Research on Leverage Effect and Risk Fluctuation of Shanghai and Shenzhen Stock Markets Based on GARCH Family Model

Liting Wang
Department of Finance, Beijing jiaotong University, Haidian, Beijing, 100044, China
\[\textit{\textmd{\textit{e-mail: 18792409607@163.com}}\]}

**Abstract.** The stock market is characterized by high risks. If there is asymmetric effect, the risk will be further aggravated. Therefore, it is particularly important to study the fluctuation characteristics of stock market prices and their asymmetric effects. 609 data were respectively selected from the Shanghai composite index and Shenzhen securities component index from July 1, 2005 to December 28, 2007, and 634 data were respectively selected from June 9, 2015 to December 29, 2017. GARCH family model is selected for data fitting and analysis. The results show that: First, the optimal model of Shanghai bull market is TGARCH (1,1), bear market is TGARCH (2,1), Shenzhen bull market is TGARCH (1,3), bear market is EGARCH (1,1). Second, the Chinese stock market has an asymmetric effect. Third, the range of risk fluctuations in China's stock market is relatively large. Finally, the problems in the Chinese stock market at the emergence stage are mentioned, and corresponding solutions are proposed. Finally, the problems in the Chinese stock market at the emergence stage are mentioned, and corresponding solutions are proposed.

1. Introduction

1.1. Research background
China's stock market is developing rapidly, but many investors do not have a clear understanding of stock market risks, and Chinese investors are highly speculative, making the Chinese stock market a high-risk feature. As the Chinese market gradually opens up to the outside world, the risks in China's Shanghai and Shenzhen stock markets are increasingly unpredictable. Frequent and violent fluctuations will increase the investor's investment risk, distort the information feedback mechanism of the stock market and reduce the efficiency of the stock market. If there is an asymmetric effect, the risk will rise further.

Therefore, this paper selects the closing price of the Shanghai and Shenzhen bull stock index during the period of 2005.7.1-2007.12.28, and the closing price of the Shanghai and Shenzhen bear stock index during the period of 2015.6.1-2017.12.29. Comprehensively study the volatility characteristics of China's Shanghai and Shenzhen stock markets and their asymmetry effects. It provides a reference for investors to construct diversified investment portfolio, prevent and control investment risks, and also provides a reference for regulators to improve relevant systems and formulate policies.
1.2. Literature review
Gu Xiangpeng (2012) used the GARCH model family to conduct research on its application. The GARCH model is fitted to the financial time series. The fitting results show that the characteristics of China’s financial market can be better fitted by the GARCH (1,1) model. SC Thushara (2014) examines whether there is a weekly effect in the stock returns of the Colombo Stock Exchange. Research shows that investors can get excess returns by making investment decisions based on past information. It is recommended to buy stocks on Mondays and Tuesdays and sell them on Wednesdays, Thursdays and Fridays to get excess returns.

Liu Qing and Yang Chao (2015) et al. solved the heteroscedastic problem and proposed the semiparametric method when estimating the time series structural parameters. The empirical comparison between the six common GARCH family structures shows that the EGARCH model is superior to other GARCH classes.

Yang Qi and Cao Xianbing (2016) used the ARMA model to analyze and predict the public stock price. The ARMA-GARCH model was obtained. The model is effective and accurate.

Cao Dong and Zhang Jia (2017) studied the impact of the introduction of stock index futures on stock market volatility by constructing GARCH-M model. The results show that with the introduction of stock index futures, the stability function of the stock market has been played to a certain extent, but its role is still limited, the impact of old information is greater than the impact of new information on the market.

2. Introduction to GARCH family models
In 1986, Bollerslev was extended to obtain a generalized conditional heteroscedasticity, also known as the GARCH model. The GARCH model is obtained by adding the lag term of the conditional variance term to the right of the model when the ARCH(r) model is too high. It has important applications in the regression model of financial data and the analysis and prediction of volatility.

