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The Relationship between Chinese and Japanese Stock Markets*

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Abstract

The global financial crisis has had various impacts on China and Japan through exchange rates, stock markets, and other elements. A consideration of the linkage of stock prices between the two countries is indispensable if we are to plan ahead for the future of the Asian economy. In this paper, the linkage between stock prices for Japan and China since the 1990s is analyzed, as well as the influences of the global financial crisis on their stock markets.

The estimation results of the EGARCH model show that for China, although stock price volatility is much more intense than Japan, the impacts of the global financial crisis of 2007 was relatively small compared with Japan. In addition, China's stock price volatility during the period of the early 1990s just after the stock market was established was more intense than the period of the global financial crisis. Furthermore, it has been revealed that the interdependence in stock prices between the Chinese and the Japanese markets has increased since the global financial crisis.

In China, since 2000, especially after accession to the WTO in December 2001, the Chinese stock market has also become easy to be affected by asset price fluctuations of other countries compared to before due to the advancement of globalization of stock markets by a series of reform measures. However, because the stock market of China, unlike Japan, has not been internationalized and liberalized completely, although it was influenced by the global financial crisis, the influence was relatively small. Currently, China has the 2nd largest economy in the world now, but the stock market is still developing and the financial system is vulnerable.

Keywords: Linkage of Stock Prices, Asian Stock Markets, Global Financial Crisis

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I Introduction

Currently, the United States, China, and Japan are the top three countries in the world with respect to size of GDP, and they play important roles in the global economy. Moreover, the total market capitalization of the world's stock markets, as of the end of 2012, was approximately 4,842.42 trillion yen.[1] Of this, China for 321.67 trillion yen, and Japan for 320.34 trillion yen, which as percentages of the global total were both 6.6%, and as percentages of their GDP, were 44.9% and 61.7%.[2] Moreover, through globalization and the sharing of information in real time that has progressed in recent years, co-movements within the global economy are increasing. The 2007 global financial crisis that originated in the United States affected the economies of Japan and China in various ways. In the future, in conjunction with the further economic development of, and increased economic exchanges between Japan and China, co-movement between stock prices is expected to increase significantly. Considering the relationship between stock prices in the two countries is important to predict the future development of their economies and the global economy.

In this paper, I analyze the stock-price volatilities and the linkage between the Japanese and Chinese markets. I also analyze the influence of the global financial crisis on the stock markets of the two countries. Concretely, EGARCH (Exponential Generalized Autoregressive Conditional Heteroskedasticity) model is used; stock price volatility in Japan and China is calculated; and the covariance between the stock markets is estimated. To examine the influence of the global financial crisis, the relationships between stock prices are analyzed, while comparing them over different periods.

The composition of this paper is as follows. First, prior research on the linkage of stock prices is surveyed. Next, the stock-price volatilities and the linkage of Japan and China are estimated. For this, first, the EGARCH model that is used for the analysis is explained. Next, the daily stock price indices used for the data are explained, and time series trends are observed. Subsequently, to analyze the linkage of stock prices in Japan and China, the EGARCH model is used to estimate stock-price volatility, and the fundamental statistics are investigated. Finally, the implications are derived based on the results of the empirical analysis.

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[1] Calculated based on the exchange rate at the end of 2012 (1 dollar = 87 yen).

[2] For market capitalization, the author referred to "Foreign Investment Data Bank: www.world401.com/data_yougo/jikasougaku_world.html" and "World Federation of Exchanges: www.world-exchanges.org." For GDP, the author referred to the IMF World Economic Outlook Databases.

Ⅱ Literature Review

There has been much previous research on the linkage of stock prices.[3] For instance, Chan, Gup, and Pan (1997) examined the integration of international stock markets by studying eighteen nations, including Australia, the US, Japan, the UK, and Pakistan covering a 32-year period from January 1961 to December 1992. Ahlgren and Antell (2002) examined the evidence for cointegration among the stock prices of Finland, France, Germany, Sweden, the UK, and the US between January 1980 and February 1997. The study found at most one cointegrating vector in monthly data and none in quarterly data. Forbes and Rigobon (2002) showed that there was no contagion during the 1997 Asian crisis, the 1994 Mexican devaluation, and the 1987 US market crash, but there was a high level of interdependence among East Asia, Latin America, and the Organization for Economic Co-operation and Development (OECD) in all periods. Fraser and Oyefeso (2005) examined long-run convergence between the US, the UK, and seven European stock markets. Boschi (2005) analyzed the effect of the financial contagion of the Argentine crisis by estimating VAR models and instantaneous correlation coefficients corrected for heteroscedasticity for Brazil, Mexico, Russia, Turkey, Uruguay, and Venezuela. No evidence of contagion was found. In addition, to examine the linkage of stock prices, Wang, Yang, and Bessler (2003) analyzed the African countries and the US; Eun and Shin (1989) analyzed nine countries, including Australia, Canada, France, Japan, the UK, and the US; Hamori and Imamura (2000) analyzed the G7; Tsutsui and Hirayama (2004a) analyzed Japan, the UK, and the US; and Tsutsui and Hirayama (2004b) (2005) analyzed Japan, the UK, Germany, and the US.[4]

