A Comparative Analysis of the Stock Markets of Japan, China, and the United States under Conditions of 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, the United States accounted for 1,740.73 trillion yen, China for 321.67 trillion yen, and Japan for 320.34 trillion yen, which as percentages of the global total were 35.9%, 6.6%, and 6.6%, respectively, and as percentages of their GDP, were 127.6%, 44.9%, and 61.7%, respectively[2]. Moreover, through globalization and the sharing of information in real time that has progressed in recent years, linkage within the global economy are increasing. The 2007 global financial crisis that originated in the United States affected the economies of Japan, China, and the United States in various ways. In the future, in conjunction with the further economic development of, and increased economic exchanges between Japan, China, and the United States, linkage between stock prices is expected to increase significantly. Considering the relationships between stock prices in these three countries is absolutely essential to predict the future development of their economies, and is important to ascertain the state of affairs in the global economy.

The stock markets of Japan and the United States have long histories and are mature, advanced markets. The level of efficiency and openness in both markets is high, and it can be said that domestic and overseas investors are free to invest in them and that they are fully accomplishing their economic function of being avenues for companies to raise funds. In contrast, China's stock markets only began in earnest from 1990, and have grown quickly in conjunction with the rapid growth of the Chinese economy[3]. Currently, they are attracting a lot of attention as stock markets of a developing nation, and they continue to have a significantly greater presence in the global marketplace. In February 2007, the market capitalization of

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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.

[3] Here, the subject of analysis is the stock markets in mainland China.

Shanghai's stock markets was no more than approximately one quarter that of Tokyo's, but stock prices in the United States and Japan suffered major declines, following a crash in the Shanghai stock market[4]. This was the first global decline in stock prices originating from China. In addition, together with the gains in the prices of Chinese stocks, the presence of Chinese companies listed on stock exchanges around the world has rapidly grown. While China's stock markets are continuing to grow, compared to Japan and the United States, they tend to experience major fluctuations in the value of their stocks and repeatedly switch between sudden gains and slumps.

In this paper, while focusing on the impact that the global financial crisis had on the stock markets of Japan, China, and the United States, the stock-price volatilities and linkage between these three countries are analyzed. In addition, the relationships between macroeconomic variables (real-economy variables and monetary-policy variables) and stock price volatility in each country are investigated. Specifically, the exponential generalized autoregressive conditional heteroskedasticity (EGARCH) model is used; stock price volatility in Japan, China, and the United States is calculated; and the covariance between the stock markets is estimated. In addition, in order to look at the influences of the global financial crisis, the relationships between stock prices are analyzed, while comparing them over different periods. Further, the effects of real-economy variables and monetary-policy variables on changes to stock-price volatility in each of the three countries are considered.

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, China, and the United States are estimated. For this, first, the EGARCH model 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, China, and the United States, the EGARCH model is used to estimate stock-price volatility, and the fundamental statistics are investigated. Further, the relationships between each country's real-economy variables and monetary-economy variables are considered. To do this, first, the data used is explained and then a unit root test is carried out to verify the stationarity of the data. Subsequently, a Granger causality test is conducted. Finally, the implications are derived based on the results of the empirical analyses.

Ⅱ Literature Review

There has been much previous research on the linkage of stock prices.[5] For instance, Chan,

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[4] On February 27, 2007, the Shanghai Stock Exchange Composite Index (SSE Composite Index) fell 268 points (8.8%) on the previous day, the biggest decline in its history.

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

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 that 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.[6]

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 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.

[6] 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.

Zhang (2010) (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.

Moreover, prior research on the linkage of stock prices that focused on the stock markets in Japan, China, and the United States can be summarised as follows. Asako, Zhang, and Liu (2013) newly advocated a non-linear-type co-integration analysis that allowed the creation, expansion, and collapse of a stock price bubble, and then actually verified it. Consequently, for example, a co-integration relationship between stock prices in Japan and the United States is fairly robustly rejected by the usual co-integration analysis. In this sense, the conclusion obtained here is that there is no co-movement. In contrast, when non-linearity is allowed, it was verified that long-term co-movement cannot be rejected. Nishimura, Tsutsui, and Hirayama (2011) used high-frequency data from July 15, 2008 to November 28, 2008, and analyzed daily volatility in the stock markets of China (mainland China and Hong Kong), Japan, and the United States. While after the outbreak of the global financial crisis, daily volatility rapidly increased in all markets, its impact was limited in China's stock markets, and its market risk was lower than that in stock markets in Japan and the United States. Further, it was verified that following the collapse of Lehman Brothers, investors' long-term memories of daily volatility strengthened, and the impact that shocks in the form of a crash in stock prices have on volatility has weakened.

Ⅲ Methodology

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.[7] 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] 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 exponential GARCH (EGARCH) 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, China, and the United States.

The EGARCH (*p*,*q*) model is expressed by equation (1) shown below.

$$\log\sigma_t^2 = w + \sum_{i=1}^{p}\alpha_i\left|\varepsilon_{t-i}\right| + \sum_{k=1}^{r}\gamma_k\varepsilon_{t-k} + \sum_{j=1}^{q}\beta_j\log\sigma_{t-j}^2 \qquad (1)$$

Here, ε_t is the standardized shock. On the left side of equation (1) is the logarithm of the conditional variance, so the non-negativity of the conditional variance is guaranteed. α and γ are the coefficients of the ARCH terms. The asymmetry of a positive and a negative shock (the existence of the leverage effect) can be tested through hypothesis $\gamma_i < 0$. If $\gamma_i \neq 0$, this effect is asymmetrical. The persistence of the volatility (shock relative to the conditional variance) is represented by the coefficient β of the GARCH term.