Let $\psi_{t-1}$ denote the set of all information at time $t-1$ and before that time, for sequence $\{a_t\}$

$$r_t = c + \sum_{i=1}^{m} \phi_r r_{t-i} - \sum_{j=1}^{n} \theta_j a_{t-j} + a_t$$  \hspace{1cm} (1)

$$h_t^2 = \alpha_0 + \sum_{i=1}^{s} \alpha_i a_{t-i}^2 + \sum_{j=1}^{s} \beta_j h_{t-j}^2$$ \hspace{1cm} (2)

$$a_t \mid \psi_{t-1} = h_t \eta_t$$ \hspace{1cm} (3)

$$\eta_t \sim \text{iidN}(0,1)$$ \hspace{1cm} (4)

The sequence $\{a_t\}$ is a sequence of GARCH $(r, s)$, the equation (1) is the mean model, and (2) is the conditional variance equation. The constraint is $\alpha_0 > 0, \alpha_i \geq 0, \beta_j \geq 0 (i > 0, \ j > 0) , \sum_{i=1}^{r} \alpha_i + \sum_{j=1}^{s} \beta_j < 1$

Later, it was found that the rate of return was affected by the fluctuation of the rate of return itself, and the conditional variance was added as a regression factor to the mean equation to obtain the GARCH-M model. The EGARCH and TGARCH models are obtained considering the asymmetric effects.

3. Empirical research

3.1. Data processing
This article divides the stock market into two stages: bull market and bear market. 609 data were respectively selected from the Shanghai composite index and Shenzhen securities component index from July 1, 2005 to December 28, 2007, and 634 data were respectively selected from June 9, 2015 to December 29, 2017. The data comes from Eastern Fortune.

Stock prices fluctuate from time to time, and the rate of return $R$ in a certain period in the future is uncertain as a random variable. The risk can be measured by conditional variance.
Let \( t = 0, 1, 2, \ldots, t \) represent the closing price of the \( t \) stock trading day, and the corresponding logarithmic return is shown in (5):

\[
\log p_t - \log p_{t-1} = r_t \tag{5}
\]

For convenience, in the bull market from July 1, 2005 to December 28, 2007 the Shanghai Composite Index return sequence is called \( r_1 \) and Shenzhen Component Index return sequence is called \( r_2 \). In the bear market from June 9, 2015 to December 29, 2017, the return sequence of Shanghai Composite Index is called \( r_3 \), and the return sequence of Shenzhen Component Index is called \( r_4 \). All the following calculations were completed on the basis of Eviews8.0. Due to space constraints, only some empirical results are shown below.

3.2. Establishment of mean model

The four sets of data stationarity tests were all passed, and the correlation between the four return series of the Shanghai Composite Index and the Shenzhen Component Index was weak and could not pass the coefficient test. Therefore, only the mean and random disturbance items are included in the return mean regression model. The mean model is shown in (6):

\[
r_t = \mu + \epsilon_t \tag{6}
\]

3.3. Examination of ARCH effect

Although the various statistical characteristics of the Shanghai Composite Index and the Shenzhen Component Index yield series indicate that it is suitable for fitting using the GARCH family model. However, whether the ARCH effect really exists still needs to be further tested by LM.

| lag | \( r_1 \) | \( r_2 \) | \( r_3 \) | \( r_4 \) |
|-----|-----------|-----------|-----------|-----------|
|     | LM value  | P value   | LM value  | P value   |
| 1   | 4.7771    | 0.0288    | 12.0434   | 0.0005    |
| 2   | 7.2180    | 0.0271    | 14.8170   | 0.0006    |
| 3   | 17.5412   | 0.0005    | 18.5767   | 0.003     |
| 4   | 18.6106   | 0.0009    | 21.9566   | 0.0002    |
| 5   | 18.8444   | 0.0021    | 22.8843   | 0.0004    |
| 6   | 19.3530   | 0.0036    | 25.1631   | 0.0003    |

It can be seen from Table 1 that the \( p \) values of the LM test of the four return sequence residuals from 1st order to the 6th order are all less than 0.05, rejecting the null hypothesis, the sequence exists and there is an ARCH effect with higher order, so the GARCH model needs to be fitted.

