World Scientific Research Journal Volume 6 Issue 6, 2020
ISSN: 2472-3703 DOI: 10.6911/WSRJ.202006_6(6).0030

The Application of VaR Method in Risk Management of Chinese Listed Commercial Banks

Weidong Jiang[1, a]

[1]School of Economics, Jinan University, Guangzhou 510000, Guangdong, China.

[a]Corresponding author e-mail:jwd927jwd927@163.com

Abstract

As the core institution of Chinese financial system, commercial banks' own development plays a vital role in the stability of Chinese financial system. Based on the daily closing price data of 16 listed commercial banks in China, this paper measures the value-at-risk of Chinese listed commercial banks based on its logarithmic return sequence "peaky thick tail" and volatility clustering characteristics, combined with the AR-GARCH model with generalized error distribution. The results show that: Among the three types of commercial banks, state-owned commercial banks have lower risks and stronger ability to deal with their own risks; while city commercial banks have higher self-risks and weaker ability to deal with their own risks.

Keywords

Value-at-risk, GARCH model, logarithmic rate of return.

1. INTRODUCTION

Sustained economic growth depends on a safe and stable financial system. The outbreak of the global economic crisis in 2008 has made people's understanding of risk spillovers deeper and broader. The occurrence of the European debt crisis and Chinese "money shortage" in 2013 all indicate the value of risk The importance of VaR. Value-at-Riskconsiders the maximum possible loss of a financial institution in a certain period of time under a certain probability level, which provides a reference for the risk management of financial institutions to a certain extent.

In 1993, a consulting group called G-30 proposed the use of value-at-risk to quantify financial risks in the report "Practices and Rules of Derivative Products" [1]. The VaR method and calculation model Riskmetrics model of JP Morgan in 1994 received extensive attention due to the theory and operational feasibility. In 1995, Beder believed that the specific value of VaR was affected by many conditions, so he used different methods to calculate the VaR value in order to obtain the different factors affecting the VaR value and the degree of its impact [2]. In 1995, Kupiec proposed to use the return test method to test VaR calculations, making the VaR calculation method system relatively complete [3]. In 1996 Jorion gave a detailed definition of VaR, various calculation methods and the characteristics of these calculation methods. Finally, through empirical analysis, compare the difference between the VaR calculation method under normal distribution and t distribution and how to improve the estimation accuracy of VaR [4]. In 2000, Billio et al. Used Morgan's Riskmetrics model and GARCH (1, 1) model to calculate the VaR values of 10 Italian stocks and the combination of these stock assets with different confidence levels [5].

Domestically, the research on VaR can be divided into two parts. Before 1999, the study phase was mainly understood, and after 1999, the in-depth research and application phase. In the learning stage, Wentong Zheng first studied the VaR method in 1997, mainly introduced the

ISSN: 2472-3703 DOI: 10.6911/WSRJ.202006_6(6).0030

background, calculation and application scope of VaR in detail, and on this basis, combined with Chinese national conditions, showed that the VaR method is practical [6]. In 1998, Naikang Gubriefly introduced the VaR method for measuring market risk, compared VaR and asset-liability market risk management methods, and pointed out the application scope and existing defects of VaR [7]. In 1998, Gang Yao briefly explained the calculation method of asset portfolio risk value, and gave both linear and nonlinear evaluation models [8]. In 1999, Yufei Liu expounded the basic content of VaR model, pointed out the application and significance of VaR model in financial supervision, and used post-mortem inspection to test the accuracy of VaR model [9]. In the research and application stage, the VaR method has been applied to Chinese banks and securities markets, and the VaR method has been improved. In 2000, Guoqiang Dai et al. mainly introduced VaR's "linear" and "non-linear" calculation methods, and on this basis, introduced the positive significance of VaR method for Chinese financial risk management [10]. In 2000, Du Haitao applied the VaR method to China's securities market, and believed that the method has a good effect on the risk management of Chinese securities market [11]. In 2000, Ying Fan discussed the definition and calculation method of VaR method, and initially discussed the application of VaR method in stock market risk analysis, and pointed out that this method is feasible for stock market risk analysis [12]. Haitao Du and Ying Fan both believe that the return sequence is subject to positive State distribution. In 2002, Meijin Wang and Hua Wang focused on the distribution of the tail of the return rate series, pointing out that the results under different assumptions of the distribution are ultimately different. The distribution assumption of the return rate sequence determines the accuracy of the VaR value [13-14]. In 2002, Shoudong Chen and Shidian Yu combined the VaR method with the GARCH model under the assumption of t distribution and GED distribution based on the thick-tailed nature of Chinese stock market return series, and analyzed the Shenzhen and Shanghai stock market risk [15]. In 2014, Qiqiu Xu and Jinxiu Zhang used the support vector quantile regression model to measure their VaR based on the Shanghai Composite Index, the Hong Kong Hang Seng Index and the S & P 500 Index, and compared with traditional VaR measurement methods (such as the GARCH model) [16]. In 2015, Xiaoqian Liu and Yong Zhou added different weights on the basis of the quantile regression method to measure the VaR value, and innovatively proposed the weighted composite quantile regression method to measure the dynamic VaR value [17].