As a special case, the EGARCH (1,1) model is represented by equation (2) below.

$$\log\sigma_t^2 = w + \alpha_1\left|\varepsilon_{t-1}\right| + \gamma_1\varepsilon_{t-1} + \beta_1\log\alpha_{t-1}^2 \qquad (2)$$

In the case of a positive shock, or, in other words, when $\varepsilon_{t-1} > 0$, equation (2) becomes equation (3).

$$\log \sigma_t^2 = w + (\alpha_1 + \gamma_1)\left|\varepsilon_{t-1}\right| + \beta_1 \log \alpha_{t-1}^2 \tag{3}$$

Conversely, in the case of a negative shock, or, in other words, when $\varepsilon_{t-1} < 0$, equation (2) becomes equation (4).

$$\log \sigma_t^2 = w + (\alpha_1 - \gamma_1)\left|\varepsilon_{t-1}\right| + \beta_1 \log \alpha_{t-1}^2 \tag{4}$$

If $\gamma_i < 0$, volatility reacts to a negative shock to a greater extent.

Ⅳ Stock-price Volatilities and Linkage

4.1 *Data*

The data consist of day-end stock market index observations.[8] This paper uses the Nikkei 225 Index (Japan), the Shanghai stock exchange composite index (Chinese mainland), and the S&P 500 Composite Stock Price Index (US). The indices of Japan and the US are taken from the Nikkei NEEDS database, and the index of China is taken from Souhucaijing. All 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;[9] and after the global financial crisis, the period from 15 August 2007 to 31 December 2012.

4.2 *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.

[8] The data are from Mondays to Fridays.

[9] 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 (level, in log)

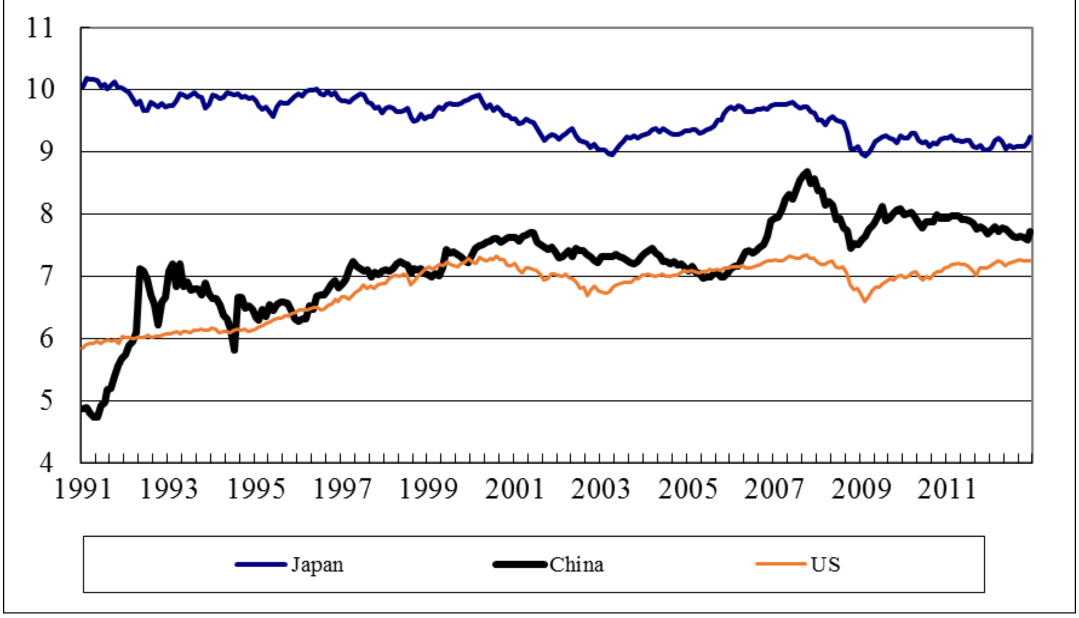
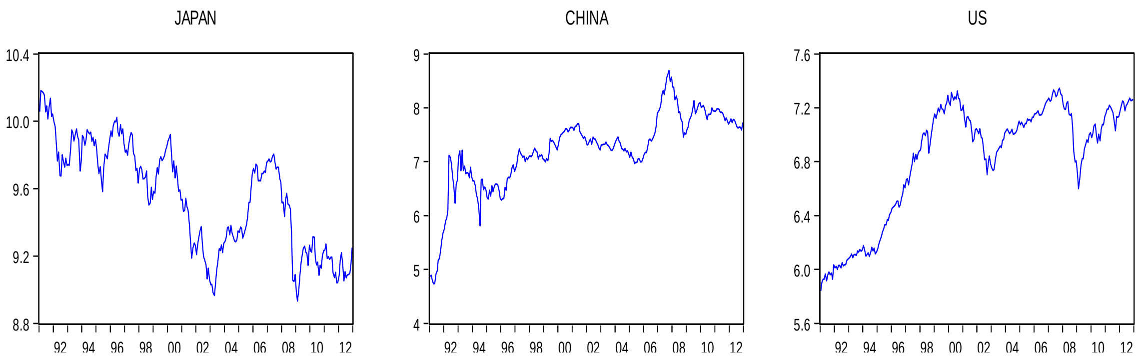


Figure 1 shows that, in general, Japanese stock prices have fallen slowly, US stock prices have risen steadily in the long run, and Chinese stock prices have risen most rapidly of all. In addition, stock prices in all markets fell sharply from about October 2007 to February 2009.

Next, Figure 2 shows the concrete transition of stock prices in each market.

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



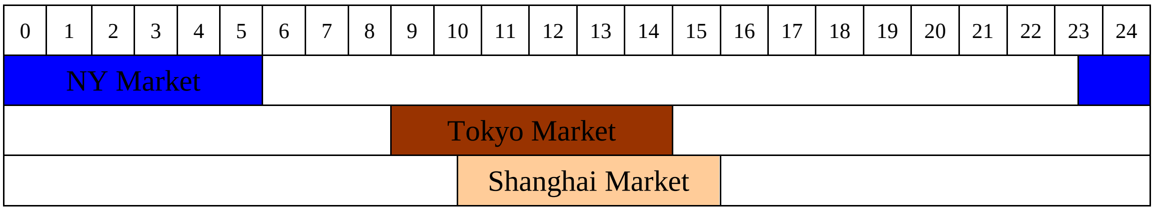
In Japan, after repeated falls and rises in the 1990s, stock prices fell away after March 2000 and reached their lowest value in April 2003. Thereafter, they rose gradually. Following the lost ten years, the recovery of the economy and the increase in the number of stock market participants, including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

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

US stock prices rose in the 1990s because of the economic expansion and the information technology revolution, but after reaching a peak in August 2000, they fell sharply until September 2002. The fall after August 2000 is regarded as a result of the bursting of the information technology bubble. Afterwards, the economy recovered, and stock prices soared in 2007, but fell sharply due to occurrence of a subprime loan problem. Recently, because of the effects of the recovery for domestic economy and quantitative easing, stock prices have risen again.