In addition, recent research on the linkage of stock prices in Asian markets is as follows. Yang, Kolari and Min (2003) examined long-run relationships and short-run dynamic causal linkage among stock markets in the US and Japan and ten Asian emerging stock markets, paying particular attention to the 1997-1998 Asian financial crisis. An important implication of the analysis is that the degree of integration among countries tends to change over time, especially around periods marked by financial crises. To examine the linkage of stock prices, Chan, Gup, and Pan (1992) analyzed Asian countries for 1983-87; Corhay, Rad, and Urbain (1995) analyzed the Asia-Pacific region, including Japan, for 1972-1992; and Hung and Cheung (1995) analyzed the Asian stock markets, excluding Japan and the US, for 1981-1991. Ghosh, Saidi, and Johnson (1999) analyzed the Asian stock markets, including Japan and the US from

[3] Refer to Zhang (2011) (2012).

[4] Tsutsui and Hirayama (2005) discussed three possible causes of international stock price linkage: 1) global common shocks, 2) portfolio adjustments by institutional investors, and 3) the sunspot phenomenon, situations in which a large change in the stock price index of one country is a special event focused on by investors in other countries.

March 1997 to December 1997; and Chen, Huang, and Lin (2007) analyzed the US and the main Asian countries. The above analyses found no linkage of stock prices among Asian stock markets, or there was some linkage of stock prices among some markets.

Zhang (2012) used vector autoregressive (VAR) techniques, i.e. the cointegration tests, the impulse response, and the forecast error variance decomposition, to analyze the linkage of stock prices in Asian markets, and the influence of both the Asian financial crisis and the global financial crisis on the Asian stock markets. The analysis demonstrated that the effects of the Japanese stock market and the Singapore stock market on the Asian markets are great, but the Chinese mainland market is little affected by other markets. It has been revealed that the interdependence in stock prices among the Asian markets has increased since the global financial crisis.

Ⅲ Empirical Analyses

3.1 Data

The data consist of day-end stock market index observations.[5] This paper uses the Nikkei 225 Index (Japan) and the Shanghai stock exchange composite index (Chinese mainland). The index of Japan is taken from the Nikkei NEEDS database, and the index of China is taken from Souhucaijing database. Both of the indices are corrected in logs. The sample period is from 1 January 1991 to 31 December 2012. The number of observations is 5740. If a value is missing, data of the previous day are used. To examine the influence of the global financial crisis, two periods are analyzed: before the global financial crisis, the period from 1 January 1991 to 14 August 2007;[6] and after the global financial crisis, the period from 15 August 2007 to 31 December 2012.

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

[5] The data are from Mondays to Fridays.
[6] 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.

