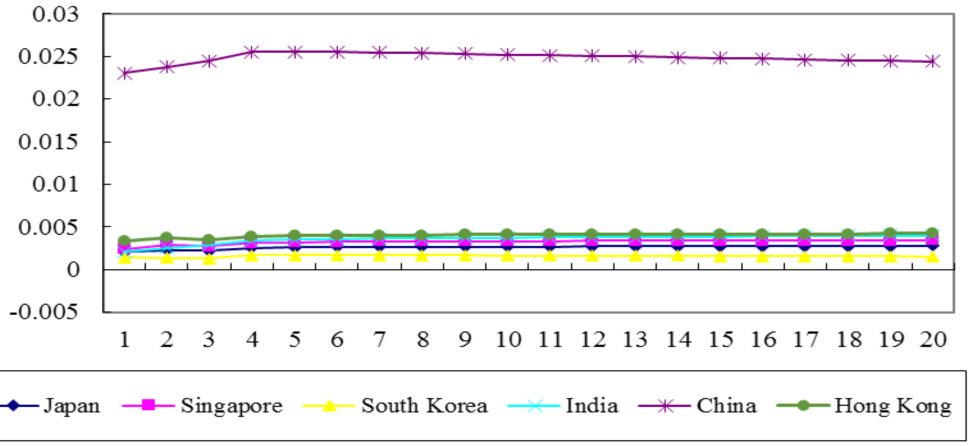


Figure 3-5. Impulse Responses of China:
sample: 1 January 1991 – 31 December 2014

Figure 3-5 indicates the impulse responses for China. It is as follows, in order of size. To a one standard deviation shock in its own value, the impulse response of China is 0.023 on the first day, and becomes larger until settles at 0.026 on the fourth day, and then smaller little by little until settles at 0.024 on the 20th day. To one standard deviation shocks in other markets, the impulse responses of China are very small: concretely, to a one standard deviation shock in Hong Kong and India, the impulse responses of China are about 0.004; to a one standard deviation shock in Singapore and Japan, they are about 0.003; and to a one standard deviation shock in South Korea, it is about 0.002 over time.

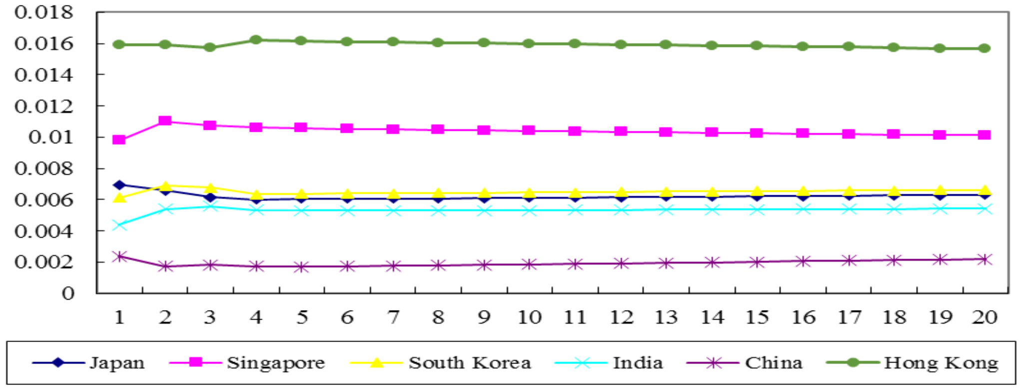


Figure 3-6. Impulse Responses of Hong Kong:
sample: 1 January 1991 – 31 December 2014

Figure 3-6 indicates the impulse responses for Hong Kong. It is as follows, in order of size. To a one standard deviation shock in its own value, the impulse response of Hong Kong is about 0.016 over time. To a one standard deviation shock in Singapore, the impulse response of Hong Kong is 0.010 on the first day, 0.011 on the second day, and then becomes smaller little by little until settles at 0.010 on the 20th day. To a one standard deviation shock in Japan, it is 0.007 on the first and second day, and settles at about 0.006 beginning on the third day. To a one standard deviation shock in South Korea, it is 0.006 on the first day, and settles at about 0.007 beginning on the second day, exceeding the impulse response of Hong Kong to a one standard deviation shock in Japan on the second day. To a one standard deviation shock in India, it is 0.004 on the first day, and settles at about 0.005 beginning on the second day. To a one standard deviation shock in China, it is about 0.002 over time.