Furthermore, I consider the trading time of each market. Figure 3 shows the stock trading opening and closing times in Japan standard time.

Figure 3. Stock Trading Opening and Closing Times (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.[10] In addition, the Tokyo market closes at 3 p.m., and the Shanghai market closes at 4 p.m. The New York market in the United States opens at 11:30 p.m., and closes at 6 a.m. the following morning[11]. The Tokyo market starts trading three hours after the New York market closes, and there is therefore a strong possibility that the New York closing price is reflected in the next day's Tokyo market closing price and Shanghai market closing price.

4.3 *Estimation*

4.3.1 Estimation Model

[10] The time difference between China and Japan is 1 hour.

[11] The time difference between the eastern US and Japan is 14 hours, and it is one hour less when Daylight Saving Time is in force.

In order to actually obtain stock-price volatilities, the AR(k)-EGARCH(p,q) model is estimated.[12] The AR (k) model is represented by equation (5) and the EGARCH (p,q) model by equation (6).

$$Y_t = \theta_0 + \sum_{i=1}^{k} \theta_i Y_{t-i} + u_t \qquad u_t | I_{t-1} \sim N(0, \sigma_t^2) \tag{5}$$

$$\log \sigma_t^2 = w + \sum_{i=1}^{p} (\alpha_i |\varepsilon_{t-i}| + \gamma_i \varepsilon_{t-i}) + \sum_{j=1}^{q} \beta_j \log \sigma_{t-j}^2 \tag{6}$$

Equation (5) 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} represents the information that can be used for the period (t-1). Equation (6) 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 $\varepsilon_t = u_t / \sigma_t$.

4.3.2 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.

[12] It indicates the autoregressive-exponential generalized autoregressive conditional heteroskedasticity (AR-EGARCH) model.

Table 1. Estimation Results of EGARCH Models

	Japan	China	US
Model	AR(2)-EGARCH(2,2)	AR(3)-EGARCH(2,2)	AR(1)-EGARCH(2,2)
Mean Equation			
$\theta 0$	-0.0140(0.3729)	0.0827(0.0000)	0.0267(0.0090)
$\theta 1$	-0.0205(0.1195)	-0.0173(0.1769)	-0.0203(0.1031)
$\theta 2$	-0.0032(0.7966)	0.0405(0.0021)	
$\theta 3$		0.0673(0.0000)	
Variance Equation			
w	-0.0388(0.0000)	-0.0039(0.0000)	-0.0389(0.0000)
$\alpha 1$	0.07369(0.0000)	0.2963(0.0000)	-0.0440(0.0116)
$\alpha 2$	-0.0160(0.4439)	-0.2901(0.0000)	0.0942(0.0000)
$\lambda 1$	-0.1632(0.0000)	-0.0025(0.6457)	-0.2323(0.0000)
$\lambda 2$	0.1366(0.0000)	0.0050(0.3483)	0.1981(0.0000)
$\beta 1$	1.6050(0.0000)	1.8613(0.0000)	1.5626(0.0000)
$\beta 2$	-0.6135(0.0000)	-0.8615(0.0000)	-0.5685(0.0000)
Diagnostic			
LM	0.8761(0.6453)	2.4943(1.0000)	1.4583(0.2272)
SC	3.3874	3.9974	2.6574

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

The estimation results of the AR-EGARCH model for Japan, China, and the United States are shown in Table 1. For Japan, the AR(2)-EGARCH(2,2) model, for China, the AR(3)-EGARCH(2,2) model, and for the United States, the AR(1)-EGARCH(2,2) model are selected, respectively. In addition, from the results of the LM tests, the *p* values of Japan, China, and the United States are obtained as 0.6453, 1.0000, and 0.2272, respectively. The null hypothesis, which indicates that there is no serial correlation, could not be rejected. In other words, there is no serial correlation for the error terms of Japan, China, and the United States.

4.3.3 Summary Statistics of Stock-price Volatility

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

Table 2. Basic 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
US	1.2521	1.7456	25.0778	0.0625	6.0184	53.9997
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
US	0.9578	0.8658	8.0669	0.0625	2.5473	12.1450
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
US	2.1601	3.0081	25.0778	0.1507	3.7655	19.7404

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 average and standard deviation in China are significantly larger than those in Japan and the United States. Further, the stock-price volatility average and standard deviation in Japan are generally larger than those in the United States.

The stock-price volatility averages and standard deviations in Japan and the United States after the global financial crisis (15 August 2007 to 31 December 2012) increased compared to those before the crisis. Further, the stock-price volatility average and standard deviation in China after the global financial crisis significantly decreased compared to those before the crisis. Moreover, China's stock-price volatility average after the global financial crisis is greater than that of Japan and the United States, but its standard deviation is less than that of Japan and the United States.