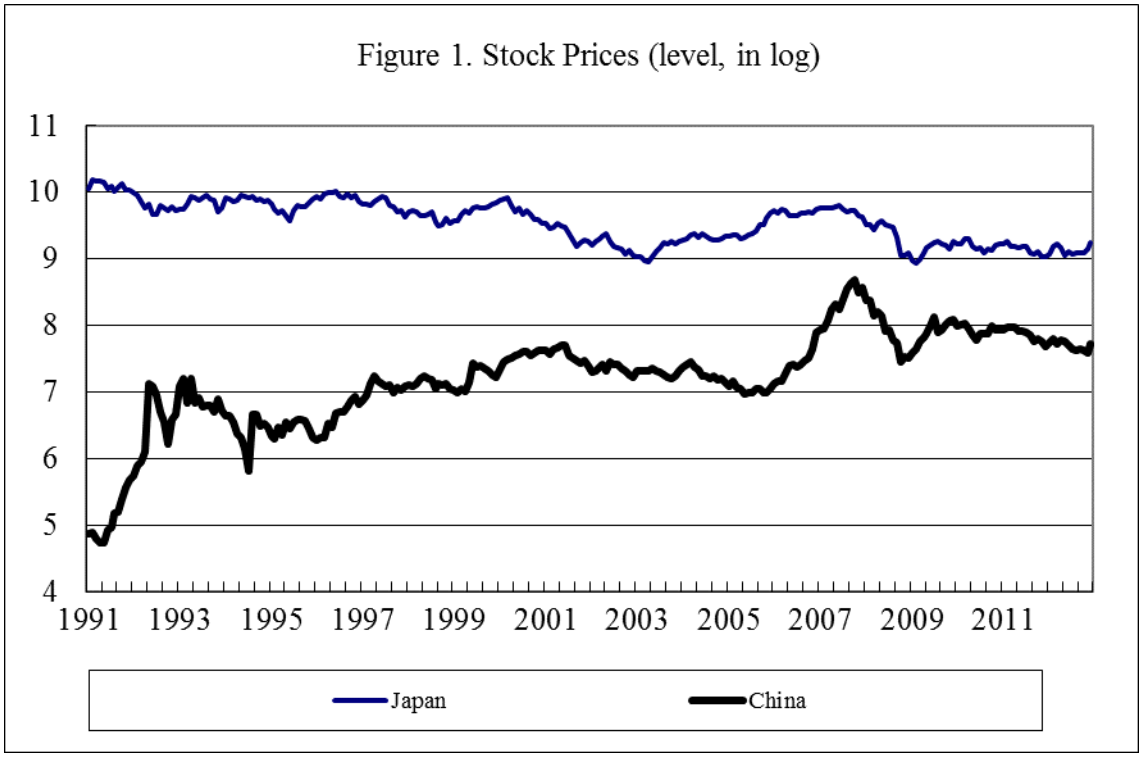
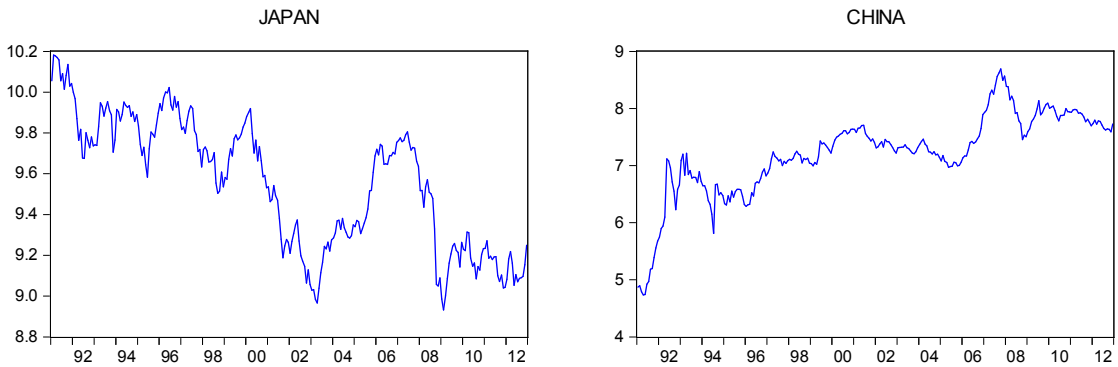


Figure 1 shows that, in general, stock prices in Japan have fallen slowly, and stock prices in China have risen greatly over time. In addition, stock prices in both markets fell sharply from October 2007 to February 2009.

Next, Figure 2 shows the concrete transition of stock prices in the two markets.

Figure 2. Transition of Stock Prices (level, in log)

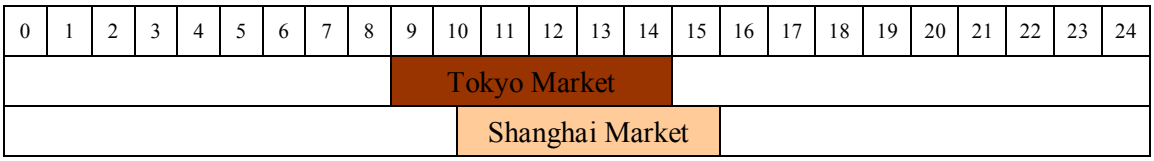


In Japan, after repeated falls and rises in the 1990s, stock prices fell away after March 2000 and reached their lowest value in April 2003. Thereafter, they rose gradually. Following the lost ten years, the recovery of the economy and the increase in the number of stock market participants, including foreign investors, had led to a rise in stock prices until the global financial crisis happened in 2007.