2. METHODOLOGY

2.1. VaR Theory

In the financial market, there are several financial risks: market risk, credit risk, operational risk, liquidity risk and legal risk. Value-at-Risk VaR considers market risk, which refers to the risk of changes in market prices of financial assets or liabilities due to fluctuations in market factors. Among these fluctuations, stock price fluctuations. Therefore, this article analyzes the risk value of Chinese banking institutions with the help of stock price daily yield data.

VaR is the value at risk, which refers to the maximum loss that a certain asset portfolio will suffer in a future period of time under a given confidence level, namely the minimum return. It can be expressed by the following formula:

$$P\left(r_t \le -VaR_t^{\,q}\right) = q \tag{1}$$

r_t represents the combined income of a financial institution, $VaR_t^{\,q}$ represents the value-at-risk at time t with a confidence level of 1-q.

2.2. Calculation Method of VaR Model

After 30 to 40 years of development, VaR has many model calculation methods. This article mainly introduces three methods, which are historical simulation method, Monte Carlo method and variance-covariance method.

The historical simulation method is a method based on past experience, which does not make assumptions about complex market structures. The specific performance in this paper is to make assumptions about the logarithmic return rate series, that is, not to discuss whether the logarithmic return series conforms to the normal distribution, t distribution, partial t distribution or GED distribution. It directly calculates according to the definition of VaR, that is, assumes that the rate of return does not change during the cycle, and simulates the future return of the asset portfolio based on the historical data of the rate of return sequence, so as to obtain the value of risk at a certain confidence level. This method is a complete valuation method.

The Monte Carlo method is also called a stochastic simulation method. The basic idea of this method is to use the historical fluctuation parameters and use the computer to simulate a large number of possible paths of future fluctuations of market factors. Unlike the historical simulation method, the historical simulation method can only generate specific or limited future fluctuations of market factors based on historical data. The Monte Carlo method can outline the approximate distribution of market factors by simulating the distribution, and then obtain the VaR value at the corresponding confidence level according to the approximate distribution.

The basic idea of the variance-covariance method is to use the historical data of asset returns to obtain the relevant standard deviation and correlation coefficient, then calculate the standard deviation of the asset portfolio based on the obtained standard deviation and correlation coefficient under a certain distribution assumption, and finally obtain the relative corresponding VaR. Specific steps are as follows:

(1) Obtain the variance and covariance of asset portfolio returns based on historical rate of return data, and further obtain the standard deviation.

(2) Assuming that the asset portfolio follows a normal distribution, a critical value that reflects the degree to which the distribution deviates from the mean under a certain confidence interval is obtained.

(3) According to the results obtained above, establish a relationship with the value of risk, and derive a specific VaR value.

Because the assumption of normal distribution sometimes seriously underestimates the VaR value under extreme risk, many scholars have proposed different improvement methods in recent years, such as the mixed normal model based on Risk Metrics, the ARCH model, and the improvement method using extreme value theory. The AR-GARCH model used in this paper belongs to the variance-covariance method.

2.3. GARCH Model

This article intends to use the GARCH (Generalized Autoregressive Conditional Heteroskedasticity) model to obtain the VaR of the bank. Before doing the analysis, it is necessary to understand the GARCH model.

As one of the above-mentioned variance-covariance methods, the ARCH model can also better estimate the VaR of risk, but sometimes the ARCH model obtained has a high order, which brings inconvenience to the calculation of VaR. The GARCH model is an important promotion of the ARCH model, proposed by Bollerslev in 1986.

