Research of Risk Measure for the CSI 300 Index Futures

Qian Zhang¹

Abstract²

The CSI 300 stock index futures are the first financial futures in China; it is also one of the effective hedging tools for investors in stock market. Effective management for risk of the CSI 300 stock index future market has important theoretical and practical significance. In this paper, on the basis of the existing risk measure research, we adopt the method of Monte Carlo respectively on long position and short position of CSI 300 stock index future to calculate the maximum loss, which is called value at risk. Additionally, we analyze the characteristics of the risk for the CSI 300 stock index future market since listed.

Keywords: CSI 300, Stock Index Future, Risk, Value at Risk

1. Introduction

Stock index futures are one kind of financial futures contracts with the stock price index as the subject matter. In the process of trading, the stock index futures contract value is calculated by using index points multiplied by the stipulated amount of units in advance. In February 1982, the first stock index future contract in the world was listed officially in Kansas exchange in the United States. Subsequently, the S&P 500 index futures, in which 400 kinds of industrial, 20 kinds of transportation stocks, 40 kinds of utility stocks and 40 kinds of financial stocks are included, was listed in April 1982, in the Chicago commodity exchange. The S&P 500 index futures are based on the average market price for sample stock from 1941 to 1943.

After 20 years of development, many countries in the world have listed stock index futures currently. For example, the S&P 500 index futures, the NYSE composite index futures, Toronto 50 index futures, the Nikkei 225 index futures, the Hang Seng Index futures, and so on.

Comparing with those western countries, development of the stock market in China seems relatively slow. And the stock index futures also experienced many twists and turns. There are three stock indexes mainly in China. They are Shanghai composite index and Shenzhen composite index and CSI 300.

The Shanghai composite index, which is calculated with the total shares listed in Shanghai stock exchange, was first released in China. The index is released since July 15, 1991, based on the day of December 19, 1990.

Shenzhen composite stock index stock index are prepared by the Shenzhen stock exchange, with the day of April 3, 1991 as the base period. The calculation method is similar to that of Shanghai composite index, with the sample of all the stocks listed in Shenzhen stock exchange.

CSI 300 index was issued by the Shanghai and Shenzhen stock exchange jointly on April 8 in 2005. This stock index reflects operation condition of the compiled target stocks of CSI 300 index, and serves as investment performance evaluation standard. The CSI 300 index is the basis for indexation investment and index derivative. The day of December 31 in 2004 was chosen as the base day of the CSI 300 index, in which samples of sixty percent of the stock-market value in Shanghai and Shenzhen stock exchange are included.

¹Department of Economics, SHU-UTS SILC Business School, Shanghai University
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This index is on good behalf of the entire stock market in China. The metallic and non-metallic, transportation, electricity, water supply, information technology, chemical industries are of the most importance for the CSI 300 index.

Under the overall deployment, elaborate organization of the Chinese securities regulatory commission, the CSI 300 stock index futures, which was listed as the first financial futures varieties in China financial futures exchange on April 16, 2010. The CSI 300 index was prepared with more than 300 component stocks. The Calculation way of the index is similar to other stock index futures in western countries. Customers can select 50 to 300 times of leverage ratio with day trading system. Compared with commodity futures, the stock index futures can use the market order.

For almost five years, the stock index future market keeps operating smoothly. Organizations practice orderly in the market. The values of hedging, price discovery, and innovation have been improved gradually. Presently, more than 60 securities companies, fund companies, trust companies and many kinds of wealth management products participate in the stock index futures hedging and arbitrage trading, supporting and promoting the development of stock spot market.

The listing of the stock index futures established confidence for the institutions, lowered the volatility in the stock market, improved the operating mechanism of the stock market. By hedging in the stock future market, the institutional investors avoided exposure risk in the stock market. The stock index futures are one kind of insurance for stocks, and have positive effect for management of the stock market.

However, the risk of the leverage effect of stock index futures, such as basis risk, contract varietal differences in risk, risk of subject matter, etc., which may lead to the volatility of the stock index market, are hard to be avoided. Therefore, risk measure and management of the stock index futures is of particularly importance.

2. Literature Review

Lingxiao Ma, Cheng Li and Shuai Guo (2007) introduced the development of stock index futures, and analyzed the impact and risk of stock index futures listed on the stock market.

Xiong Xiong, Jinhua Xu and Jin Zhang (2009) argued that is a process of system analysis, and stock index futures risk monitoring can be divided into three dimensions; they are types of risk, procedure, application tools. Monitoring of China financial futures risk and the overall planning of the monitoring system need to be further strengthened. At the same time, the related information processing system needs to be improved.