Stock prices in the China experienced a fall on several occasions after May 1992, but in general, they have kept rising, reaching an all-time historic high in October 2007. The rise in stock prices in China from May 2005 to October 2007 is thought to be a result of excess liquidity arising from expectations of a Yuan revaluation, the increase in the foreign reserves, a series of security sector reforms, the reinforcement of the real estate speculation regulations, and the new listing of the large-scale enterprises.

Furthermore, the trading time of the two markets is considered. Figure 3 shows the stock trading opening and closing times in Japan standard time. The Tokyo market in Japan opens at 9 a.m., and the Shanghai market in China opens at 10:30 a.m.[7] In addition, the Tokyo market closes at 3 p.m., and the Shanghai market closes at 4 p.m.

Figure 3. Stock Trading Opening and Closing Times (Japan Standard Time)



3.2 Estimation Model

Stock-price volatility is ascertained from the variance and the standard deviation of the rate of change of stock prices. Therefore, it is necessary to estimate it from stock price data. The prevailing concept of quantitative financial analysis is that volatility changes stochastically each day, and attention has been focused on models that analyze changes in volatility and that explicitly formulize this sort of volatility. Within the models, the EGARCH model is said to be the most suitable in analyzing changes in volatility.[8] The reasons for this are as follows.

Engle (1982) proposed the Autoregressive Conditional Heteroskedasticity (ARCH) model, which was used to analyze inflation. However, it was subsequently used for financial time series

[7] The time difference between China and Japan is 1 hour.
[8] Refer to Wang (2010).

analyses that showed conditional heteroskedasticity. Further, the Generalized ARCH (GARCH) model, which generalized the ARCH model, was proposed by Bollerslev (1986). As estimates can be easily made with the GARCH model using the maximum likelihood method, it is frequently used for analyzing asset prices.

However, the ARCH model and the GARCH model have major flaws as they express changes in the volatility of the stock-price earnings ratio. In stock markets, there is a tendency that the volatility of the stock-price earnings ratio increases less on the day after the day stock prices increase than the day after the day stock prices decline. However, the residual is squared in the ARCH model and the GARCH model and, therefore, they cannot ascertain the asymmetry of this kind of change in volatility. The EGARCH (Exponential GARCH) model proposed by Nelson (1991) is the model that takes into account this sort of phenomenon. Moreover, in the ARCH model and GARCH model, it is possible that the volatility value will end up being negative even when only one parameter is negative. In the EGARCH model, volatility is not assumed to be a dependent variable; its logarithm value is assumed to be a dependent variable. Through this, it is possible to remove the non-negative constraint of the parameters. Therefore, in this paper, the EGARCH model is used to analyze stock-price volatilities in Japan and China.

In order to actually obtain stock-price volatilities, the AR(*k*)-EGARCH(*p*,*q*) model is estimated.[9] The AR (*k*) model is represented by equation (1) below and the EGARCH (*p*,*q*) model by equation (2).

$$Y_t = \theta_0 + \sum_{i=1}^{k} \theta_i Y_{t-i} + u_t \qquad u_t | I_{t-1} \sim N(0, \sigma_t^2) \tag{1}$$

$$\log \sigma_t^2 = w + \sum_{i=1}^{p} (\alpha_i |\varepsilon_{t-i}| + \gamma_i \varepsilon_{t-i}) + \sum_{j=1}^{q} \beta_j \log \sigma_{t-j}^2 \tag{2}$$

Equation (1) is a mean equation that expresses the AR(*k*) model. Here, θ_0 is the constant, *k* is the length of the lag, u_t is the error term, and I_{t-1} is the information that can be used for the period (*t*-1). Equation (2) is a variance equation that expresses the EGARCH(*p*,*q*) model. Here, *p* is the number of ARCH terms, and *q* is the number of GARCH terms. Moreover, *w* is the constant, ε_t is in accordance with the normal distribution of mean 0 and variance 1. ε_t and σ_t are statistically independent, and $\varepsilon_t = u_t / \sigma_t$.

[9] It indicates the Autoregressive-Exponential Generalized Autoregressive Conditional Heteroskedasticity (AR-EGARCH) model.

3.3 Estimation Results

The EGARCH model analyzes the changes in the volatility of the stock-price earnings ratio. Therefore, the stock-price earnings ratio is obtained as the rate of increase of the stock price index. For the estimates from AR(k)-EGARCH(p,q), it is necessary to determine the orders k*, p*, and q*. The method of applying the orders is shown below. First, the estimates in the AR(k) model are carried out, and the order k* is selected in order to minimize the Schwarz Criterion (SC). Next, in the AR(k*)-EGARCH(p,q) model, the estimates are carried out with (p,q) = (1,1), (1,2), (2,1) (2,2), and the order (p*,q*) is selected in order to minimize the SC.