ISSN: 2472-3703 DOI: 10.6911/WSRJ.202006_6(6).0030

For a logarithmic rate of return series, assume that its mean equation is an ARMA model. Suppose $a_t = r_t - u_t$ is the mean-corrected logarithmic rate of return or called the new information series, if it satisfies the following conditions:

$$a_t = \sigma_t \varepsilon_t \tag{2}$$

$$\sigma_t^{\ 2} = \alpha_0 + \sum_{i=1}^{p} \alpha_i a_{t-i}^{\ 2} + \sum_{j=1}^{q} \beta_j \sigma_{t-j}^{\ 2} \tag{3}$$

Where $\{\varepsilon_t\}$ is a sequence of independent and identically distributed random variables with zero mean unit variance, usually assumed to follow a standard normal distribution or t distribution, $\alpha_0 > 0$, $\alpha_i \geq 0, i = 1,2,3,\cdots$, $\beta_j \geq 0, j = 1,2,3,\cdots$, $\sum_{i=1}^{\max(p,q)} (\alpha_i + \beta_i) < 1$ (if $i > q, \alpha_i = 0$, if $j > p, \beta_j = 0$);So a_t is said to obey the GARCH (p, q) model.

3. AR-GARCH MODEL ESTIMATES VAR

3.1. Data Sources and Preliminary Analysis

In order to measure the risk spillover effect of China's banking industry, a total of 16 publicly listed banking institutions were selected for the intra-day closing price of stock data to calculate the rate of return. Including 5 state-owned commercial banks (ICBC, China Construction Bank, Bank of China, Bank of Communications, Agricultural Bank of China), 8 joint-stock commercial banks (China Merchants Bank, China CITIC Bank, Industrial Bank, Shanghai Pudong Development Bank, Minsheng Bank, Huaxia Bank, Ping An Bank, China Everbright Bank), 3 city commercial banks (Bank of Nanjing, Bank of Beijing, Bank of Ningbo). Since both Agricultural Bank of China and China Everbright Bank were listed in 2010, the listing time was later. Therefore, the latest time of China Everbright Bank was used as the standard. The data selection time span was August 19, 2010 to November 1, 2019. The bank contains data for 2237 trading days.

First, the intraday closing price is processed, and the daily rate of return adopts the logarithmic rate of return, namely

$$r_t = \ln P_t - \ln P_{t-1} = \ln \frac{P_t}{P_{t-1}} \tag{4}$$

Where P_t represents the stock closing price on day t, and significance level is 0.01.

Then, the descriptive statistics of the logarithmic returns of the selected banks are shown in Table 1.

ISSN: 2472-3703 DOI: 10.6911/WSRJ.202006_6(6).0030

Table 1. Descriptive statistics of yield

Bank	Maximum value	Mean	Minimum value	Skewness	Kurtosis
ICBC	0.0953102	0.0001604	-0.1232982	-0.39	11.15
Construction Bank	0.0956611	0.0001894	-0.1057661	-0.26	9.13
Bank of China	0.0965800	0.0000274	-0.1163000	-0.04	12.87
Bank of Communications	0.0962500	-0.0000465	-0.1095000	-0.13	11.43
ABC	0.0964137	0.0001377	-0.1042331	0.00	10.38
China Merchants Bank	0.0955424	0.0004336	-0.1044031	0.35	4.16
CITIC Bank	0.0961300	0.0000235	-0.1056000	0.38	5.95
Industrial Bank	0.0957911	-0.0001451	-0.6198015	-9.59	224.47
Shanghai Pudong Development Bank	0.0956000	-0.0000513	-0.2694000	-1.68	26.39
Minsheng Bank	0.0954400	0.0000457	-0.1956000	-0.80	16.86
HSBC Bank	0.0958015	-0.0002085	-0.3407919	-3.16	48.79
Ping An Bank	0.0955475	-0.0000169	-0.5428650	-5.10	108.03
China Everbright Bank	0.0966268	0.0000924	-0.1044427	0.42	7.02
Bank of Nanjing	0.0955289	-0.0001199	-0.6074417	-8.14	183.58
Bank of Beijing	0.0958015	-0.0003855	-0.2109196	-2.11	27.49
Bank of Ningbo	0.0956337	0.0003692	-0.2723561	-1.25	18.08

It can be obtained from Table 1 that the average logarithmic returns of 16 listed commercial banks fluctuate around 0, the skewness is generally not equal to 0, and the kurtosis is generally greater than 3, indicating the logarithmic returns of the 16 listed banks selected does not obey the normal distribution. Because the skewness of the normal distribution is equal to 0, the kurtosis is equal to 3. And the logarithmic return series shows a significant "peak and thick tail" phenomenon, which is generally owned by financial time series. Among them, the skewness of the logarithmic returns of state-owned commercial banks is less than 0, and the kurtosis fluctuates around 10. Among the joint-stock banks, the skewness of Industrial Bank and Ping An Bank is larger among all banks, and their kurtosis is also significantly greater than 3, which is 224.47 and 108.03, respectively. Among the city commercial banks, Nanjing Bank has a relatively large skewness, and its kurtosis is also significantly greater than 3, at 183.58. In addition, the minimum values of the three banks, Industrial Bank, Ping An Bank and Nanjing Bank, are also generally higher than other commercial banks, indicating that the logarithmic returns of these three banks are relatively volatile.