In summary, based on the results of the impulse responses, the effect of the Hong Kong market on the Singapore market is large, and at the same time, the effect of the Singapore market on the Hong Kong market is large. On the other hand, the Chinese mainland market and the India market do not seem to have been much affected by the other stock markets.

Both Singapore and Hong Kong are the principal international financial centers in Asia and are highly dependent on international trade and finance. Both of them have high degrees of economic freedom, attractive business environment, and ample foreign exchange reserves. The capital can freely enter and exit Singapore and Hong Kong without foreign investors' regulation and foreign currency restrictions. They also have strong legal systems and low-taxation systems. In addition, in Singapore and Hong

Kong, most people make use of English and Chinese, which expands business opportunities. All of the factors make the Singapore and Hong Kong markets exhibit close ties, and can affect each other easily.

Both the Chinese mainland market and the India market are not completely internationalized and liberalized yet. The capital cannot flow inside and outside the two countries freely, and foreign investors and foreign currency are restricted. The regulation of capital dealings makes it impossible to adequately cope with the growing globalization of the securities market.

4.4 *Variance Decomposition*

Forecast error variance decomposition is used to indicate the contribution of the innovation to the variation in each variable. The results are shown in Tables 4-1 to 4-6. In this case, 20 days are analyzed. Here, for the whole sample period, the period after the Asian financial crisis and before the global financial crisis, and the period of the global financial crisis, cointegration relationships exist, so Vector Error Correction Models (VECM) are used instead of VAR models. For the other sample periods, VAR models are used.

Table 4. Variance Decomposition (Unit: %)

Table 4-1. Variance Decomposition of Japan

	1 January 1991 – 31 December 2014					
	Japan	Singapore	South Korea	India	China	Hong Kong
1 day	100.00	0.00	0.00	0.00	0.00	0.00
4 days	97.79	1.51	0.08	0.53	0.09	0.01
8 days	97.16	1.95	0.07	0.67	0.14	0.00
12 days	96.90	2.14	0.06	0.72	0.17	0.00
20 days	96.62	2.37	0.05	0.74	0.22	0.00

	1 January 1991 – 30 June 1997					
	Japan	Singapore	South Korea	India	China	Hong Kong
1 day	100.00	0.00	0.00	0.00	0.00	0.00
4 days	99.85	0.05	0.04	0.01	0.03	0.02
8 days	99.85	0.05	0.04	0.01	0.03	0.02
12 days	99.85	0.05	0.04	0.01	0.03	0.02
20 days	99.85	0.05	0.04	0.01	0.03	0.02

	1 July 1997 – 31 December 1998					
	Japan	Singapore	South Korea	India	China	Hong Kong
1 day	100.00	0.00	0.00	0.00	0.00	0.00
4 days	98.78	0.25	0.37	0.21	0.28	0.10
8 days	98.78	0.25	0.37	0.21	0.28	0.10
12 days	98.78	0.25	0.37	0.21	0.28	0.10
20 days	98.78	0.25	0.37	0.21	0.28	0.10

	1 January 1999 – 14 August 2007					
	Japan	Singapore	South Korea	India	China	Hong Kong
1 day	100.00	0.00	0.00	0.00	0.00	0.00
4 days	91.06	0.85	0.14	1.39	0.88	5.68
8 days	88.89	0.74	0.14	1.73	1.10	7.40
12 days	88.00	0.71	0.14	1.88	1.18	8.09
20 days	87.21	0.68	0.14	2.01	1.26	8.69

	15 August 2007 – 31 December 2009					
	Japan	Singapore	South Korea	India	China	Hong Kong
1 day	100.00	0.00	0.00	0.00	0.00	0.00
4 days	83.54	13.20	0.09	1.37	1.39	0.42
8 days	81.49	15.31	0.06	0.93	1.51	0.69
12 days	80.24	16.25	0.12	0.74	1.59	1.05
20 days	78.51	17.13	0.41	0.53	1.68	1.74

