The Empirical Study of VaR Method in China’s Financial Risk Management

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Abstract: We discuss the main applications of VaR to finance currently, introduce the three main VaR methods (historical simulation method, parameter method and Monte Carlo simulation method), analyze their advantages and disadvantages respectively, and using the China’s data and software such as Excel and STATA10.0, we study the application of VaR to China's financial risk and portfolio selection empirically. The results shows values of VaR in the three methods were relatively close, after backtesting, it reveals that all of them estimated VaR highly and underestimated the risks.

Key words: VaR; financial risk management; portfolio

1 Introduction

The process of financial risk management is very complex; it usually includes risk identification, risk measurement, risk management, decision-making, and implementation and risk control. In which, risk measure is the most important part, there are different types of Market risk measurement methods, VaR method developed by P.J.Morgan in recent years is most famous. VaR tests the potentially biggest loss value of market price of financial investment tool due to market volatility over a period of time under a certain confidence probability. As VaR can express the market risk simply and clearly, and it relies on the rigorous probability statistical theory, more importantly, it has settled many problems which traditional risk measurement can not solve, thus the approach receives the support and endorsement of international financial community. The study and application of VaR has been relatively mature and popular abroad, but we only have the concept and principle of VaR in China, the application of VaR to the specific risk management is relatively less. Therefore, from the principle and calculation method of VaR, this article focuses on the applications of VaR to China's financial market risk management.

The paper’s structure is as follows: Part II discusses the main applications of VaR to finance; part III introduces the three main method (historical simulation method, parameter method, Monte Carlo simulation method), and analyses their advantages and disadvantages respectively; Part IV, based on the datum from China's Shanghai stock market, we use the above three methods to analyze and verify VaR empirically; the last part is conclusion.

2 VaR Measurements

So far, there are many ways to calculate VaR, which can be classified into three main categories: historical simulation method, the parameter (variance-covariance) and the Monte Carlo simulation method.

2.1 Historical simulation methods

Historical simulation method is a simple method based on experience, it does not need to assume the statistical distribution of market factors, but directly calculate VaR by the definition. In the estimation model, the historical simulation method revalues cash according to the price of the future market factors, and calculates changes of the value (profit and loss); finally, sort the combined value ascending to get distribution, and then obtain VaR with the certain confidence degree. It has many advantages: (1) it is simple and easy to implement; (2) it does not require assuming the statistical distribution of the market factors, which can effectively deal with non-symmetric problem and thick tail;
(3) it need not estimate rate of fluctuation and other relevant parameters, and there is no parameter estimation risk. However, there are many defects: (1) the income distribution in the entire sample is fixed; (2) it can not offer expected losses worse than that provided by the smallest income in the sample; (3) the sample size would have a greater impact on VaR value; (4) it can’t do sensitivity test under extreme circumstances.

2.2 Monte Carlo simulation method

Compared to Historical simulation method, Monte Carlo simulation model don’t use historical observations but computer to simulate the rates of return of the market factors or assets. Then, according to the calculated distribution of profit and loss, deducting(at 95% probability level) 50 worst values, we can calculate VaR value.

Its main advantages: (1) the large number of scenarios simulated by computer can generate more reliable, more accurate and more comprehensive conclusions; (2) It embodies the convex of non-linear assets and considers the change of fluctuation over time; (3) This method can be used to simulate.

There are also some drawbacks: (1)if datum generated is pseudo-random number sequence, it may lead to erroneous results; (2) it wastes a lot of observations and reduces the efficiency of the simulation for cluster effect of random number; (3)it needs lots of calculations and longer time.

2.3 Analysis method

"Variance-Covariance" is the standard method used by RiskMetrics, because it needs to estimate variance and covariance of the portfolio, it’s also known as parameter method. It assumes that the portfolio yield is linear combinations of return on all assets. Therefore, once we obtain the standard deviation of return on portfolio, the corresponding VaR is also identified. Basic steps are as follows: First, use the historical datum to obtain variance, standard deviation and covariance of return on portfolio; Secondly, under the assumption of the normal distribution, we obtain the corresponding critical value in a certain confidence level; Finally, put the data obtained in the former two steps into VaR formula to calculate the corresponding VaR.

3 Empirical Analysis of China's Securities Market Risks

3.1 Datum selection and sources

We only consider simple cases and directly analyze the stock market index, so, we choice Shanghai negotiable securities Composite Index as object to calculate rate of return. Because the Shanghai negotiable securities Composite Index more accurately reflects overall changes and development trend of the Shanghai stock market. Shanghai negotiable securities composite index data is from Sohu website: www.sohu.com. We select the datum from February 20, 2004 to February 20, 2006 as the original sample, totaling 481 objects, and select those from February 20, 2006 to February 20, 2008 as the test sample, which is used to test and compare the accuracy of results, totaling 495 objects. For the purpose of this paper is to analyze the risk of China's securities market, we select 95% confidence level in the empirical research below.