The logarithmic returns of ICBC, China Merchants Bank and Bank of Beijing are shown below.

ISSN: 2472-3703 DOI: 10.6911/WSRJ.202006_6(6).0030

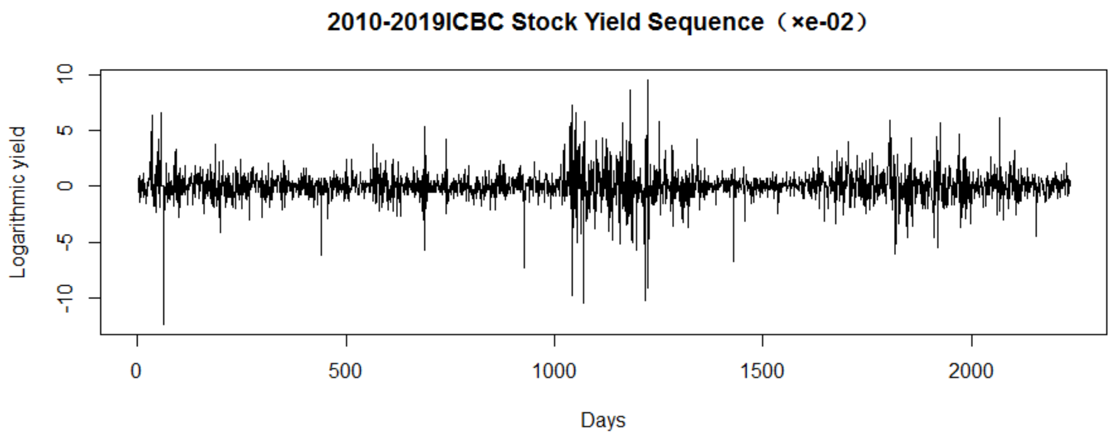

Figure 1. ICBC's logarithmic yield fluctuation

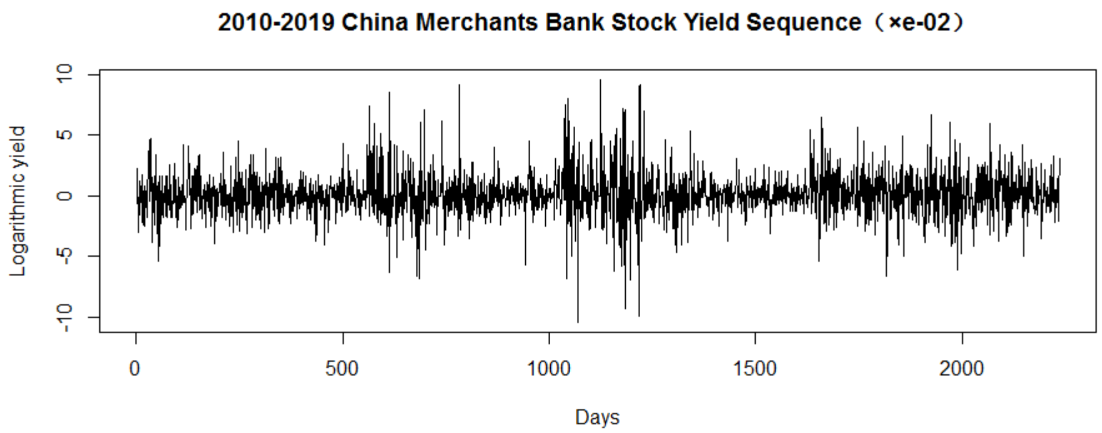

Figure 2. China Merchants Bank's logarithmic yield fluctuation

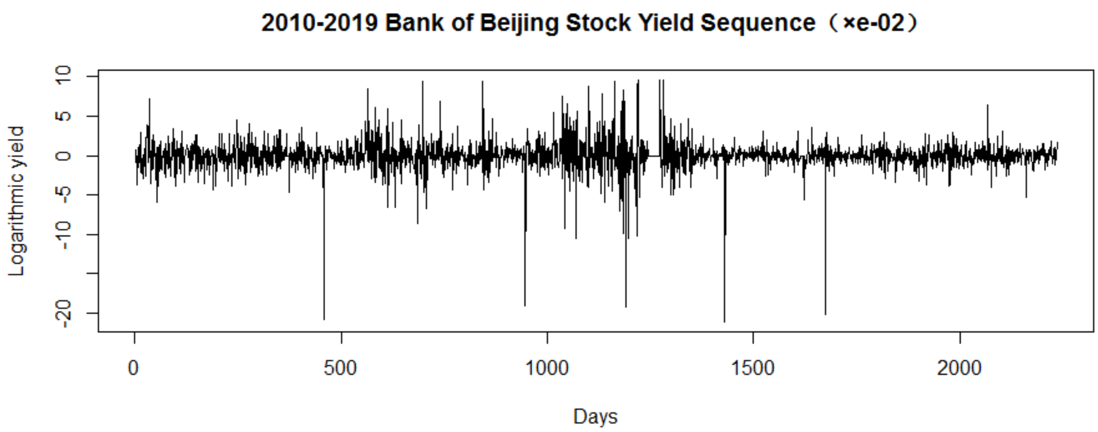

Figure 3. Bank of Beijing's logarithmic yield fluctuation

The data obtained from the logarithmic yield graph and descriptive analysis can be obtained: on average, the volatility of the state-owned commercial banks is small, the volatility of the joint-stock commercial banks is closely followed by the volatility of the city commercial banks The volatility of Industrial Bank, Ping An Bank and Bank of Nanjing is the largest among all banks, which corresponds to its peak. In addition, the bank's logarithmic rate chart generally

ISSN: 2472-3703 DOI: 10.6911/WSRJ.202006_6(6).0030

has a volatility aggregation effect, that is, volatility has a positive correlation, large volatility is followed by large volatility, and small volatility is followed by small volatility.

3.2. Stationarity Test

First of all, the stationarity test is performed on the logarithmic rate series. This paper uses ADF unit root test, the test results are shown in Table 2.

Table 2. ADF unit root test

Bank	DF value	Lag order	P-value
ICBC	-13.773	13	<0.01
Construction Bank	-13.712	13	<0.01
Bank of China	-13.388	13	<0.01
Bank of Communications	-14.043	13	<0.01
ABC	-13.424	13	<0.01
China Merchants Bank	-13.299	13	<0.01
CITIC Bank	-13.855	13	<0.01
Industrial Bank	-12.138	13	<0.01
Shanghai Pudong Development Bank	-13.038	13	<0.01