	1 January 2010 – 31 December 2014					
	Japan	Singapore	South Korea	India	China	Hong Kong
1 day	100.00	0.00	0.00	0.00	0.00	0.00
4 days	96.71	2.06	0.20	0.91	0.09	0.03
8 days	96.71	2.06	0.20	0.91	0.09	0.03
12 days	96.71	2.06	0.20	0.91	0.09	0.03
20 days	96.71	2.06	0.20	0.91	0.09	0.03

Table 4-1 shows the results of the variance decomposition for Japan from 1 January 1991 to 31 December 2014: for Japan, the variation of 100% depends on a shock from Japan itself on the first day, as does the variation of 96.62% on the 20th day. For the other five variables, the shocks of Singapore, South Korea, India, China, and Hong Kong on Japan account for only 2.37%, 0.05%, 0.74%, 0.22%, and 0.00%, respectively, on the 20th day, indicating that the degree to which these five markets influence Japan is very small.

Furthermore, during the Asian financial crisis, the period from 1 July 1997 to 31 December 1998, for Japan, its own shock and the shocks of Singapore, South Korea, India, China and Hong Kong did not change greatly, indicating that the degree to which the five markets influence Japan is very small during the Asian Financial crisis; during the global financial crisis, the period from 15 August 2007 to 31 December 2009, for Japan, its own shock decreased, but the shock of Singapore on Japan rose slightly. Therefore, it can be said that the Japan stock market became easily affected by the Singapore market because of the global financial crisis.

Table 4-2. Variance Decomposition of Singapore

	1 January 1991 – 31 December 2014					
	Japan	Singapore	South Korea	India	China	Hong Kong
1 day	16.11	83.89	0.00	0.00	0.00	0.00
4 days	14.27	85.31	0.05	0.09	0.03	0.26
8 days	14.19	85.02	0.12	0.09	0.04	0.54
12 days	14.59	84.35	0.26	0.08	0.03	0.68
20 days	15.66	82.71	0.69	0.07	0.02	0.85

	1 January 1991 – 30 June 1997					
	Japan	Singapore	South Korea	India	China	Hong Kong
1 day	4.38	95.62	0.00	0.00	0.00	0.00
4 days	4.52	94.94	0.08	0.02	0.04	0.39
8 days	4.52	94.94	0.08	0.02	0.04	0.39
12 days	4.52	94.94	0.08	0.02	0.04	0.39
20 days	4.52	94.94	0.08	0.02	0.04	0.39

	1 July 1997 – 31 December 1998					
	Japan	Singapore	South Korea	India	China	Hong Kong
1 day	8.17	91.83	0.00	0.00	0.00	0.00
4 days	7.93	88.75	0.39	0.26	0.66	2.02
8 days	7.93	88.75	0.39	0.26	0.66	2.02
12 days	7.93	88.75	0.39	0.26	0.66	2.02

20 days	7.93	88.75	0.39	0.26	0.66	2.02

	1 January 1999 – 14 August 2007					
	Japan	Singapore	South Korea	India	China	Hong Kong
1 day	17.74	82.26	0.00	0.00	0.00	0.00
4 days	14.45	84.53	0.03	0.18	0.05	0.76
8 days	13.64	85.20	0.02	0.20	0.06	0.87
12 days	13.31	85.48	0.02	0.21	0.07	0.92
20 days	13.02	85.72	0.02	0.21	0.07	0.96

	15 August 2007 – 31 December 2009					
	Japan	Singapore	South Korea	India	China	Hong Kong
1 day	36.36	63.64	0.00	0.00	0.00	0.00
4 days	29.14	69.72	0.03	0.17	0.56	0.37
8 days	27.54	71.27	0.02	0.09	0.65	0.43
12 days	26.75	71.98	0.01	0.06	0.69	0.51
20 days	25.80	72.74	0.04	0.04	0.72	0.67

	1 January 2010 – 31 December 2014					
	Japan	Singapore	South Korea	India	China	Hong Kong
1 day	22.95	77.05	0.00	0.00	0.00	0.00
4 days	22.50	75.51	0.22	0.89	0.49	0.38
8 days	22.50	75.51	0.22	0.89	0.49	0.38
12 days	22.50	75.51	0.22	0.89	0.49	0.38
20 days	22.50	75.51	0.22	0.89	0.49	0.38

Table 4-2 shows the results of the variance decomposition for Singapore from 1 January 1991 to 31 December 2014: for Singapore, the variation of 83.89% depends on a shock from Singapore itself on the first day, as does 82.71% on the 20th day. Among the other five variables, the shock of Japan on Singapore accounts for 15.66% on the 20th day, indicating that the degree to which Japan influences Singapore is comparably large. The shocks of South Korea, India, China, and Hong Kong on Singapore account for only 0.69%, 0.07%, 0.02%, and 0.85%, respectively, on the 20th day; hence, it can be said that these four markets influence Singapore very little.