Table 1. Estimation Results of EGARCH Models

	Japan	China
Model	AR(2)-EGARCH(2,2)	AR(3)-EGARCH(2,2)
Mean Equation		
θ_0	-0.0140(0.3729)	0.0827(0.0000)
θ_1	-0.0205(0.1195)	-0.0173(0.1769)
θ_2	-0.0032(0.7966)	0.0405(0.0021)
θ_3		0.0673(0.0000)
Variance Equation		
w	-0.0388(0.0000)	-0.0039(0.0000)
α_1	0.07369(0.0000)	0.2963(0.0000)
α_2	-0.0160(0.4439)	-0.2901(0.0000)
λ_1	-0.1632(0.0000)	-0.0025(0.6457)
λ_2	0.1366(0.0000)	0.0050(0.3483)
β_1	1.6050(0.0000)	1.8613(0.0000)
β_2	-0.6135(0.0000)	-0.8615(0.0000)
Diagnostic		
LM	0.8761(0.6453)	2.4943(1.0000)
SC	3.3874	3.9974

Note: The figures in the parentheses represent the p values.

The estimation results of the AR-EGARCH model for Japan and China are shown in Table 1. For Japan, the AR(2)-EGARCH(2,2) model, and for China, the AR(3)-EGARCH(2,2) model is selected. In addition, from the results of an LM test, the p values of Japan and China are

obtained as 0.6453 and 1.0000. The null hypothesis, which indicated that there is no serial correlation, cannot be rejected. In other words, there is no serial correlation for the error terms of Japan and China.

3.4 Summary Statistics of Stock-price Volatility

Table 2 displays the summary statistics describing stock-price volatility.

Table 2. Summary Statistics of Stock-price Volatility

Sample: 1 January 1991 to 31 December 2012						
	Mean	Std. Dev.	Maximum	Minimum	Skewness	Kurtosis
Japan	2.1294	2.0372	38.0291	0.3041	6.8267	77.1714
China	7.7118	151.9222	10789.3200	0.2765	64.8608	4481.8400
Sample: 1 January 1991 to 14 August 2007						
	Mean	Std. Dev.	Maximum	Minimum	Skewness	Kurtosis
Japan	1.9414	1.2304	9.5793	0.3041	1.6713	7.0056
China	9.0211	174.7944	10789.3200	0.2765	56.3700	3385.2010
Sample: 15 August 2007 to 31 December 2012						
	Mean	Std. Dev.	Maximum	Minimum	Skewness	Kurtosis
Japan	2.7095	3.4417	38.0291	0.3817	5.1075	34.8193
China	3.6720	2.6850	19.6147	0.7294	1.3878	5.1572

During the whole sample period (1 January 1991 to 31 December 2012) and before the global financial crisis (1 January 1991 to 14 August 2007), the stock-price volatility mean and standard deviation in China are significantly larger than those in Japan. The stock-price volatility mean and standard deviation in Japan and after the global financial crisis (15 August 2007 to 31 December 2012) increased compared to those before the crisis. Further, the stock-price volatility mean and standard deviation in China after the global financial crisis significantly decreased compared to those before the crisis. Moreover, China's stock-price volatility mean after the global financial crisis is greater than that of Japan, but its standard deviation is less than that of Japan.

3.5 Covariance of Japanese and Chinese Stock Prices

Furthermore, Figure 4 illustrates the conditional variance-covariance of Japanese and Chinese stock prices obtained by the EGARCH model.[10]

Figure 4. Conditional Variance-Covariance

Figure 4-1. Conditional Variance-Covariance (1991-2012)