Minsheng Bank	-13.519	13	<0.01
HSBC Bank	-13.656	13	<0.01
Ping An Bank	-12.827	13	<0.01
China Everbright Bank	-13.442	13	<0.01
Bank of Nanjing	-12.713	13	<0.01
Bank of Beijing	-13.424	13	<0.01
Bank of Ningbo	-13.682	13	<0.01

It can be seen from the results that all P values are less than 0.01, so under the 99% confidence level, it can be considered that the logarithmic return sequence of the daily closing price of the selected listed bank is stable.

3.3. ARCH Effect Test

The ARCH model effect refers to the sequence correlation of conditional heteroscedastic sequences. The original hypothesis of the ARCH effect: There is no ARCH effect in this sequence. Perform the ARCH effect test on each bank through R language to find the corresponding P value and chi-square statistics, as shown in Table 3.

ISSN: 2472-3703 DOI: 10.6911/WSRJ.202006_6(6).0030

Table 3. The results of ARCH effect test

Bank	Chi-square statistics	P-value
ICBC	222.91	<2.2e-16
Construction Bank	384.59	<2.2e-16
Bank of China	369.94	<2.2e-16
Bank of Communications	309.75	<2.2e-16
ABC	293.24	<2.2e-16
China Merchants Bank	156.3	<2.2e-16
CITIC Bank	250.9	<2.2e-16
Industrial Bank	21.841	0.004327
Shanghai Pudong Development Bank	28.083	0.007661
Minsheng Bank	43.883	1.599e-05
HSBC Bank	31.259	0.004012
Ping An Bank	16.649	0.01917
China Everbright Bank	342.75	<2.2e-16
Bank of Nanjing	13.974	0.02856
Bank of Beijing	27.044	0.007616
Bank of Ningbo	74.951	3.753e-11

According to the above test results, at the 95% confidence level, the original hypothesis that there is no ARCH effect is rejected, so the logarithmic return data of the selected banks all have the ARCH effect.