4.3.4 Covariance of Japanese, Chinese, and US Stock Prices

Furthermore, Figure 4 illustrates the conditional variance-covariance of Japanese, Chinese, and US stock prices obtained by the EGARCH model. [13]

[13] Var (JAPAN), Var (CHINA) and Var (US) indicates the variance of Japan, China and the US, respectively. Cov (JAPAN, CHINA), Cov (JAPAN, US), and Cov (CHINA, US) indicates the

Figure 4. Conditional Variance-Covariance

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

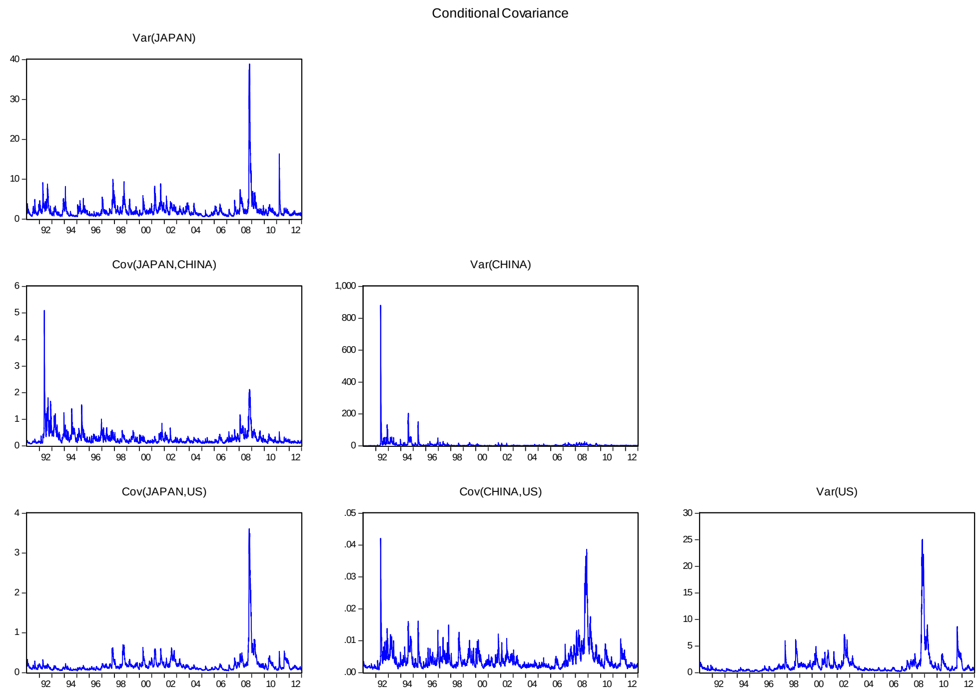
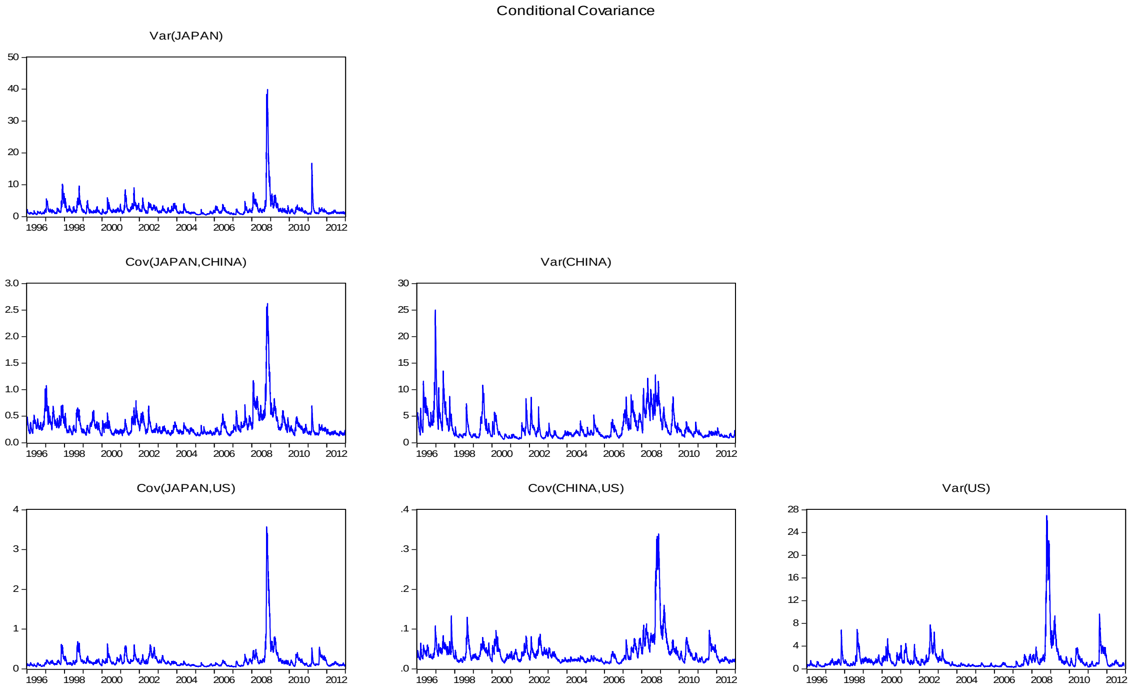


Figure 4-1 illustrates the conditional variance-covariance of Japanese, Chinese, and US stock prices during the period from 1991 to 2012. Concretely, after the global financial crisis had hit the world in 2007, the volatility of Japanese and US stock prices increased sharply. As a result, the conditional covariance of Japanese and US 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 in January 1991, the number of listed companies was only 8 and 2, respectively.[14] 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.

covariance between Japan and China, Japan and the US, and China and the US, respectively.

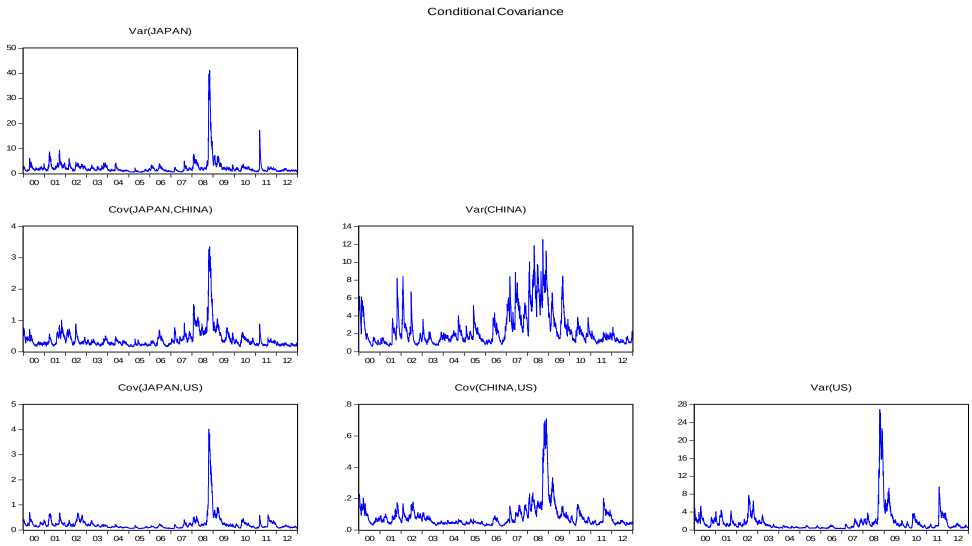
[14] Refer to *the China Securities and Futures Statistical Yearbook* and the websites of the Shanghai Stock Exchange and the Shenzhen Stock Exchange.