3.2 VaR by variance-covariance method

The premise of measuring risk in Covariance method is based on the assumption that change of the risk factor submits to multivariate normal distribution, we need to estimate the variance and correlation coefficients that is covariance matrix. Based on the GARCH model and the previous results to estimate the fluctuation, we put the fluctuation sequence into the formula:

$$ \Delta \text{VaR}_t = \alpha \cdot \bar{P}_t \cdot (\exp(\sigma) - 1) $$

In which, $\alpha = 0.05$, $Z_{\alpha} = 1.645$, $\bar{P}_t$ is closing price of the Shanghai negotiable securities composite index each day. Sorting it ascending and adopting the value in the first five percent (24) of the sequence, we get the VaR: 25.089697/1307.5699 = 0.01918803.
3.3 VaR by historical simulation method

First, according to the formula: \( r_t = \ln(\text{index}_t) - \ln(\text{index}_{t-1}) \), we calculate geometric rate of return of the original sample, and draw the fluctuations by STATA10.0 software, Figure 1 shows the VaR obtained by the historical simulation method. Sorting the geometric rate of return above ascendingly, adopting the value in the first five percent (24%) of the sequence, so we get the VaR: 0.02052689.

3.4 VaR by Monte Carlo simulation method

First of all, according to the original sample, we estimate mean and standard deviation: \( \mu = 0.00064, \sigma = 0.013284 \), then we use computer to generate random numbers with normal distribution and use stochastic processes to simulate \( \text{Index}_{t+1} = \text{Index}_t (1 + \mu + \sigma \epsilon) \), resulting in \( S_{t}, t = 1, 2, \ldots, 481 \). Using software STATA10.0 to repeat it 1000 times, we get 1000 \( S_{t} \), \( t = 1, 2, 481 \), and obtain 1000 possible closing quotation index in the future. Secondly, sort the values of 481 days ascending and repeat it 1000 times, take the data in the first 5% (24) as VaR of each sequence (Figure 2). Finally, we calculate their average: VaR=-0.02071.

3.5 Back testing the three models

Choosing the Shanghai negotiable securities composite index from February 20, 2006 to February 20, 2008 as the test sample with 495 objects, we use the failure frequency test advanced by Kupiec to check the three models, the steps is as follows: (1) at the 5% confidence level, we calculate VaR by
historical simulation, analytical method and Monte Carlo simulation method in the original sample. (2) According to Kupiec test method, under the condition of 495 objects and 5% confidence level, we calculate the non-rejected region of the failure frequency N: 16 < N < 35, if the result is less than 16, it means the model is too conservative, underestimates VaR and overestimates the risk, if more than 35, the model overestimates the VaR and underestimates the risk, if the result is in the non-rejected region, that model can estimate the risk of the stock market rightly. (3) Sort 495 geometric rates of return above ascending to get N in the three models respectively.

<table>
<thead>
<tr>
<th>Model</th>
<th>VaR</th>
<th>Failure times</th>
<th>Non-rejected region</th>
<th>Test result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Historical simulation</td>
<td>-0.02053</td>
<td>55</td>
<td>refusal</td>
<td></td>
</tr>
<tr>
<td>Analytical method</td>
<td>-0.01919</td>
<td>60</td>
<td>16 &lt; N &lt; 35</td>
<td>refusal</td>
</tr>
<tr>
<td>Monte Carlo simulation</td>
<td>-0.02071</td>
<td>55</td>
<td>refusal</td>
<td></td>
</tr>
</tbody>
</table>

From table 1, the failure times of both historical simulation and Monte Carlo simulation method is 55, that of analytical method is 60, they are in the right of non-rejected region, which means that the three models did not pass the test, they overestimated VaR and underestimated the risks. From the test results above, we can draw a conclusion: Historical simulation, analytical method and Monte Carlo simulation in the process of measuring China's securities market risk underestimate the risks, but we can not deny the models' correctness. With the development of the stock market and improving financial regulatory system, China's stock market is gradually becoming more mature and volatility has gradually become smaller, therefore, when we use those methods to measure China's stock market risk, the specific method should be made greater improvements.

4 Conclusions

In this paper, the main results are achieved as follows:

(1) We discuss the main applications of VaR in the area of finance, introduce the three main method (the history/historical simulation method, parameter method, Monte Carlo simulation method) and their respective advantages and disadvantages.

(2) Based on the statistical characteristics of index and related hypothesis, we use the above three methods to analyze VaR of the Shanghai negotiable securities composite index. The results showed the values of VaR by three methods are closer, but they have not passed the test, all of the estimates overestimate VaR and underestimate the risks.

(3) We used Markowitz model to study the application of VaR to Portfolio optimization, the result shows that with the same income, the risk of Portfolio after adding VaR to the model decreased. VaR has been widely used in foreign financial institutions; however, we still need to use it cautiously in China. China's securities market is not perfect, and the effectiveness of the securities market has yet to be verified. On the other hand, there are many researches on how to optimize the Portfolio, but the application is still lagging far behind the theoretical research. Moreover, the VaR are more concentrated on variance-covariance method, and VaR calculated has not yet decisive impact on the actual investment guidance and risk control.

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