3.4. Calculation of VaR Based on AR-GARCH Model

After analyzing the logarithmic rate of return of each bank to obtain the respective AR-GARCH model, calculate VaR according to the actual parameters obtained by the model. The main calculation steps are as follows:

(1) Estimate the unknown parameters of the AR-GARCH model;

(2) Calculate the conditional heteroscedasticity in different periods according to the AR-GARCH model, and further obtain the conditional standard deviation in different periods;

(3) Substitute the conditional standard deviations in different periods into the equation to obtain the absolute value of VaR in different periods, which represents the quantile under the GED distribution with confidence, and the mean value of the logarithmic return.

The following takes a total of 16 banks from three types of listed commercial banks as an example to obtain the corresponding AR-GARCH model.

(1) ICBC

According to the ACF (autocorrelation coefficient) graph and PACF (partial autocorrelation coefficient) graph of the ICBC's logarithmic return series, choose the AR (6) model to fit the mean equation; when establishing the variance equation, the model should reflect its simplicity as much as possible. And because the logarithmic return series exhibits a "peaky thick tail" characteristic, they are fitted with normal distribution, t distribution, partial t distribution and GED distribution, respectively. Finally, the GARCH (1, 1) model with GED distribution is selected according to the constraints of the GARCH model and the respective AIC values. The model results are shown below.

ISSN: 2472-3703 DOI: 10.6911/WSRJ.202006_6(6).0030

Mean equation: $$\begin{aligned} r_t &= 0.000075114 - 0.0274 r_{t-1} - 0.0092525 r_{t-2} - 0.0092155 r_{t-3} \\ &- 0.001539 r_{t-4} - 0.0353 r_{t-5} - 0.0356 r_{t-6} + a_t \end{aligned}$$

Variance equation: $\sigma_t^{2} = 0.000005561 + 0.1171 a_{t-1}^{2} + 0.8545 \sigma_{t-1}^{2}$

The initial fluctuation of the logarithmic rate of return sequence can be calculated $\sigma_0 = 0.014274$.At the same time, the standard deviation of the conditions in different periods can be obtained according to the above equation, and then substituted into the equation to obtain the absolute value of VaR in different periods under different confidence levels. With a confidence level of 99%, the average VaR is 0.030883.

(2) Construction Bank

According to the ACF (autocorrelation coefficient) graph and PACF (partial autocorrelation coefficient) graph of the CCB's logarithmic rate of return sequence, as well as the constraints of the ARCH model and the AIC values of different GARCH models that follow different distributions, select GARCH that follows the GED distribution (1, 1) The model. The model results are shown below.

Mean equation: $r_t = 4.1717 \times 10^{-8} + a_t$

Variance equation: $\sigma_t^{2} = 0.00000775 + 0.1134 a_{t-1}^{2} + 0.8516 \sigma_{t-1}^{2}$

The initial fluctuation of the logarithmic rate of return sequence can be calculated $\sigma_0 = 0.016175$.At the same time, the standard deviation of the conditions in different periods can be obtained according to the above equation, and then substituted into the equation to obtain the absolute value of VaR in different periods under different confidence levels. With a confidence level of 99%, the average VaR is 0.034238.

(3) Bank of China

According to the ACF (autocorrelation coefficient) graph and PACF (partial autocorrelation coefficient) graph of the Bank of China's logarithmic return series, the constraints of the ARCH model and the AIC values of different GARCH models that follow different distributions, choose GARCH (GARCH) 1, 1) The model. The model results are shown below.

Mean equation: $r_t = -3.9598 \times 10^{-10} + a_t$

Variance equation: $\sigma_t^{2} = 0.00000621 + 0.1120 a_{t-1}^{2} + 0.8440 \sigma_{t-1}^{2}$

The initial fluctuation of the logarithmic rate of return sequence can be calculated $\sigma_0 = 0.014646$.At the same time, the standard deviation of the conditions in different periods can be obtained according to the above equation, and then substituted into the equation to obtain the absolute value of VaR in different periods under different confidence levels. With a confidence level of 99%, the average VaR is 0.029547.

(4) Bank of Communications

According to the ACF (autocorrelation coefficient) graph and PACF (partial autocorrelation coefficient) graph of the Bank of Communications's logarithmic rate of return sequence, as well as the constraints of the ARCH model and the AIC values of different GARCH models that follow different distributions, select GARCH that follows the GED distribution (1, 1) The model. The model results are shown below.