Yue Lan (2010) analyzed the estimate method of risk early warning. She selected day samples of IF0806 contracts and the VaR - GARCH model to measure the risk. According to the empirical results, she gave some suggestions for risk management of stock index futures market in China.

Junshan Duan and Zhiyong Gong (2011) took days of closing price data for Hong Kong's Hang Seng Index future from July 30, 1998 to July 30, 2008 as sample, with different GARCH model respectively, to calculate VaR and CVaR of the futures day yield. Additionally, R/S analysis method was used to estimate the Hang Seng Index. The results show that the PARCH model is more suitable for risk measure of index future.

Fengchu Ding (2011) analyzed and compared the similarities and differences of the basic legislation, institutional investors and stock index futures regulatory system in the United States, Japan, Korea, Singapore and other countries. He pointed out the problems in legislation, system and regulatory problems of China's stock index futures risk prevention legal system currently, and puts forward related Suggestions.

Qingfu Liu and Renhai Hua (2011), respectively, used the asymmetric EGARCH model , double-variant GARCH model and impact trading model on sample data of the CSI 300 stock index futures, based on the good news and bad news, and tested the transfer effect between the stock spot market and the stock index
future market in China. They argued that there are two-way price guidance and the volatility spillover relations between the two markets, and the influence of information transmission is asymmetric.

Haifjun Cao and Yonghang Zhu (2012) did research of overflows and linkage effect between the Chinese stock index futures and the risk of Chinese stock market, with capital inflows as a starting point. According to the change of hot money, they divided the capital inflow from 2010 to 2012 into three phases. Additionally, they used the error correction term of multiple MGARCH model to analyze the volatility spillover relationships and asymmetric impact effect of risk transfer. The results showed that the Chinese stock index futures market volatility has strong sustainability, and increases with the capital inflow declining.

Mianmiao Zhu (2012) analyzed the risks existing in the current China's CSI 300 stock index future markets mainly, including market risk, liquidity risk, legal risk, basis risk, settlement risk and operation risk, etc. He argued that some difference of the degree of speculation in the Chinese stock index futures market, infant stock index futures law, and asymmetric access to the information for investors, are the main reasons for the existence of the risk.

Gede Xiang and Kaiyan Shen (2012) used the assumption of EC - EGARCH model to test the short-term and long-term stock index futures market price discovery price. The results showed that the CSI 300 stock index future and the spot market have symmetrical price discovery function and different characteristics about short-term volatility spillover effects.

Menghua Tong, Xuebing Qi and Han Shuang (2012) took the closing price of CSI 300 stock index futures from April 16 2010 to May 7 2012 as sample data, and use dSJC copulas connect - GJR model, to calculate the value at risk of CSI 300 stock index futures for long and short positions separately. Additionally, he constructed the nonlinear correlation coefficient to calculate the optimal hedging ratio. Results showed that the CSI 300 stock index futures and spot index market have the relatively consistent trend and highly correlation.

Gaoxiu Qiao and Qiang Liu (2013) took the 500 milliseconds high-frequency data of CSI 300 index futures from in April 16, 2010 to July 15, 2011 as samples, to find possible factors for pricing deviation of the CSI 300 stock index futures. They used the threshold autoregressive model to analyze characteristics of the CSI 300 stock index futures nonlinear adjustment. The results showed that positive pricing deviation is the mainly deviation in the stock index futures market, and the negative price deviation is relatively low.

Rencai Zhou (2013) took data of the East-red no.4 from April 16, 2010 to July 5, 2012 as sample, solving the corresponding optimal hedging ratio with stock index futures hedging model of the variance decomposition. Results showed that the model can appropriately and effectively reflect different investor s’ risk appreciations.

Jun Dai (2013) examined the practicability of the optimal hedge ratio model of stock index futures in China securities market with the CSI 300 index futures and spot prices as sample data. The results showed that this model is superior to the traditional variance hedge ratio model, and better effects will be shown during great volatility in the stock market.

The research has been done on China’s stock index future risk measure is mainly focusing on the GARCH model, or analysis on interactive relationship between the spot market and future market. But it’s hard to find the risk measure with the method of the Monte Carlo. The empirical research of this paper is to calculate the value at risk of the CSI 300 index futures, using Monte Carlo stochastic simulation method.

