Analysis of the Stock Market Volatility and Its Spillover Effect in China

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Abstract: Employing Shanghai composite index and Shenzhen composite index as research samples, this paper is concerned with the analysis of the volatility of Shanghai and Shenzhen market and the volatility spillover effect. It is concluded that the shock of previous news causes a lasting impact on current volatility in both markets, the spillover effects is one-way from Shanghai to Shenzhen. The innovation of this paper mainly reflects in: research sample selections are both new and valuable; the traditional model was modified to analyze the fluctuations between Shanghai and Shenzhen and the two markets' spillover effect; According to the empirical results the author gives reasonable explanations, conclusions and corresponding suggestions based on this situation.
Key words: Stock market; Volatility; Volatility spillover effect; Granger causality test; GARCH

1 Introduction

In Economics, volatility is a measure for variation of an economic instrument over time. Volatilities in financial activities have been seen more frequent and fierce than other areas. The stock market plays a big role in the whole financial system. Variations of all kinds of factors in stock market can affect supply and demand in different degrees, thus, affect the price of stock. Since stock returns have a strong pertinence and close relationship with the volatility of the market, study the effects of positive or bad news on stock price fluctuations will be helpful to understand the market behavior. And along with the advancement of global integration, one market is no longer operating independently. The relationship between different markets becomes more complex and closely. Volatility in one market interaction with that in other market and may transmit from one to another. The volatility transmission in different markets is called "volatility spillover effects". This phenomenon is obvious in financial market, especially in the stock market. Shanghai Stock Exchange and Shenzhen Stock Exchange both belong to mainland China and face with an identical external environment. This will lead to some fluctuation between the two markets. Study the interactive effect and correlations between the two stock markets have very important functions for analysis and research on the stock market structure, the trend of stock market and the process of risk transfer.

Scholars have made a lot of research on the relationship of volatility between different markets. Hamao, Masulis and Victor Ng (1990) employed the GARCH (1, 1)-M model to study the relationship of fluctuation among London, Japan and New York stock market, and concludes that there are spillover effects from New York to Tokyo, London to Tokyo, New York to London. In China, Zhao Liuyan and Wang Yiming (2003) estimate the A share and B share market separately, found that there is only one-way fluctuation overflow from A share to B share. Hong Yongmiao, Cheng Siwei (2004) analyzed the relationship among A share, B share and H share in China securities market, and the extreme spillover risk between China stock market and other stock markets, the conclusion is that the market segmentation between A share and B share makes A share effectively avoid heavy impact and influence from other security markets.

2 Methodology and Data

2.1 GARCH model

The general mean and conditional variance equation of the GARCH (p, q) model can be expressed as follows:

$$y_t = \beta x_t + \varepsilon_t \tag{1}$$

$$h_t = \text{var}(\varepsilon_t \left| \Omega_{t-1} \right.) = \alpha_0 + \sum_{i=1}^{q} \alpha_i \varepsilon_{t-i}^2 + \sum_{j=1}^{p} \beta_j h_{t-j} \tag{2}$$

Compare with ARCH (q) model, the conditional variance of GARCH (p, q) model is a linear function of not only the squares of the lagged errors, but also previous conditional variances. To more accurately describe the "fat tail" characteristic of financial time series, assumptions about the distribution of random errors should be employed (usually include normal distribution, student t distribution and Generalized Error Distribution (GED)). The necessary and sufficient condition of the stationary time series ε_t is:

$$\sum_{i=1}^{q}\alpha_i + \sum_{i=1}^{p}\beta_i < 1 \tag{3}$$

In order to ensure that σ_t^2 is nonnegative, parameter α_i (i=1,2,…,q) and β_i (i=1,2,…,p) should be all nonnegative.