3.4. Fitting GARCH model

Under AIC criteria, the appropriate GARCH models for \( r_1 \) and \( r_2 \) are GARCH (1,1) and GARCH (1,3) respectively, and the appropriate GARCH models for \( r_3 \) and \( r_4 \) are GARCH (2,2) and GARCH (1,1) respectively.

The adaptability test of the model shows that the \( P \) statistic values of the residual series of the four return series up to the 6th order LM statistic are all greater than 0.05. The null hypothesis is accepted, and the residual series does not have ARCH effect, which indicates that GARCH model fitting the return series is suitable.

3.5. Fitting asymmetric effect GARCH family model

The positive and negative effects of the stock market's earnings information on the volatility often show an asymmetrical effect. In order to study the above problems in the stock market, the three
models of EGARCH, TGARCH and GARCH-M are fitted to the return series based on the obtained GARCH model.

First, three models are fitted to the return sequence \( r_1 \) respectively. The TGARCH (1,1) model is better in the three, and the equation is as shown in (7):

\[
\begin{align*}
    r_t &= 0.0024 + a_t \\
    h_t^2 &= 0.0620a_{t-1}^2 - 0.0771a_{t-1}^2d_{t-1} + 0.9861h_{t-1}^2 \\
    &\quad (4.5042) \\
    &\quad (5.6779) \quad (-6.6256) \quad (157.4098)
\end{align*}
\]

The adaptability test of the equation passed, and the residual does not have ARCH effect.

In model (8), \( r = -0.0771 \), \( r \neq 0 \) is sufficient to indicate that the impact of the information is asymmetric. There was a 0.062 times impact on the market when there was good news (\( a_1 > 0 \)), and the bad news (\( a_1 < 0 \)) had a -0.0151 times impact on the market. This shows that the positive news causes the risk fluctuation (conditional variance) to change more sharply than the bad news.

Second, the TGARCH (1,3) model is better for the Shenzhen bull market return series \( r_2 \). So the equation is:

\[
\begin{align*}
    r_2 &= 0.002789 + a_t \\
    h_t^2 &= 7.6e - 07 + 0.032a_{t-1}^2 - 0.50a_{t-1}^2d_{t-1} + 0.428h_{t-1}^2 + 0.313h_{t-2}^2 + 0.246h_{t-3}^2 \\
    &\quad (4.7935) \\
    &\quad (3.4279) \quad (19.446) \quad (-6.4740) \quad (12.0549) \quad (33.7781) \quad (-8.4659)
\end{align*}
\]

The equation passes the adaptive test, and the residual has no ARCH effect.

The impact of information is asymmetric. Good news has a 0.032 times impact on the market, and bearish news has a -0.018 times impact on the market, which also shows that the positive news leads to a greater change in the intensity of the fluctuations.

Third, for the Shanghai bear market return series \( r_3 \), the TGARCH (2, 2) model is better, so the equation is:

\[
\begin{align*}
    r_3 &= -7.65e - 05 + a_t \\
    h_t^2 &= 6.68e - 07 + 0.1197a_{t-1}^2 + 0.1402a_{t-1}^2d_{t-1} + 0.0794a_{t-2}^2d_{t-1} + 0.6653h_{t-1}^2 \\
    &\quad (3.6082) \\
    &\quad (5.1534) \quad (2.4157) \quad (5.3525) \quad (-3.0023) \quad (213.2235)
\end{align*}
\]

The equation passes the adaptive test, and the residual has no ARCH effect.

The impact of information is asymmetric. Good news has a 0.259 times impact on the market, and bearish news has a -0.3393-fold impact on the market, which indicates that the bad news causes the change in the volatility to be greater than the change caused by the good news.