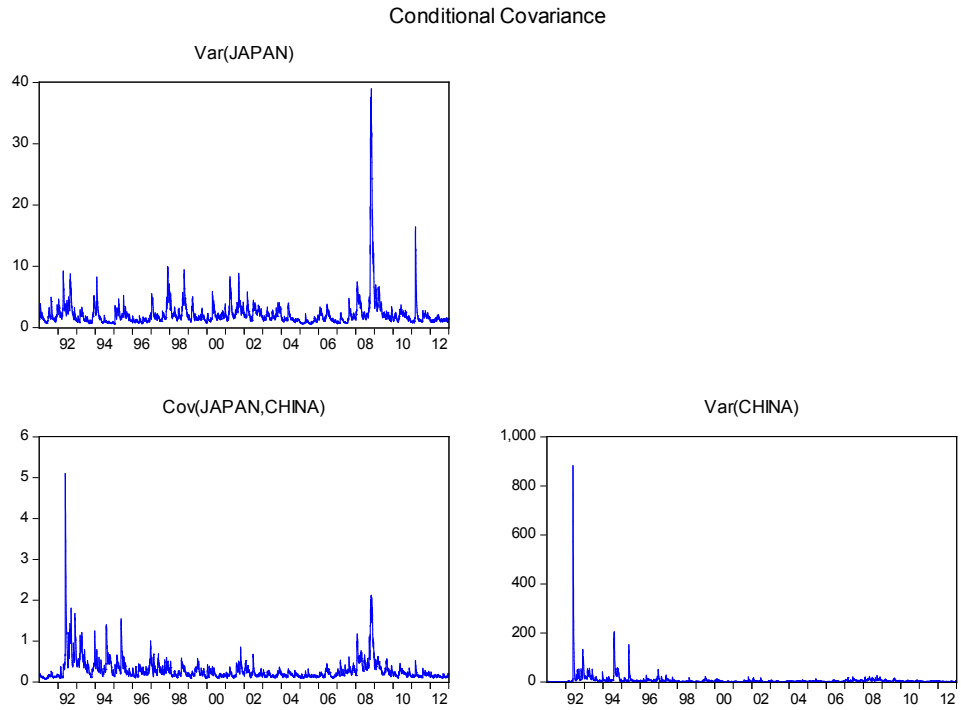
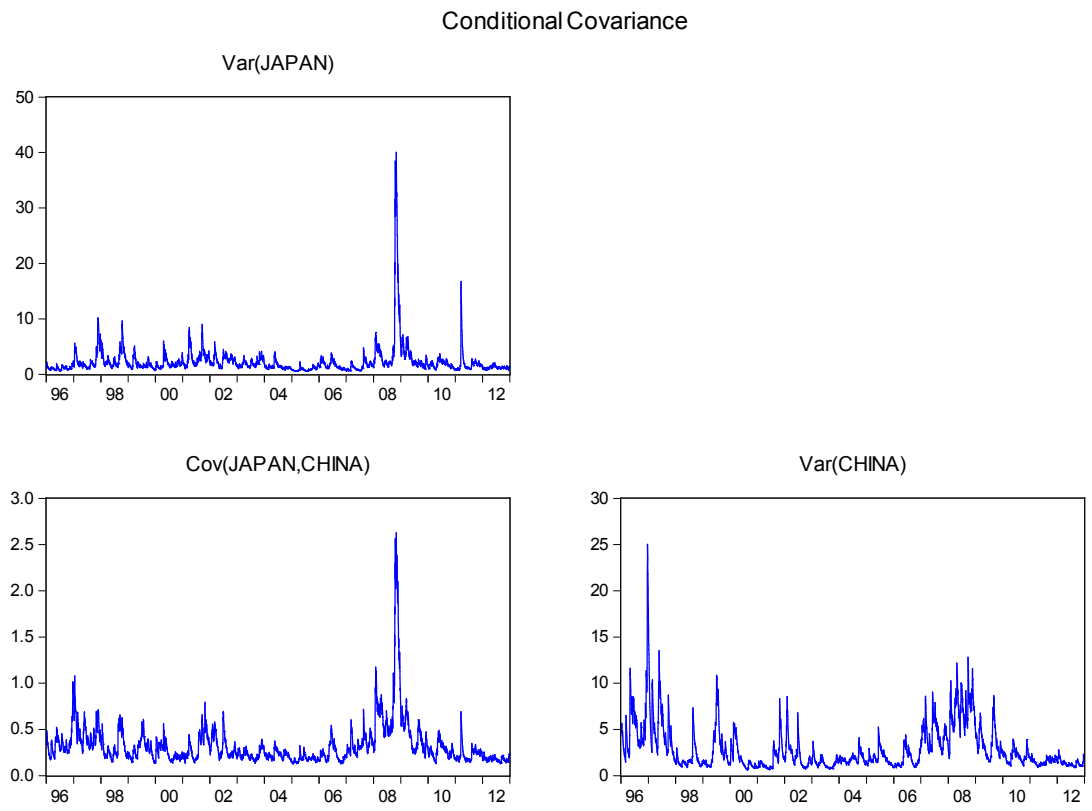