Mean equation: $$\begin{aligned} r_t &= -0.000061171 - 0.0232 r_{t-1} - 0.0161 r_{t-2} \\ &- 0.0187 r_{t-3} - 0.0086934 r_{t-4} - 0.043 r_{t-5} + a_t \end{aligned}$$

Variance equation: $\sigma_t^{2} = 0.00000645 + 0.0836 a_{t-1}^{2} + 0.8816 \sigma_{t-1}^{2}$

ISSN: 2472-3703 DOI: 10.6911/WSRJ.202006_6(6).0030

The initial fluctuation of the logarithmic rate of return sequence can be calculated $\sigma_0 = 0.016578$.At the same time, the standard deviation of the conditions in different periods can be obtained according to the above equation, and then substituted into the equation to obtain the absolute value of VaR in different periods under different confidence levels. With a confidence level of 99%, the average VaR is 0.034445.

(5) ABC

According to the ACF (autocorrelation coefficient) graph and PACF (partial autocorrelation coefficient) graph of the ABC's logarithmic rate of return sequence, as well as the constraints of the ARCH model and the AIC values of different GARCH models that follow different distributions, select GARCH that follows the GED distribution (1, 1) The model. The model results are shown below.

Mean equation: $r_t = 1.9392 \times 10^{-7} + a_t$

Variance equation: $\sigma_t^{\ 2} = 0.00000337 + 0.0926 a_{t-1}^{\ 2} + 0.8874 \sigma_{t-1}^{\ 2}$

The initial fluctuation of the logarithmic rate of return sequence can be calculated $\sigma_0 = 0.014054$.At the same time, the standard deviation of the conditions in different periods can be obtained according to the above equation, and then substituted into the equation to obtain the absolute value of VaR in different periods under different confidence levels. With a confidence level of 99%, the average VaR is 0.029983.

(6) China Merchants Bank

According to the ACF (autocorrelation coefficient) graph and PACF (partial autocorrelation coefficient) graph of the China Merchants Bank's logarithmic rate of return sequence, as well as the constraints of the ARCH model and the AIC values of different GARCH models that follow different distributions, select GARCH that follows the GED distribution (1, 1) The model. The model results are shown below.

Mean equation: $r_t = -0.000157 - 0.0349 r_{t-1} - 0.0272 r_{t-5} - 0.0429 r_{t-6} + a_t$

Variance equation: $\sigma_t^{\ 2} = 0.00000365 + 0.0538 a_{t-1}^{\ 2} + 0.9354 \sigma_{t-1}^{\ 2}$

The initial fluctuation of the logarithmic rate of return sequence can be calculated $\sigma_0 = 0.017994$.At the same time, the standard deviation of the conditions in different periods can be obtained according to the above equation, and then substituted into the equation to obtain the absolute value of VaR in different periods under different confidence levels. With a confidence level of 99%, the average VaR is 0.041414.

(7) CITIC Bank

According to the ACF (autocorrelation coefficient) graph and PACF (partial autocorrelation coefficient) graph of the CITIC Bank's logarithmic rate of return sequence, as well as the constraints of the ARCH model and the AIC values of different GARCH models that follow different distributions, select GARCH that follows the GED distribution (1, 1) The model. The model results are shown below.

Mean equation: $$\begin{aligned} r_t &= -0.000558 - 0.0386 r_{t-1} - 0.0272 r_{t-2} - 0.0241 r_{t-3} \\ &- 0.0315 r_{t-4} - 0.0540 r_{t-5} - 0.0245 r_{t-6} + 0.0237 r_{t-7} + a_t \end{aligned}$$

Variance equation: $\sigma_t^{\ 2} = 0.00001245 + 0.1073 a_{t-1}^{\ 2} + 0.8604 \sigma_{t-1}^{\ 2}$

The initial fluctuation of the logarithmic rate of return sequence can be calculated $\sigma_0 = 0.020184$.At the same time, the standard deviation of the conditions in different periods can be obtained according to the above equation, and then substituted into the equation to

ISSN: 2472-3703 DOI: 10.6911/WSRJ.202006_6(6).0030

obtain the absolute value of VaR in different periods under different confidence levels. With a confidence level of 99%, the average VaR is 0.044814.

(8) Industrial Bank

According to the ACF (autocorrelation coefficient) graph and PACF (partial autocorrelation coefficient) graph of the Industrial Bank's logarithmic rate of return sequence, as well as the constraints of the ARCH model and the AIC values of different GARCH models that follow different distributions, select GARCH that follows the GED distribution (1, 1) The model. The model results are shown below.