Furthermore, during the Asian financial crisis, the period from 1 July 1997 to 31 December 1998, for Singapore, its own shock decreased, but the shock of Japan on

Singapore rose slightly; during the global financial crisis, the period from 15 August 2007 to 31 December 2009, for Singapore, its own shock decreased, but the shock of Japan on Singapore rose. Therefore, it can be said that the Singapore stock market has become easily affected by the Japan market because of the Asian financial crisis and the global financial crisis.

Table 4-3. Variance Decomposition of South Korea

	1 January 1991 – 31 December 2014					
	Japan	Singapore	South Korea	India	China	Hong Kong
1 day	12.79	6.83	80.38	0.00	0.00	0.00
4 days	13.13	12.59	73.60	0.45	0.09	0.14
8 days	13.40	14.53	70.96	0.71	0.13	0.26
12 days	13.42	15.50	69.84	0.81	0.14	0.28
20 days	13.36	16.84	68.46	0.95	0.14	0.25

	1 January 1991 – 30 June 1997					
	Japan	Singapore	South Korea	India	China	Hong Kong
1 day	0.37	0.25	99.39	0.00	0.00	0.00
4 days	0.37	0.50	99.05	0.03	0.03	0.01
8 days	0.37	0.50	99.05	0.03	0.03	0.01
12 days	0.37	0.50	99.05	0.03	0.03	0.01
20 days	0.37	0.50	99.05	0.03	0.03	0.01

	1 July 1997 – 31 December 1998					
	Japan	Singapore	South Korea	India	China	Hong Kong
1 day	3.11	1.80	95.09	0.00	0.00	0.00
4 days	3.72	1.94	93.82	0.01	0.02	0.48
8 days	3.72	1.94	93.82	0.01	0.02	0.48
12 days	3.72	1.94	93.82	0.01	0.02	0.48
20 days	3.72	1.94	93.82	0.01	0.02	0.48

	1 January 1999 – 14 August 2007					
	Japan	Singapore	South Korea	India	China	Hong Kong
1 day	19.30	8.41	72.29	0.00	0.00	0.00
4 days	16.82	10.58	71.68	0.13	0.15	0.64
8 days	16.14	10.90	71.87	0.16	0.16	0.78

12 days	15.88	11.06	71.91	0.17	0.17	0.83
20 days	15.65	11.20	71.93	0.18	0.17	0.87

	15 August 2007 – 31 December 2009					
	Japan	Singapore	South Korea	India	China	Hong Kong
1 day	46.80	10.21	42.99	0.00	0.00	0.00
4 days	35.37	26.73	35.55	1.44	0.67	0.25
8 days	32.74	30.41	34.07	1.45	0.82	0.50
12 days	31.44	32.89	32.36	1.33	0.89	1.08
20 days	29.61	36.37	29.33	1.07	0.97	2.64

	1 January 2010 – 31 December 2014					
	Japan	Singapore	South Korea	India	China	Hong Kong
1 day	24.61	14.83	60.57	0.00	0.00	0.00
4 days	23.57	15.79	58.15	2.08	0.18	0.23
8 days	23.57	15.79	58.15	2.08	0.18	0.23
12 days	23.57	15.79	58.15	2.08	0.18	0.23
20 days	23.57	15.79	58.15	2.08	0.18	0.23

Table 4-3 shows the results of the variance decomposition for South Korea from 1 January 1991 to 31 December 2014: for South Korea, the variation of 80.38% depends on a shock from South Korea itself on the first day, as does 68.46% on the 20th day. Next to its own shock, the shocks of Singapore and Japan have comparably large effects on South Korea, accounting for 16.84% and 13.36%, respectively, on the 20th day. Hence, it can be said that the Singapore market and the Japan market influence the South Korea market. The shocks of India, China, and Hong Kong on South Korea account for only 0.95%, 0.14%, and 0.25%, respectively, on the 20th day, indicating that the degree to which these three markets influence South Korea is very small.