Figure 4-1 illustrates the conditional variance-covariance of Japanese and Chinese stock prices during the period from 1991 to 2012. Concretely, after the global financial crisis hit the world in 2007, the volatility of Japanese stock prices increased sharply. As a result, the conditional covariance of Japanese stock prices rose dramatically after the global financial crisis. In the case of China, the volatility of stock prices sharply increased in the early 1990s, particularly in 1992, not after the shock of the global financial crisis in 2007. When the Shanghai Stock Exchange opened in December 1990 and the Shenzhen Stock Exchange opened

[10] Var (JAPAN) indicates the variance of Japan, Var (CHINA) indicates the variance of China, and Cov (JAPAN, CHINA) indicates the covariance between Japan and China.

in January 1991, the number of listed companies was only 8 and 2, respectively.[11] After the establishment of the stock exchanges, stock prices repeatedly experienced sharp jumps and falls. In particular, immediately after the foundation of the stock exchanges, stock prices were highly volatile. For example, the Shanghai Composite Index was 616.99 on 20 May 1992, but it more than doubled to 1266.49 the following day.

Figure 4-2. Conditional Variance-Covariance (1996-2012)

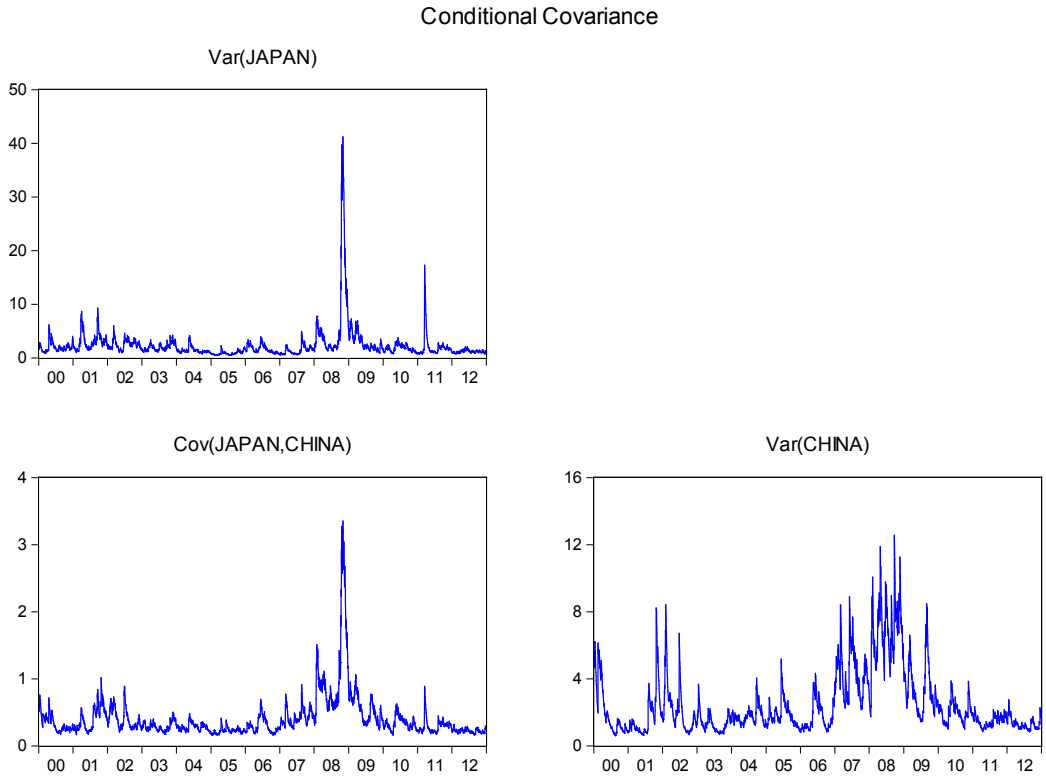


Furthermore, the conditional variance-covariance of Japanese and Chinese stock prices, excluding the early 1990s when Chinese stock prices became increasingly volatile, is examined. Figure 4-2 illustrates the conditional variance-covariance of Japanese and Chinese stock prices during the period from 1996 to 2012. The volatility of Japanese stock prices and their conditional covariance sharply increased in the aftermath of the global financial crisis in 2007; this is not different from what is illustrated in Figure 4-1. The volatility of Chinese stock prices also became increasingly volatile in the wake of the global financial crisis in 2007, but it was

[11] Refer to the China Securities and Futures Statistical Yearbook and the websites of the Shanghai Stock Exchange and the Shenzhen Stock Exchange.

higher in late December 1996. For example, the volatility of Chinese stock prices hit 26.3 on 23 May 1996.