Fourth, for the Shenzhen bear market return series \( r_4 \), the EGARCH (1,1) model is better, so the equation is:

\[
\begin{align*}
    r_4 &= -0.0003 + a_t \\
    \ln(h_t^2) &= -0.1057 + 0.0613 \left( \frac{a_t}{h_{t-1}} - E \frac{a_t}{h_{t-1}} \right) - 0.0631 \frac{a_t}{h_{t-1}} + 0.9932 \log(h_{t-1}^2) \\
    &\quad (-7.7816) \quad (6.1986) \quad (-4.6778) \quad (646.7205)
\end{align*}
\]

The equation passes the adaptive test, and the residual has no ARCH effect.

Also indicate that the impact of the information is asymmetric. Good news has a -0.0018 times impact on the market, bad news has a 0.1244 times impact on the market, and the same bad news has led to greater changes in volatility.
Through analysis, it can be concluded that the Chinese stock market has an asymmetric effect whether it is in a bull market or a bear market. When it is in a bull market, the positive news has a big impact. When it is in a bear market, the situation is just the opposite. This may be due to the stock market's continued rise in stock prices during the bull market, investors in the stock market over-optimistic expectations of stock prices, that the bad news is accidental. On the contrary, when the stock market is in a bear market, the stock price continues to fall, investors have an excessively pessimistic expectation of the stock price, and they are transformed into risk averse. The investors are competing to sell the stocks held by the stocks, causing the stock market to fluctuate and the stock price to fall further.

3.6. Estimation and analysis of risk fluctuation in Shanghai and Shenzhen stock markets

From the sequence of conditional variances estimated from the sample period of 2005/7/1~2007/12/28, it can be seen that the maximum value of the Shanghai Composite Index is nearly 10 times the minimum value. The maximum value of the Shenzhen component index is nearly 12 times the minimum value. It shows that China's stock market risk fluctuates within a large range.

The average and standard deviation of the Shenzhen Component Index are higher than the Shanghai Composite Index, indicating that the overall risk level of the Shenzhen stock market is higher than that of the Shanghai stock market, and the volatility is greater than that of the Shanghai stock market.

It can also be obtained that the maximum value of the Shanghai Composite Index is nearly 130 times the minimum value during the sample period from 2015/6/9 to 2017/12/29, and the maximum value of Shenzhen Component Index is nearly 40 times the minimum value. The range of risk fluctuations has increased sharply compared to 10 years ago. The overall risk level and volatility of the Shenzhen stock market is still higher than the Shanghai stock market.

4. Conclusion

4.1. Empirical summary

In this paper, 609 data were respectively selected from the Shanghai composite index and Shenzhen securities component index from July 1, 2005 to December 28, 2007, and 634 data were respectively selected from June 9, 2015 to December 29, 2017. GARCH family model is selected for data fitting and analysis. The results show that the optimal model of \( r_1 \) is TGARCH(1,1), the optimal model of \( r_2 \) is TGARCH(1,3), the optimal model of \( r_3 \) is TGARCH(2,1), and the optimal model of \( r_4 \) is EGARCH(1,1).

There are asymmetric effects in China's stock market. In the bull market, the positive news has a greater impact on the stock market risk volatility than the bad news, and the opposite is true in the bear market. The risk volatility of China's stock market has changed a lot and has become larger and larger over time. The risk level and volatility of the Shenzhen stock market are larger than the Shanghai stock market in both sample periods, indicating that the risk of China's Shenzhen stock market is slightly higher.

4.2. Problems and suggestions in China's stock market

According to the stock market surge before the financial crisis in 2008 and the stock market crash in 2015, after analysis, the Chinese stock market has problems such as insufficient supervision system, large influence from government policies, serious information asymmetry and large proportion of retail investors. In response to existing problems, the government should rationally introduce policies, improve the regulatory system, improve information disclosure, and enhance information transparency. Individual investors should strive to improve their own quality.

Generally speaking, the development of China's stock market still has a long way to go. During this period, the government, society, and individuals need to work together to promote the maturity and stability of China's stock market.
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