Furthermore, during the Asian financial crisis, the period from 1 July 1997 to 31 December 1998, for South Korea, its own shock and the shocks of Japan, Singapore, India, China and Hong Kong did not change greatly, indicating that the degree to which the five markets influence South Korea is very small during the Asian Financial crisis; during the global financial crisis, the period from 15 August 2007 to 31 December 2009, for South Korea, its own shock decreased, but the shocks of Japan and Singapore on South Korea rose rapidly. Therefore, it can be said that the South Korea stock market became easily affected by other stock markets because of the global financial crisis.

Table 4-4. Variance Decomposition of India

	1 January 1991 – 31 December 2014					
	Japan	Singapore	South Korea	India	China	Hong Kong
1 day	3.51	5.92	0.80	89.78	0.00	0.00
4 days	3.73	7.26	1.03	87.94	0.01	0.03
8 days	4.22	7.88	1.14	86.68	0.01	0.07
12 days	4.45	8.02	1.27	86.14	0.01	0.12
20 days	4.76	8.03	1.56	85.40	0.02	0.23

	1 January 1991 – 30 June 1997					
	Japan	Singapore	South Korea	India	China	Hong Kong
1 day	0.01	0.09	0.03	99.87	0.00	0.00
4 days	0.05	0.09	0.13	99.58	0.02	0.12
8 days	0.05	0.09	0.13	99.58	0.02	0.12
12 days	0.05	0.09	0.13	99.58	0.02	0.12
20 days	0.05	0.09	0.13	99.58	0.02	0.12

	1 July 1997 – 31 December 1998					
	Japan	Singapore	South Korea	India	China	Hong Kong
1 day	0.81	2.39	1.66	95.14	0.00	0.00
4 days	2.05	2.40	1.72	93.38	0.32	0.13
8 days	2.05	2.40	1.72	93.38	0.32	0.13
12 days	2.05	2.40	1.72	93.38	0.32	0.13
20 days	2.05	2.40	1.72	93.38	0.32	0.13

	1 January 1999 – 14 August 2007					
	Japan	Singapore	South Korea	India	China	Hong Kong
1 day	8.82	3.70	0.86	86.62	0.00	0.00
4 days	13.51	4.11	1.13	78.88	0.27	2.10
8 days	15.05	4.18	1.13	76.55	0.34	2.74
12 days	15.65	4.23	1.13	75.63	0.37	2.99
20 days	16.16	4.27	1.14	74.84	0.40	3.19

	15 August 2007 – 31 December 2009					
	Japan	Singapore	South Korea	India	China	Hong Kong

1 day	14.40	27.68	0.33	57.59	0.00	0.00
4 days	17.08	34.71	0.37	47.23	0.49	0.12
8 days	17.51	38.14	0.20	43.68	0.39	0.08
12 days	17.32	39.43	0.18	42.62	0.35	0.09
20 days	16.74	40.77	0.29	41.71	0.32	0.18

	1 January 2010 – 31 December 2014					
	Japan	Singapore	South Korea	India	China	Hong Kong
1 day	7.41	17.60	1.19	73.80	0.00	0.00
4 days	7.42	17.55	1.54	73.03	0.06	0.41
8 days	7.42	17.55	1.54	73.03	0.06	0.41
12 days	7.42	17.55	1.54	73.03	0.06	0.41
20 days	7.42	17.55	1.54	73.03	0.06	0.41

Table 4-4 shows the results of the variance decomposition for India from 1 January 1991 to 31 December 2014: for India, the variation of 89.78% depends on a shock from India itself on the first day, as does 85.40% on the 20th day. For the other five variables, the shocks of Japan, Singapore, South Korea, China, and Hong Kong on India account for only 4.76%, 8.03%, 1.56%, 0.02%, and 0.23%, respectively, on the 20th day, indicating that the degree to which these five markets influence India is very small.