3. Methodology and Results

There are different ways to measure assets’ value at risk. For example, non-parametric method, half parameter method and parameter method, etc. Among them, the method of autoregressive conditional
heteroskedasticity model\textsuperscript{3}, which focus on the theory that if the disturbance of the conditional variance depends on its previous value to estimate value at risk, is also one of the commonly used analytical tools.

The Monte Carlo stochastic simulation method will use the sample data to estimate the possible distribution, then estimate the parameters on the basis of the distribution and get the possible profit and loss distribution, and finally to measure the maximum loss or value at risk. This method can simulate the actual physical process, which is relatively conformed to the actual situation. So it’s an effectively method to measure any asset’s value at risk. In order to guarantee the comprehensiveness of the empirical, this paper will use the Monte Carlo stochastic simulation method to measure the value at risk of CSI 300 index futures with different confidence level respectively.

4. Data Analysis

The CSI 300 index futures have four different contracts, namely that month, next month and two season months later. In order to guarantee the validity of the empirical results, we select the day closing price data of composite CSI 300 stock index futures contracts, which is from April 16, 2010 to February 5, 2015 to calculate value at risk. The data has 1168 samples totally, which is from Web-stock financial data sources. According to the logarithm yield of day closing price of the CSI 300 index futures, the logarithm yield chart is as follows:

\textbf{Figure 1: The Day Logarithm Yield Chart of the CSI 300 Stock Index Futures}

Figure 1 shows that, price of the CSI 300 index futures dropped down heavily in early since listed in 2010. After that, the day yield continued to fluctuate, but mainly between -1% and 1%. The minimum CSI 300 index futures average yield is nearly -5%, and the maximum is nearly 3%. For the entire sample period, during 2012 and 2013, the volatility of the yield is relatively intense, and the CSI 300 stock index future yields reached the minimum point in early 2015.

\textbf{Value at Risk Results}

Since there are long and short positions in futures trading, we calculate the value at risk of short and long positions separately. In this paper, we use Matlab software to execute the Monte Carlo stochastic simulation method. The value at risk for long positions of CSI 300 stock index futures will be calculated with the five different confidence level of 95%, 97.5%, 98%, 99%, 99% respectively. The value at risk for short positions of CSI 300 stock index futures will be calculated with the five different confidence levels of 5%, 2.5%, 2%, 5% and 2.5% respectively. The value at risk results for long positions of CSI 300 stock index futures are shown in Figure 2.

\textsuperscript{3} Autoregressive conditional heteroskedasticity model is so called GARCH model
For investors with long positions of stock index futures, if price of the stock index future is falling down, the loss will be greater. According to the calculation results, since April 16, 2010 to February 5, 2015, with 95% confidence level, the maximum loss of the CSI 300 index futures is about -3.614%. With the 97.5% confidence level, the maximum loss of the CSI 300 stock index futures is about -4.346%. With the 98% confidence level, the maximum loss of the CSI 300 stock index futures is about -4.55%. With the 99% confidence level, the maximum loss of the CSI 300 stock index futures is about -5.195%. With the 99.5% confidence level, the maximum loss of the CSI 300 stock index futures is about -5.802%. With the same way, we get all the calculation value at risk results chart for short positions of the CSI 300 stock index futures with the five confidence levels, as shown in Figure 3.

For investors with short positions of the CSI 300 stock index futures, if price of the stock index future is going up, the loss for them will be greater. According to the calculation results, from April 16, 2010 to February 5, 2015, with 5% confidence level, the maximum loss for short positions of the CSI 300 stock index futures is about 3.8%. With the 2.5% confidence level, the maximum loss for short positions of the CSI 300 stock index futures is about 4.528%. With the 2% confidence level, the maximum loss for short positions of the CSI 300 stock index futures is about 4.738%. With the 1% confidence level, the maximum loss for short positions of the CSI 300 stock index futures is about 5.384%. With the 0.5% confidence level, the maximum loss for short positions of the CSI 300 stock index futures is about 5.943%.
Back-Testing Results

In order to guarantee the validity of the empirical results, we need to do back-testing for the all the value at risk results. There are different ways of back-testing, such as failure rate test, distribution prediction method, the variance test, likelihood ratio test, etc. Since one single test may not be the best one, this paper select two methods to test the effectiveness of the value at risk results for long and short positions with five different confidence levels, they are failure rate and likelihood ratio.