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



Furthermore, the conditional covariance of Japanese, Chinese, and US stock prices, excluding the early 1990s when Chinese stocks became increasingly volatile, is examined. Figure 4-2 illustrates the conditional variance-covariance of Japanese, Chinese and US stock prices during the period from 1996 to 2012. The volatility of Japanese and US 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 quite 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 covariance of Japanese, Chinese, and US stock prices after the 2000s is examined. Figure 4-3 illustrates the conditional variance-covariance of Japanese, Chinese, and US stock prices during the period from 2000 to 2012. As 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 and US stock prices. In addition, in the aftermath of the global financial crisis, the conditional covariance of Japanese and Chinese stock prices, the conditional covariance of Chinese and US stock prices, and the conditional covariance of US and Japanese stock prices also increased rapidly, which suggests a rise in the linkage of stock prices.

After 2000, particularly after its accession to the WTO in December 2001, China has undergone more active capital exchanges both within and outside the country and a closer integration into the world market. Amidst such a situation, China implemented a wide range of reforms for the internationalization and liberalization of stock markets to have an advantage in global competition.[15] Concretely, in 2000, the stock flotation system was changed from a screening-based model by artificial allotment to a sanction-based model, which was a significant step to market liberalization. In July 2002, the Chinese government lifted the ban on the establishment of foreign-owned joint venture securities firms and investment trusts, and liberalized stock brokerage commission of securities firms. In addition, in China, stocks are divided into A-shares and B-shares. Initially, only foreign investors were permitted to buy B-shares; however, in February 2001, B share stock market was also opened to domestic

[15] Refer to Zhang (2004), (2008b), (2009), and (2011) for the Chinese stock markets. This is also relevant for related descriptions in other parts of this paper.

investors.[16] Moreover, initially, only Chinese investors were permitted to invest in A-shares. However, the qualified foreign institutional investors (QFII) system was introduced in 2002, which enabled foreign institutional investors to buy A-shares. This succession of reforms made the Chinese stock market more vulnerable to asset price movements in other countries than before, although the Chinese stock market has not completely been internationalized and liberalized yet. Consequently, the linkage of the Japanese, Chinese, and US stock prices became higher after the global financial crisis in 2007.

V Effects of Macroeconomic Variables on Stock-price Volatility

5.1 *Data*

In this section, the effects that macroeconomic variables have on stock-price volatility are analyzed using monthly data. First, for monthly stock-price volatility (*V*), the daily stock-price volatility values obtained from the EGARCH model in the previous section are converted into monthly values and used. The effects of macroeconomic variables on stock-price volatility (*V*) are considered from two aspects: real-economy variables and monetary-policy variables. For the real-economy variables, the rate of increase in industrial production (*Y*) and the rate of increase in the consumer price index (*P*) are used. For the monetary-policy variables, the rate of increase in M2 (*M*) is used as the money supply variable, and the one-year lending interest rate (*I*) is used as the interest rate variable. The data are taken from the IMF database. The estimation period is from January 1991 to December 2012. For each variable, the monthly data prior to seasonal adjustments are used. Below, the analyses are carried out in the following order: Japan, China, and the United States.

5.2 *Unit Root Tests*

First, in order 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 for the two cases, with both a trend and a constant, and with a constant only. The lags are based on the Schwarz information criterion in the ADF tests and on the Newey–West bandwidth in the PP tests. The unit root test results are presented in Table 3.[17]

Table 3-1, 3-2 and 3-3 show the results of the unit root tests for Japan, China and the United States, respectively. As presented in tables, the null hypotheses proposing that unit roots are

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[16] B-shares began to be issued as a means for businesses to directly procure foreign currencies on the Shanghai Stock Exchange and the Shenzhen Stock Exchange in 1992, when foreign currencies were in short supply in China. B-shares are traded in US dollars on the Shanghai Stock Exchange and in Hong Kong dollars on the Shenzhen Stock Exchange.

[17] Here, ***, **, and * show that the null hypothesis proposing that unit roots exist is rejected at the significance level of 1 %, 5 %, and 10 %, respectively.

present are all rejected in the first differences of the variables represented by *Δ*. 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.

Table 3. Unit Root Tests

Table 3-1. Unit Root Tests (Japan)

	ADF test		PP test	
	With trend and constant	With constant	With trend and constant	With constant
VJ *Lag*	-6.0355*** 2	-6.0424*** 2	-6.9074*** 7	-6.9119*** 7
ΔVJ *Lag*	-16.3518*** 1	-16.3823*** 1	-37.4124*** 71	-37.2245*** 71
YJ *Lag*	-2.9989 13	-3.0275** 13	-4.2037*** 5	-4.2074*** 5
ΔYJ *Lag*	-9.0270*** 12	-9.0463*** 12	-16.1071*** 3	-16.1357*** 3
PJ *Lag*	-2.7401 12	-2.7923* 12	-3.6385** 2	-3.5986*** 3
ΔPJ *Lag*	-7.0618*** 11	-7.0149*** 11	-15.2189*** 7	-15.1996*** 7
MJ *Lag*	-4.6211*** 0	-4.7276*** 0	-4.8522*** 8	-4.9420*** 8
ΔMJ *Lag*	-15.3658*** 0	-15.3732*** 0	-15.3630*** 5	-15.3698*** 5
IJ *Lag*	-4.7937*** 4	-5.8994*** 4	-4.0017*** 10	-7.0347*** 10
ΔIJ *Lag*	-4.3330*** 5	-3.0471** 5	-6.8383*** 6	-5.3853*** 6