Furthermore, during the Asian financial crisis, the period from 1 July 1997 to 31 December 1998, for India, its own shock and the shocks of Japan, Singapore, South Korea, China and Hong Kong did not change greatly, indicating that the degree to which the five markets influence India is very small during the Asian Financial crisis; during the global financial crisis, the period from 15 August 2007 to 31 December 2009, for India, its own shock decreased, but the shocks of Singapore and Japan rose. Therefore, it can be said that the India stock market became easily affected by other stock markets because of the global financial crisis.

Table 4-5. Variance Decomposition of China

	1 January 1991 – 31 December 2014					
	Japan	Singapore	South Korea	India	China	Hong Kong
1 day	0.81	0.58	0.01	0.34	98.26	0.00
4 days	0.90	0.74	0.00	0.66	97.69	0.01
8 days	1.00	0.82	0.00	0.88	97.28	0.01
12 days	1.05	0.87	0.00	0.99	97.07	0.01

20 days	1.13	0.94	0.00	1.16	96.77	0.01

	1 January 1991 – 30 June 1997					
	Japan	Singapore	South Korea	India	China	Hong Kong
1 day	0.01	0.11	0.04	0.30	99.54	0.00
4 days	0.09	0.14	0.10	0.30	99.36	0.00
8 days	0.09	0.14	0.10	0.30	99.36	0.00
12 days	0.09	0.14	0.10	0.30	99.36	0.00
20 days	0.09	0.14	0.10	0.30	99.36	0.00

	1 July 1997 – 31 December 1998					
	Japan	Singapore	South Korea	India	China	Hong Kong
1 day	0.02	0.01	0.00	0.04	99.93	0.00
4 days	0.29	0.23	0.08	0.77	98.56	0.06
8 days	0.29	0.23	0.08	0.77	98.56	0.06
12 days	0.29	0.23	0.08	0.77	98.56	0.06
20 days	0.29	0.23	0.08	0.77	98.56	0.06

	1 January 1999 – 14 August 2007					
	Japan	Singapore	South Korea	India	China	Hong Kong
1 day	0.08	0.35	0.04	0.30	99.22	0.00
4 days	0.45	0.67	0.03	1.23	94.51	3.12
8 days	0.54	0.72	0.01	1.55	93.08	4.09
12 days	0.57	0.75	0.01	1.67	92.53	4.47
20 days	0.60	0.77	0.01	1.77	92.06	4.80

	15 August 2007 – 31 December 2009					
	Japan	Singapore	South Korea	India	China	Hong Kong
1 day	8.06	3.96	1.51	1.01	85.46	0.00
4 days	7.01	8.54	1.41	2.34	80.63	0.06
8 days	6.68	9.11	1.11	2.34	80.63	0.13
12 days	6.16	9.23	0.84	2.22	81.31	0.25
20 days	5.31	9.20	0.52	1.96	82.45	0.56

	1 January 2010 – 31 December 2014					
	Japan	Singapore	South Korea	India	China	Hong Kong
1 day	7.35	5.15	2.34	0.16	85.01	0.00
4 days	7.42	5.14	2.33	0.49	84.61	0.00
8 days	7.42	5.14	2.33	0.49	84.61	0.00
12 days	7.42	5.14	2.33	0.49	84.61	0.00
20 days	7.42	5.14	2.33	0.49	84.61	0.00

Table 4-5 shows the results of the variance decomposition for China from 1 January 1991 to 31 December 2014: for China, the variation of 98.26% depends on a shock from China itself on the first day, as does 96.77% on the 20th day. For the other five variables, the shocks of Japan, Singapore, South Korea, India, and Hong Kong on China account for only 1.13%, 0.94%, 0.00%, 1.16%, and 0.01%, respectively, on the 20th day, indicating that the degree to which these five markets influence China is very small.

Furthermore, during the Asian financial crisis, the period from 1 July 1997 to 31 December 1998, for China, its own shock and the shocks of Japan, Singapore, South Korea, India, and Hong Kong did not change greatly, indicating that the degree to which the five markets influence China is very small during the Asian Financial crisis; during the global financial crisis, the period from 15 August 2007 to 31 December 2009, for China, its own shock decreased, but the shocks of Singapore and Japan rose slightly. Therefore, it can be said that the China stock market became affected by other stock markets because of the global financial crisis.