Figure 4-3. Conditional Variance-Covariance (2000-2012)



Lastly, the conditional variance-covariance of Japanese and Chinese stock prices after the 2000s is examined. Figure 4-3 illustrates the conditional variance-covariance of Japanese and Chinese stock prices during the period from 2000 to 2012. As is illustrated in the figure, although the volatility of Chinese stock prices became higher after the global financial crisis in 2007, Chinese stock prices were comparatively less affected by the crisis than Japanese stock prices. In addition, in the aftermath of the global financial crisis, the conditional covariance of Japanese and Chinese stock prices also increased rapidly, which suggests a rise in the linkage of stock prices.

Ⅳ Conclusion

In this paper, while focusing on the influence that the global financial crisis had on the stock markets of Japan and China, the stock-price volatilities and the linkage between the two countries were analyzed. The estimation results of the EGARCH model revealed that although the volatility of Chinese stock prices was far greater than that of Japanese stock prices, China was less affected by the global financial crisis in 2007 than Japan. Conversely, Japanese stock prices became rather volatile in the wake of the global financial crisis in 2007, which suggests that the Japanese stock markets were hugely affected by the global crisis. For China, the volatility of stock prices was greater in the early 1990s, shortly after the stock market had been established, than in 2007 when the global financial crisis erupted. In addition, the covariance of Japanese and Chinese stock prices became fairly greater in the aftermath of the global financial crisis in 2007, which suggests that the linkage of Japanese and Chinese stock prices increased in this period.

The reasons why the linkage of the Japanese and Chinese stock markets has increased after the global financial crisis in 2007 can be considered as follows.[12] After 2000, particularly after its accession to the WTO in December 2001, China implemented a succession of economic reforms and facilitated the globalization of the stock market. Consequently, the Chinese market has become more likely to be affected than before by asset price movement in other countries. In addition, with the widespread use of the Internet and the progress of communication technology, stock price movement of a certain country can be known rapidly by investors all over the world and 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. Therefore, with the increasing presence of the Chinese economy, the movement of Chinese stocks has a growing effect on the investment behaviors of overseas investors, including China-related stocks in overseas stock markets. In addition, Hong Kong, which was returned to China in 1997, has a free stock market and is believed that international investors are adjusting their portfolio well. However, the Hong Kong economy is greatly affected by China's policies and economic conditions. In this situation, the Hong Kong market has increasingly reflected China's economic conditions and the Chinese mainland stock markets. All these factors seem to make the linkage between the stock markets of China and other countries increase.

[12] Tsutsui (2004), and Tsutsui and Hirayama (2005) indicated the following three reasons regarding the linkage of stock prices. (1) common macro-shocks, (2) portfolio adjustments by international investors, and (3) the importance of news on stock price crashes.

However, the Chinese stock market is different from the Japanese stock market because it is not completely internationalized and liberalized yet. Although the Chinese stock market was affected by the global financial crisis in 2007, the effect was relatively small. Moreover, currently, although China is the world's second largest economic power, its stock market is not completely developed yet and its financial system is fragile. Learning the lesson that the flight of investment capital triggered the Asian currency crisis in 1997, the Chinese government regulates its capital dealings to secure the stability of domestic financial markets, which prevents overseas investors to freely invest in the Chinese stock market. The rate of domestic investors to investments in the stock market of mainland China is more than 99%. Basically, the Chinese stock market is speculative and major institutional investors that make investment decisions on the basis of economic fundamentals, such as corporate performance, have not completely grown to a full-fledged level. Market participants are dominated by capital gain-oriented individual investors. They cause unstable stock price fluctuations and make the market more speculative. In addition, many listed companies are state-owned and their management reflects the intentions of the central government, which holds their shares. Therefore, corporate governance does not function properly. Furthermore, listed companies' shares include nontradable shares that cannot be publicly traded in the stock market. Such special type of stock causes wild stock price fluctuations, and makes the Chinese stock market become obscure.[13]

To prevent another global financial crisis in the future, Japan and China 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 risks. If they do so, we can expect the financial liberalization and unification of the world economy to advance smoothly, and the financial system to be strengthened further.

[13] Nontradable shares are the shares that are not publicly traded. They were created shortly after the stock market was established to retain government's control over listed companies. Nontradable shares comprise national shares, corporate shares, and employees' shares, and are held mainly by government and state-owned companies.

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