Table 3-2. Unit Root Tests (China)

	ADF test		PP test	
	With trend and constant	With constant	With trend and constant	With constant
VC	-15.9729***	-15.7069***	-15.9719***	-15.7075***
Lag	0	0	2	2
ΔVC	-34.3988***	-31.0030***	-248.6524***	-249.1218***
Lag	15	15	261	261
YC	-3.3320*	-3.0275**	-11.0572***	-10.1362***
Lag	3	3	9	9
ΔYC	-15.7116***	-15.7431***	-64.5169***	-64.0931***
Lag	2	2	43	43
PC	-1.9978	-1.7020	-2.0479	-1.7066
Lag	12	12	8	8
ΔPC	-5.1495***	-5.1649***	-12.5801***	-12.5862***
Lag	11	11	6	6
MC	-1.4161	-1.1436	-2.2572	-1.8654
Lag	12	12	5	5
ΔMC	-7.5486***	-7.5711***	-13.7569***	-13.7814***
Lag	11	11	3	3
IC	-1.1163	-1.0430	-1.5113	-1.2598
Lag	0	0	7	7
ΔIC	-14.8101***	-14.8316***	-15.1905***	-15.2083***
Lag	0	0	6	6

Table 3-3. Unit Root Tests (US)

	ADF test		PP test	
	With trend and constant	With constant	With trend and constant	With constant
VU	-6.7879***	-6.5342***	-5.3705***	-5.1836***
Lag	1	1	7	7
ΔVU	-12.4154***	-12.4383***	-17.8109***	-17.8483***
Lag	2	2	26	26
YU	-2.9739	-2.5675	-2.9206	-2.7611*

Lag	12	12	8	8
ΔYU	-6.0768***	-6.0864***	-15.7295***	-15.7493***
Lag	11	11	7	7
PU	-2.6688	-2.6682*	-4.2283***	-4.2120***
Lag	12	12	4	4
ΔPU	-9.8022***	-9.8157***	-10.3292***	-10.3477***
Lag	11	11	5	5
MU	-3.2062*	-2.1875	-2.7749	-2.2433
Lag	5	4	6	5
ΔMU	-6.8413***	-6.8555***	-11.8363***	-11.8561***
Lag	11	11	3	3
IU	-2.6655	-1.6651	-2.1287	-1.6488
Lag	3	2	10	10
ΔIU	-5.8701***	-5.8805***	-8.3453***	-8.3631***
Lag	1	1	6	6

5.3 *Granger Causality Tests*

In order to view the effects of macroeconomic variables on stock-price volatility (*V*), Granger causality tests are conducted. Granger causality tests verify whether or not there exists causality between each of the variables. Tables 4 to 6 show whether or not there exist Granger causality between stock-price volatility (*V*) and each real-economy variable, and also between stock-price volatility (*V*) and each monetary-policy variable, in Japan, China, and the United States, respectively. As mentioned before, here, the rate of increase in industrial production (*Y*) and the rate of increase in the consumer price index (*P*) are used as real-economy variables, and the rate of increase in M2 (*M*) and the one-year lending rate (*I*) are used as monetary-policy variables.

Table 4. Granger Causality Tests (Japan)

Table 4-1. Granger Causality Tests (Japan, Janaury1991-December 2012)

Null Hypothesis	F-Statistic	Probability
YJ does not Granger cause *VJ*	10.6756	0.0012***
VJ does not Granger cause *YJ*	0.5004	0.4799
PJ does not Granger cause *VJ*	3.7746	0.0531*
VJ does not Granger cause *PJ*	1.8101	0.1797
MJ does not Granger cause *VJ*	0.0493	0.8244
VJ does not Granger cause *MJ*	1.1201	0.2909
IJ does not Granger cause *VJ*	0.1524	0.6965
VJ does not Granger cause *IJ*	1.1589	0.2827

Table 4-2. Granger Causality Tests (Japan, Janaury1991-August 2007)

Null Hypothesis	F-Statistic	Probability
YJ does not Granger cause *VJ*	0.0869	0.7685
VJ does not Granger cause *YJ*	0.0147	0.9037
PJ does not Granger cause *VJ*	0.6949	0.4055
VJ does not Granger cause *PJ*	0.5192	0.4720
MJ does not Granger cause *VJ*	0.8022	0.3716
VJ does not Granger cause *MJ*	1.0745	0.3012
IJ does not Granger cause *VJ*	0.0088	0.9254
VJ does not Granger cause *IJ*	1.8199	0.1789

Table 4-3. Granger Causality Tests (Japan, September 2007-December 2012)

Null Hypothesis	F-Statistic	Probability
YJ does not Granger cause *VJ*	6.6039	0.0127**
VJ does not Granger cause *YJ*	0.0964	0.7572
PJ does not Granger cause *VJ*	2.9308	0.0921*
VJ does not Granger cause *PJ*	2.0683	0.1556
MJ does not Granger cause *VJ*	0.1476	0.7022
VJ does not Granger cause *MJ*	0.5937	0.4441
IJ does not Granger cause *VJ*	3.5996	0.0626*
VJ does not Granger cause *IJ*	2.4516	0.1227

Table 4-1 shows the results of the Granger causality tests in Japan from January 1991 to December 2012. As to the real-economy variables, the rate of increase in industrial production (*YJ*) and the rate of increase in the consumer price index (*PJ*) Granger cause stock-price volatility (*VJ*) at the significance level of 1% and 10%, respectively. As to the monetary-policy variables, the rate of increase in M2 (*MJ*) and the one-year lending rate (*IJ*) do not Granger cause stock-price volatility (*VJ*). Moreover, stock-price volatility (*VJ*) does not Granger cause all the macroeconomic variables (real-economy variables and monetary-policy variables).