2.2 Granger causality test

Granger (1969) and Sims (1972) put forward Granger causality test. The Granger causality test is a statistical hypothesis test for determining whether one time series is useful in forecasting another. A time series X is said to Granger-cause Y if it can be shown, usually through a series of t-tests and F-tests on lagged values of X and Y, that those X and Y values provide statistically significant information about future values of Y. The test model is as follows:

$$y_t = \sum_{i=1}^{k}\alpha_i y_{t-i} + \sum_{i=1}^{k}\beta_i x_{t-i} + u_t \tag{4}$$

2.3 Analysis of return and volatility spillover effects

Volatility spillover effects may exist in different regional financial markets. For instance, the U.S. stock market fluctuations could affect China stock market fluctuations; it may also be found in different financial varieties (e.g. foreign exchange market, bond market and equity market) and the same market but different plate. In order to determine whether there is volatility spillover effect between the volatility of the daily return of one stock market (use $X_t = (R_t - E(R_t))^2$ to describe volatility) and the daily return of another, we can add volatility to model as independent variable:

$$\begin{cases} \Phi(L)R_t = \Theta(L)\varepsilon_t + \gamma X_t \\ \varepsilon_t \mid I_{t-1} \sim N(0,\sigma_t^2) \\ h_t = \alpha_0 + \sum_{i=1}^{q}\alpha_i\varepsilon_{t-i}^2 + \sum_{j=1}^{p}\beta_j h_{t-j} \end{cases} \tag{5}$$

Given the level of significance, if parameter γ is statistically and significantly not zero, volatility spillover effects are considered existed, otherwise does not exist.

2.4 Sample selection and processing

This paper employs the Shanghai composite index and Shenzhen composite index (referred to SHI and SZI). This paper specifies 2006 as a starting point, with the closing price of SHI and SZI between January 4, 2006 and 9 March, 2011 as the samples.

Due to take the logarithm can improve data, this paper calculate the logarithmic rate of return.

$$r_t = \ln R_t - \ln R_{t-1} \tag{6}$$

r_t is the logarithmic rate of return， R_{t-1} and R_t are referred to the closing prices of two consecutive trading day.

The variable names and its meanings are shown in table 1.

Table 1 Names and Meanings of Variables

Name	Meaning	Name	Meaning
rsh	Logarithmic rate of return of SHI	*xsh*	Daily market volatility of SHI
rsz	Logarithmic rate of return of SZI	*xsz*	Daily market volatility of SZI
h_t or $\ln\sigma_t^2$	Conditional variance in period t	ε_t	Residual in period t

3 Volatility Analyses and Results

3.1 Stationarity test

Before employing time series model, the stability of the variable must be determined. Granger and Newbold found that nonstationary time series may lead to spurious regression. We use Augmented Dickey-Fuller method, check intercept item but uncheck tendency item in EViews, the results are shown in table 3.

Table 2 Results of Unit Root Test

	t statistic	Prob.
rsh	-35.25965	0.0000
rsz	-33.00928	0.0000

As shown in table 3, both the two series of yield reject the random walk hypothesis, they are stationary time series.

3.2 ARCH-LM test

Then we do ARCH effect test. In this paper, we use LM (Lagrange multiplier) test, the results are shown in table 4.

Table 3 ARCH LM Test

	F statistic	Prob.	Obs.*R^2	Prob.
rsh	8.081654	0.000000	76.52846	0.000000
rsz	8.693117	0.000000	81.93788	0.000000

From table 4, it is known that the F statistics have reached a certain scale and its probability is very small, reject the null hypothesis of "ARCH effect does not exist ". The following will employ GARCH model and its expansion forms to depict this characteristic.

3.3 Establishing GARCH model

Generally, GARCH (1, 1) model can fully capture the volatility clustering effect and there appeared a large number of studies confirm this simple and effective model (Bollerslev, 1992).

$$r_t = c + \varepsilon_t \tag{7}$$

$$h_t = \alpha_0 + \alpha_1 \varepsilon_{t-1}^2 + \beta_1 h_{t-1} \tag{8}$$

The results are shown in Table 5.