Table 4-6. Variance Decomposition of Hong Kong

	1 January 1991 – 31 December 2014					
	Japan	Singapore	South Korea	India	China	Hong Kong
1 day	19.12	23.08	1.31	0.48	0.46	55.55
4 days	16.07	29.47	1.90	1.24	0.15	51.16
8 days	15.02	29.55	1.83	1.33	0.11	52.16
12 days	14.87	29.36	1.88	1.39	0.11	52.40
20 days	15.11	28.87	2.03	1.52	0.15	52.32

	1 January 1991 – 30 June 1997					
	Japan	Singapore	South Korea	India	China	Hong Kong
1 day	3.76	15.47	0.07	0.16	0.00	80.54
4 days	3.75	15.74	0.11	0.16	0.00	80.25

8 days	3.75	15.74	0.11	0.16	0.00	80.25
12 days	3.75	15.74	0.11	0.16	0.00	80.25
20 days	3.75	15.74	0.11	0.16	0.00	80.25

	1 July 1997 – 31 December 1998					
	Japan	Singapore	South Korea	India	China	Hong Kong
1 day	14.51	26.19	0.30	1.31	0.24	57.45
4 days	14.22	25.22	1.74	1.83	2.01	54.98
8 days	14.22	25.22	1.74	1.83	2.01	54.98
12 days	14.22	25.22	1.74	1.83	2.01	54.98
20 days	14.22	25.22	1.74	1.83	2.01	54.98

	1 January 1999 – 14 August 2007					
	Japan	Singapore	South Korea	India	China	Hong Kong
1 day	17.00	22.25	4.86	2.82	0.02	53.04
4 days	10.61	33.34	7.47	12.55	3.66	32.37
8 days	7.74	38.42	8.79	17.08	5.03	22.94
12 days	6.45	40.72	9.38	19.09	5.65	18.71
20 days	5.24	42.88	9.93	20.96	6.23	14.75

	15 August 2007 – 31 December 2009					
	Japan	Singapore	South Korea	India	China	Hong Kong
1 day	40.21	25.14	1.34	1.57	4.40	27.35
4 days	33.25	48.86	1.23	2.81	1.18	12.67
8 days	31.23	55.12	0.74	2.45	0.71	9.74
12 days	29.69	58.89	0.59	2.17	0.56	8.09
20 days	27.22	63.54	0.99	1.73	0.45	6.07

	1 January 2010 – 31 December 2014					
	Japan	Singapore	South Korea	India	China	Hong Kong
1 day	22.51	28.01	6.35	1.36	5.76	36.01
4 days	21.82	28.17	6.18	2.81	6.04	34.97
8 days	21.82	28.17	6.18	2.81	6.04	34.97
12 days	21.82	28.17	6.18	2.81	6.04	34.97
20 days	21.82	28.17	6.18	2.81	6.04	34.97

Table 4-6 shows the results of the variance decomposition for Hong Kong from 1 January 1991 to 31 December 2014: for Hong Kong, the variation of 55.55% depends on a shock from Hong Kong itself on the first day, as does 52.32% on the 20th day. Next to its own shock, the shocks of Singapore and Japan on Hong Kong account for 28.87% and 15.11%, respectively, on the 20th day; hence, it can be said that the Singapore market and the Japan market influence the Hong Kong market. The shocks of South Korea, India, and China on Hong Kong account for only 2.03%, 1.52%, and 0.15%, respectively, on the 20th day, indicating that the degree to which these three markets influence the Hong Kong market is very small.

Furthermore, during the Asian financial crisis, the period from 1 July 1997 to 31 December 1998, for Hong Kong, its own shock decreased, but the shocks of Singapore and Japan rose; during the global financial crisis, the period from 15 August 2007 to 31 December 2009, for Hong Kong, its own shock decreased, but the shocks of Singapore and Japan rose greatly. Therefore, it can be said that the Hong Kong stock market has become easily affected by other stock markets because of the Asian financial crisis and the global financial crisis.

The results of the above-mentioned variance decomposition are as follows: the Singapore market and the Japan market considerably influence the other Asian markets. Furthermore, during the Asian financial crisis, the Singapore market was affected by the Japan market, and the Hong Kong market was affected by the Singapore market and the Japan market. The Asian six stock markets have become easily affected by other stock markets because of the global financial crisis, so it can be said that compared with the Asian financial crisis, the global financial crisis has affected the linkage of the Asian stock markets more greatly.