Moreover, Table 4-2 shows the results of the Granger causality tests in Japan before the global financial crisis, from January 1991 to August 2007, and Table 4-3 shows the results of the Granger causality tests in Japan after the global financial crisis, from September 2007 to December 2012.

For the period of January 1991 to August 2007, all the macroeconomic variables do not Granger cause stock-price volatility (*VJ*), and stock-price volatility (*VJ*) also does not Granger cause all the macroeconomic variables.

For the period of September 2007 to December 2012, the rate of increase in industrial production (*YJ*) and the rate of increase in the consumer price index (*PJ*) Granger cause stock-price volatility (*VJ*) at the significance level of 5% and 10%, respectively. As to the monetary-policy variables, the one-year lending rate (*IJ*) Granger causes stock-price volatility (*VJ*) at the significance level of 10%, while the rate of increase in M2 (*MJ*) does not Granger cause stock-price volatility (*VJ*). Moreover, stock-price volatility (*VJ*) does not Granger cause all the macroeconomic variables.

Table 5. Granger Causality Tests (China)

Table 5-1. Granger Causality Tests (China, Janaury1991-December 2012)

Null Hypothesis	F-Statistic	Probability
YC does not Granger cause *VC*	0.0958	0.7572
VC does not Granger cause *YC*	0.1789	0.6726
PC does not Granger cause *VC*	9.3919	0.0024***
VC does not Granger cause *PC*	0.2247	0.6359
MC does not Granger cause *VC*	0.0161	0.8992
VC does not Granger cause *MC*	0.5038	0.4785
IC does not Granger cause *VC*	0.0008	0.9780
VC does not Granger cause *IC*	0.0150	0.9026

Table 5-2. Granger Causality Tests (China, Janaury1991-August 2007)

Null Hypothesis	F-Statistic	Probability
YC does not Granger cause *VC*	0.0763	0.7827
VC does not Granger cause *YC*	0.1426	0.7061
PC does not Granger cause *VC*	8.9674	0.0031***
VC does not Granger cause *PC*	0.3006	0.5841
MC does not Granger cause *VC*	0.0225	0.8810
VC does not Granger cause *MC*	0.5813	0.4467
IC does not Granger cause *VC*	0.0011	0.9737
VC does not Granger cause *IC*	0.0146	0.9039

Table 5-3. Granger Causality Tests (China, September 2007-December 2012)

Null Hypothesis	F-Statistic	Probability
YC does not Granger cause *VC*	2.1158	0.1510
VC does not Granger cause *YC*	5.5054	0.0223**
PC does not Granger cause *VC*	0.0005	0.9820
VC does not Granger cause *PC*	0.3690	0.5458
MC does not Granger cause *VC*	1.6154	0.2086
VC does not Granger cause *MC*	0.1967	0.6590
IC does not Granger cause *VC*	2.6528	0.1086
VC does not Granger cause *IC*	0.7290	0.3966

Table 5-1 shows the results of the Granger causality tests in China from January 1991 to December 2012. The rate of increase in the consumer price index (*PC*) Granger causes stock-price volatility (*VC*) at the significance level of 1%. The rate of increase in industrial production (*YC*), the rate of increase in M2 (*MC*) and the one-year lending rate (*IC*) do not Granger cause stock-price volatility (*VC*). Moreover, stock-price volatility (*VC*) does not Granger cause all the macroeconomic variables (real-economy variables and monetary-policy variables).

Moreover, Table 5-2 shows the results of the Granger causality tests in China before the global financial crisis, from January 1991 to August 2007, and Table 5-3 shows the results of the Granger causality tests in China after the global financial crisis, from September 2007 to December 2012.

For the period of January 1991 to August 2007, the rate of increase in the consumer price index (*PC*) Granger causes stock-price volatility (*VC*) at the significance level of 1%. The other variables do not Granger cause stock-price volatility (*VC*). Moreover, stock-price volatility (*VC*) does not Granger cause all the macroeconomic variables.

For the period of September 2007 to December 2012, all the macroeconomic variables do not Granger cause stock-price volatility (*VC*). Moreover, stock-price volatility (*VC*) only Granger causes the rate of increase in industrial production (*YC*) at the significance level of 5%.

Table 6. Granger Causality Tests (US)

Table 6-1. Granger Causality Tests (US, Janaury1991-December 2012)

Null Hypothesis	F-Statistic	Probability
YU does not Granger cause *VU*	2.4578	0.1182
VU does not Granger cause *YU*	0.0000	0.9990
PU does not Granger cause *VU*	6.4110	0.0119**
VU does not Granger cause *PU*	24.0889	0.0000***
MU does not Granger cause *VU*	1.1675	0.2809
VU does not Granger cause *MU*	0.0324	0.8573
IU does not Granger cause *VU*	3.6729	0.0564*
VU does not Granger cause *IU*	11.0520	0.0010***

Table 6-2. Granger Causality Tests (US, Janaury1991-August 2007)

Null Hypothesis	F-Statistic	Probability
YU does not Granger cause *VU*	5.1180	0.0248**
VU does not Granger cause *YU*	1.8343	0.1772
PU does not Granger cause *VU*	0.1435	0.7052
VU does not Granger cause *PU*	0.8384	0.3610
MU does not Granger cause *VU*	3.5086	0.0625*
VU does not Granger cause *MU*	1.9751	0.1615
IU does not Granger cause *VU*	1.4767	0.2258
VU does not Granger cause *IU*	5.0297	0.0260**

Table 6-3. Granger Causality Tests (US, September 2007-December 2012)

Null Hypothesis	F-Statistic	Probability
YU does not Granger cause *VU*	3.8496	0.0544*
VU does not Granger cause *YU*	0.4794	0.4914
PU does not Granger cause *VU*	3.7139	0.0587*
VU does not Granger cause *PU*	22.3631	0.0000***
MU does not Granger cause *VU*	0.0942	0.7600
VU does not Granger cause *MU*	0.0286	0.8664
IU does not Granger cause *VU*	3.0787	0.0844*
VU does not Granger cause *IU*	7.8582	0.0068***

Table 6-1 shows the results of the Granger causality tests in the United States from January 1991 to December 2012. The rate of increase in the consumer price index (*PU*) and the one-year lending rate (*IU*) Granger cause stock-price volatility (*VU*) at the significance level of 5% and 10%, respectively. Moreover, stock-price volatility (*VU*) also Granger causes both the rate of increase in the consumer price index (*PU*) and the one-year lending rate (*IU*) at the significance level of 1%. However, there is no Granger causality between stock-price volatility (*VU*) and the rate of increase in industrial production (*YU*) or the rate of increase in M2 (*MU*).