Table 4 Estimated Results of GARCH(1,1) Model

	c	α_0	α_1	β_1	$\alpha_1+\beta_1$	*AIC*	*SC*
rsh	0.002148 (5.11)	4.35E-06 (2.08)	0.064637 (4.53)	0.926723 (61.1)	0.993	-5.170561	-5.150116
rsz	0.003409 (7.29)	6.97E-06 (2.32)	0.077153 (4.57)	0.911681 (51.8)	0.988	-4.997739	-4.977294

In table 5, all the estimated parameters are significant in 95% level; residual does not have ARCH effect. The sum of the sustainable parameter of volatility - the coefficient of ARCH (1), α_1 - and the coefficient of GARCH (1) β_1, is very close to 1 in both markets. So whether in Shanghai stock market or the Shenzhen stock market, precious impact had lasting consequences on prospective conditional variances, persistent fluctuation seems obvious. The difference of the coefficients α_1 is small, so the two markets have information absorbing capacity by the same degree. Old news takes up a large component about the future fluctuations.

3.4 Volatility spillover effect between Shanghai and Shenzhen market

Exactly, previous results are respectively calculated in their own markets, and therefore there are some limitations. Now we will connect the two markets, considering whether volatility in one market affect the other.

First we employ Granger causality test to inquiry the linkage of two market fluctuations. $X_t = (R_t - E(R_t))^2$ refers to the volatility of stock market. R_t is daily return. From this we can calculate daily X_t of SHI and SZI. The results are shown in table 6.

Table 5 Estimated Results of Granger Causality Test

lag	1	2	3	4	5	6
xsz does not granger cause *xsh*	0.02397 (0.87699)	2.13867 (0.11824)	2.29559 (0.07614)	1.66373 (0.15603)	2.05435 (0.06867)	1.79342 (0.09705)
xsh does not granger cause *xsz*	14.0585 (0.00019)	-11.44760 (0.04613)	7.82124 (3.6E-05)	3.11615 (0.01453)	2.14539 (0.05780)	3.00658 (0.00639)

Table 6 listed the F statistics and the corresponding probability with 1 to 6 lag. That is, in the chosen sample, the volatility of the Shanghai stock market can be used to improve the prediction of fluctuations of future Shenzhen stock market, not vice versa. We use conditional heteroscedastic model to further depict this phenomenon. If the dependent variable is the daily return of Shanghai market, then X_t is the volatility of the daily return of Shenzhen market, vice versa. The corresponding parameter is γ . The results are listed in table 7.

Table 6 Estimated Results of Volatility Spillover Effect

Market	γ	Z statistic	Prob.
Shanghai	0.073007	0.845713	0.3977
Shenzhen	-11.44760	-18.68303	0.0000

From table 7, when the volatility of SZI is independent variable, γ is positive but not significant. With the volatility of SHI to explain the daily returns of SZI, γ is negative and significant. Thus, in the chosen sample, the volatility spillover effect from Shanghai market to Shenzhen market is obvious, not vice versa. It is consistent with the results of Granger causality test. To a certain extent, the information transmission efficiency in higher in Shanghai, the leading securities market in China.

5 Conclusions

In both Shanghai and Shenzhen market, precious impact had lasting consequences on prospective conditional variances, persistent fluctuation seems obvious and they have information absorbing capacity by identical degree, this kind of circumstance should cause attention. For example, the government agencies should set out policies on the basis of the absorption capacity of the market, and assess the influencing of possible outcomes. Thereby, the reaction to news will also be more rapid and accurate.

In the chosen sample, the volatility of the Shanghai stock market can be used to improve the prediction of fluctuations of future Shenzhen stock market, not vice versa. The information transmission efficiency is higher in Shanghai. It also further explains that Shanghai stock market is the dominant market in China. At the same time, the effect makes manipulating a market through controlling another market possible, the possibility of this increase market supervision, this put forward higher request of market supervision. So, on one hand we should improve the design of the trading system, strengthen the education to investors, and on the other hand to improve market transparency, strengthen the supervision of market manipulation of individual and organization and prevent abnormal mass capital flow in order to ensure the healthy development of China's capital market.

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