For long positions, failure rate test refers to find that, if the failure rate of the value at risk, which is calculated by the number of days that the actual yield is lower than the value at risk divide the number of days in total samples, is with the related significance level. For example, with the confidence level of 95%, the significance level is 5%, and then the failure rate is supposed to be close to 5%. For short positions, we need to find the number of days that the actual yield is higher than the value at risk divide the number of days in total samples.

Likelihood ratio test are put forward by Kupiec in 1995, whether the likelihood value of LR satisfies the $\chi^2$ distribution is taken as the accuracy inspection standard. Assuming that the number of days in total samples is $T$, the number of failure days is $N$, the failure rate is $N/T$, the confidence level of $p^*$, then the computation formula for likelihood values of LR is:

$$LR = -2\ln[(1 - p^*)^{T-N}p^N] + 2\ln[(1 - (N/T)^{T-N}(N/T)^N]...... i$$

With the confidence level of $p^*$, the likelihood values of LR are supposed to satisfy $\chi^2$ distribution with degrees of freedom for 1. If the likelihood values of LR, which will be calculated by the number of days in total samples and the number of failure days in total samples, is lower than the corresponding critical value of $\chi^2$ distribution, then the value at risk results calculated will be considered as having passed the back-testing test, otherwise the calculation results are invalid. According to the calculation formula, back-testing results for long and short positions of the CSI 300 index futures are shown in Table 1.

<table>
<thead>
<tr>
<th>Position</th>
<th>Confidence level</th>
<th>Days of failure</th>
<th>Failure rate</th>
<th>Value of LR</th>
</tr>
</thead>
<tbody>
<tr>
<td>long</td>
<td>95.0%</td>
<td>62</td>
<td>5.3%</td>
<td>0.073998</td>
</tr>
<tr>
<td></td>
<td>97.5%</td>
<td>39</td>
<td>3.3%</td>
<td>1.327737</td>
</tr>
<tr>
<td></td>
<td>98.0%</td>
<td>36</td>
<td>3.1%</td>
<td>2.605615</td>
</tr>
<tr>
<td></td>
<td>99.0%</td>
<td>28</td>
<td>2.4%</td>
<td>6.807294</td>
</tr>
<tr>
<td></td>
<td>99.5%</td>
<td>22</td>
<td>1.8%</td>
<td>10.82906</td>
</tr>
<tr>
<td>short</td>
<td>5.0%</td>
<td>52</td>
<td>4.4%</td>
<td>0.387481</td>
</tr>
<tr>
<td></td>
<td>2.5%</td>
<td>29</td>
<td>2.5%</td>
<td>0.000612</td>
</tr>
<tr>
<td></td>
<td>2.0%</td>
<td>25</td>
<td>2.1%</td>
<td>0.024271</td>
</tr>
<tr>
<td></td>
<td>1.0%</td>
<td>17</td>
<td>1.5%</td>
<td>0.93196</td>
</tr>
<tr>
<td></td>
<td>0.5%</td>
<td>11</td>
<td>0.9%</td>
<td>1.577602</td>
</tr>
</tbody>
</table>

According to the results in Table 1, as a whole, the value at risk results for long or short positions with five different confidences level are good explanations for risk of the CSI 300 index futures. For example, with the confidence level of 95%, the failure rate for value at risk results of long positions of the CSI 300 index futures is 5.3%, which is relatively close to 5%, and the corresponding likelihood values of LR is lower than the threshold value of $\chi^2$ distribution with degrees of freedom for 1 and confidence level of 95%. Additionally, the failure rate for value at risk results of short positions of the CSI 300 index futures is 4.4%, which is less than 5%, and the corresponding likelihood values of LR threshold value is lower than the threshold value of $\chi^2$ distribution with degrees of freedom for 1 and confidence level of 95%. Overall, results with confidence level of 95%, 97.5% and 98% are better than results with confidence level of 99% and 99.5%.
5. Conclusion

By measuring the value at risk of the CSI 300 stock index futures, we can further understand the whole situation of the stock index futures market in China. From the calculation results, for both long and short positions of the CSI 300 index futures, at the beginning of the market in 2010, corresponding risk for the future positions are higher. But after that, the risk for almost all the positions tends to reduce. This suggests that, the stock index futures market system in China gradually goes well, and the market is more and more mature. The CSI 300 stock index futures are the first financial futures in China, its development is of vital significance to the future development of financial futures in China. Comparing with the developed countries like the United States or countries in Europe, the development of financial futures market in China is still in its infancy, with few listed derivatives and relatively low participation for institutional investors. Additionally, the risk management in the stock index future market needs to be further strengthened.

References