Moreover, Table 6-2 shows the results of the Granger causality tests in the United States before the global financial crisis, from January 1991 to August 2007, and Table 6-3 shows the results of the Granger causality tests in the United States after the global financial crisis, from September 2007 to December 2012.

For the period of January 1991 to August 2007, the rate of increase in industrial production (*YU*) and the rate of increase in M2(*MU*) Granger cause stock-price volatility (*VU*) at the significance level of 5% and 10%, respectively. Moreover, stock-price volatility (*VU*) Granger causes the one-year lending rate (*IU*) at the significance level of 5%.

For the period of September 2007 to December 2012, the rate of increase in industrial production (*YU*), the rate of increase in the consumer price index (*PU*) and the one-year lending rate (*IU*) Granger cause stock-price volatility (*VU*) at the significance level of 10%. Moreover, stock-price volatility (*VU*) Granger causes the rate of increase in the consumer price index (*PU*) and the one-year lending rate (*IU*) at the significance level of 1%.

Finally, the results of the Granger causality tests in the whole sample period (January 1991 to December 2012) are as follows. Japan's real-economy variables (the rate of increase in industrial production and rate of increase in the consumer price index) Granger cause Japan's stock-price volatility. Only China's rate of increase in the consumer price index Granger causes

China's stock-price volatility. The United States' rate of increase in the consumer price index and the one-year lending rate Granger cause the United States' stock-price volatility. The monetary-policy variables (the rate of increase in M2 and the one-year lending rate) of Japan and China do not Granger cause each country's respective stock-price volatility.

Ⅵ Summary and Concluding Remarks

In this paper, while focusing on the impact that the global financial crisis had on the stock markets of Japan, China, and the United States, the stock-price volatilities and linkage between these three countries are analyzed, as well as the relationships between macroeconomic variables (real-economy variables and monetary-policy variables) and stock price volatility in each country.

The estimation results of the EGARCH model revealed that although the volatility of Chinese stock prices was far greater than that of Japanese and US stock prices, China was less affected by the global financial crisis in 2007 than Japan and the United States. Conversely, Japanese and US stock prices became rather volatile in the wake of the global financial crisis in 2007, which suggests that the Japanese and US 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, Chinese, and US stock prices volatitity became fairly greater in the aftermath of the global financial crisis in 2007, which suggests that the linkage of Japanese, Chinese, and US stock prices increased in this period.

Moreover, Granger causality testing revealed the following results. Japan's real-economy variables (both industrial output and prices) affect the volatility of stock prices, while in the case of China and the United States, only prices affect the volatility of stock prices. In addition, US interest rate affects the volatility of stock prices while Japan and China's monetary-policy variables (M2 and lending interest rate) do not affect the volatility of their stock prices, respectively.

The reasons why the linkage of the Japanese, Chinese, and US stock markets has increased after the global financial crisis in 2007 can be considered as follows.[18] 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 movements in other countries. In addition, with the widespread use of the Internet and the progress of communication

[18] 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.

technology, stock price movements 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.

However, the Chinese stock market is different from the Japanese stock market and US 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 has 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.[19] Such special type of stock causes wild stock price fluctuations, and makes the Chinese stock market become obscure.

[19] 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.

Unlike the United States, Japanese and Chinese financial policies do not affect the volatility of stock prices very much. The reason for this is that in Japan and China, indirect finance dominates direct finance and it cannot yet be said that the arbitrage and adjustment functions of the 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 Japan and China, to diversify the financing of enterprises and the choice of investments, and to use risk analysis to exchange information more widely in the future. However, currently, China still regulates capital dealings and has not yet liberalized interests. The regulation of capital dealings and interests is likely to make it impossible to adequately cope with the growing globalization of the securities market. China should liberalize capital dealings and interests in a steady and deliberate manner in the future.

In recent years, the Abe administration of Japan has been implementing economic measures that have come to be termed "Abenomics"; these measures include an emergency economic stimulus package and quantitative easing of the monetary policy to tackle deflation in an effort to create a resilient economy. The yen's depreciation is expected to improve the performance of export industries, accelerate corporate activities, and stimulate domestic demands. In addition, more capital is invested in the stock market and the prices of Japanese stocks are recovering. Amidst the economic slowdown triggered by the shocking failure of Lehman Brothers in September 2008, the US government has been implementing the quantitative monetary easing policy to support the economy and prevent deflation. The policy is now functioning in favor of the real economy. It is stimulating investment and consumption and the economy is recovering. This has resulted in the economic recovery pushing up stock prices and providing vitality to the stock market. However, if Japan and the United States continue to adopt a bold accommodative monetary policy in step with each other, it could "heat up" the global financial market beyond the real economy and eventually lead to global financial bubbles.

For China, "shadow banking"—lending money through a different route from ordinary bank loans—is spreading rapidly. This has caused a temporary confusion in the Chinese financial market due to a sharp rise in short-term interest and a decline in stock prices. The Chinese government has begun to control the spread of money far beyond the real economy. However, if those brakes work too hard, investment and consumer spending will go down, which will place a downward pressure on the real economy. Conversely, if loans through shadow banking continue to increase, it will cause the gaps between the real economy and finance to widen, which will lead to the formation of credit bubbles. Thus, shadow banking could threaten to shake the Chinese economy.

Learning a lesson from the global financial crisis in 2007, many countries have accumulated foreign reserves and have enhanced their financial systems. These efforts brought about a gradual recovery of the real economy. To prevent another global financial crisis in the future, Japan, China, and the United States 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 world economy to advance smoothly, and the financial system to be strengthened further.

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