The Japan and Singapore stock markets are well established, and are major international financial markets. The two markets play important roles in financing enterprise and in the investment activity of investors in Asia. In addition, after 2000, with the widespread use of the Internet and the progress of communication technology, stock price movements of a certain country can be known rapidly by investors all over the world and can influence their investment behaviors. Furthermore, amidst the situation in which trades are expanding and global corporations are tapping new overseas markets, the world economy is being increasingly integrated and events of a certain country quickly ripple through other countries in the field of finance as well.

After the global financial crisis occurred, the banks which had expanded their businesses adjusted the balance sheet, so the financial shocks propagated across the globe, and securitized products and other financial instruments were intricately linked. The investors could not quickly grasp the size and transmission mechanism of the shocks, and then they took the risk avoidance behavior simultaneously. Portfolio adjustments by international investors have made the linkage of the financial markets increase.

Ⅴ Summary and Concluding Remarks

In this paper, the linkage of stock prices in Asian markets (including Japan, Singapore, South Korea, India, the Chinese mainland, and Hong Kong) since the 1990s is analyzed, as well as the influences of the Asian financial crisis and the global financial crisis on the Asian stock markets. The analyses demonstrate that the effects of the Japan stock market and the Singapore stock market on the Asian markets are great, and the Chinese mainland market and the India market are little affected by the other markets. On the whole, it has been revealed that the global financial crisis has affected the linkage of the Asian stock markets more greatly compared with the Asian financial crisis, and the interdependence in stock prices among the Asian markets has increased since the global financial crisis.

After the burst of the Bubble Economy in 1991, the Japan stock market was sluggish for a while. To rebuild the Japan stock market into a world-class financial center, the Japanese Financial Big Bang was implemented in 1997 under the three principles of “free, fair and global.” The Big Bang has deregulated the Japan stock market, and has opened the doors to foreign competitors and global investors. Since then, the Japan stock market has been recovering gradually, and has grown to one of the world's largest stock markets. Singapore has a geographical advantage, and is the Asia's financial and business terminal. Political environment is stable, and the government has focused on promotion and development of the stock market. The Securities and Exchange Commission of Singapore has a strong authority in the management and supervision of listed companies. A strict disclosure system is implemented, and shareholders' rights are protected. Singapore has an efficient and a corruption-free regulatory framework, and has attracted assets and foreign investors formerly. Therefore, the Japan market and the Singapore market affect the Asian markets greatly. However, since Hong Kong was handed back to China in 1997, it has been gradually influenced by political and economic trends in China, so the Hong Kong market does not affect the other Asian markets as the Japan and Singapore markets.

Currently, although China and India are the two most attractive economic powers in the world, their stock markets have not completely developed yet and their financial systems are fragile. As for the Chinese mainland market, the reason the influence from other countries is small is thought to be that capital transactions are not currently liberalized in China. The majority of investors in the Chinese mainland stock market are domestic investors; foreigner investors cannot yet invest freely. In addition, the investment in overseas assets is limited to the Chinese mainland domestic investors. The Chinese mainland market is basically speculative; domestic investors do not pass the judge investments based on fundamentals like the corporate performance, but simply seek capital gains. Similar with the Chinese mainland market, as for the India market, foreigner investors have not yet been permitted to invest in Indian domestic assets directly,[7] and Indian domestic investors also cannot yet invest in overseas assets freely.

The Asian financial markets have now developed into an important part of the global market. However, it cannot yet be said that the arbitrage and adjustment functions of the Asian financial markets are sufficient. Because the degree of enterprises' dependence on bank loans remains high, it is necessary to make efforts to develop the stock markets more in the Asian countries, to diversify the financing of enterprises and the choice of investments, and to use risk analysis to exchange information more widely in the future. To prevent another global financial crisis in the future, Asian countries should not only strengthen their economic fundamentals and implement structural reform, but also adopt closer collaborative measures in the field of finance to respond jointly to financial risk. If they do so, we can expect the financial liberalization and unification of the Asian economy to advance smoothly, and the financial system to be strengthened further.

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[7] Foreigner investors need to invest in Indian domestic assets by either of two ways: ADR (American Depositary Receipt) and ETF (Exchange Traded Fund).

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