Mean equation: $$r_t = -0.000227 - 0.0285 r_{t-1} - 0.0201 r_{t-2} - 0.0049653 r_{t-3} - 0.02 r_{t-4} - 0.0241 r_{t-5} - 0.0499 r_{t-6} + 0.0145 r_{t-7} + a_t$$

Variance equation: $\sigma_t^2 = 0.00000624 + 0.1285 a_{t-1}^2 + 0.8652 \sigma_{t-1}^2$

The initial fluctuation of the logarithmic rate of return sequence can be calculated $\sigma_0 = 0.02485$.At the same time, the standard deviation of the conditions in different periods can be obtained according to the above equation, and then substituted into the equation to obtain the absolute value of VaR in different periods under different confidence levels. With a confidence level of 99%, the average VaR is 0.047524.

(9) Shanghai Pudong Development Bank

According to the ACF (autocorrelation coefficient) graph and PACF (partial autocorrelation coefficient) graph of Shanghai Pudong Development Bank's logarithmic rate of return sequence, as well as the constraints of the ARCH model and the AIC values of different GARCH models that follow different distributions, select GARCH that follows the GED distribution (1, 1) The model. The model results are shown below.

Mean equation: $$r_t = -0.000217 - 0.0358 r_{t-1} - 0.003841 r_{t-2} - 0.003792 r_{t-3} - 0.0245 r_{t-4} - 0.0198 r_{t-5} - 0.0224 r_{t-6} + 0.0094552 r_{t-7} + a_t$$

Variance equation: $\sigma_t^2 = 0.00001907 + 0.1444 a_{t-1}^2 + 0.7924 \sigma_{t-1}^2$

The initial fluctuation of the logarithmic rate of return sequence can be calculated $\sigma_0 = 0.018918$.At the same time, the standard deviation of the conditions in different periods can be obtained according to the above equation, and then substituted into the equation to obtain the absolute value of VaR in different periods under different confidence levels. With a confidence level of 99%, the average VaR is 0.040895.

(10) Minsheng Bank

According to the ACF (autocorrelation coefficient) graph and PACF (partial autocorrelation coefficient) graph of Minsheng Bank's logarithmic rate of return sequence, as well as the constraints of the ARCH model and the AIC values of different GARCH models that follow different distributions, select GARCH that follows the GED distribution (1, 1) The model. The model results are shown below.

Mean equation: $$r_t = -0.000321 - 0.0221 r_{t-1} - 0.0177 r_{t-2} - 0.0248 r_{t-4} - 0.0233 r_{t-5} - 0.0047347 r_{t-6} + 0.0165 r_{t-7} - 0.0125 r_{t-8} + 0.0234 r_{t-9} + 0.0085 r_{t-11} - 0.0122 r_{t-12} - 0.02 r_{t-13} - 0.0272 r_{t-14} + a_t$$

Variance equation: $\sigma_t^2 = 0.00000631 + 0.1298 a_{t-1}^2 + 0.8536 \sigma_{t-1}^2$

The initial fluctuation of the logarithmic rate of return sequence can be calculated $\sigma_0 = 0.018276$.At the same time, the standard deviation of the conditions in different periods can be obtained according to the above equation, and then substituted into the equation to

ISSN: 2472-3703 DOI: 10.6911/WSRJ.202006_6(6).0030

obtain the absolute value of VaR in different periods under different confidence levels. With a confidence level of 99%, the average VaR is 0.039489.

(11) HSBC Bank

According to the ACF (autocorrelation coefficient) graph and PACF (partial autocorrelation coefficient) graph of HSBC Bank's logarithmic rate of return sequence, as well as the constraints of the ARCH model and the AIC values of different GARCH models that follow different distributions, select GARCH that follows the GED distribution (1, 1) The model. The model results are shown below.

Mean equation: $$r_t = -0.000362 - 0.0594 r_{t-1} - 0.0065323 r_{t-2} - 0.0117 r_{t-3} - 0.025 r_{t-4} - 0.0657 r_{t-5} - 0.0623 r_{t-6} + a_t$$

Variance equation: $\sigma_t^2 = 0.0000061 + 0.1048 a_{t-1}^2 + 0.8831 \sigma_{t-1}^2$

The initial fluctuation of the logarithmic rate of return sequence can be calculated $\sigma_0 = 0.020765$.At the same time, the standard deviation of the conditions in different periods can be obtained according to the above equation, and then substituted into the equation to obtain the absolute value of VaR in different periods under different confidence levels. With a confidence level of 99%, the average VaR is 0.044868.

(12) Ping An Bank

According to the ACF (autocorrelation coefficient) graph and PACF (partial autocorrelation coefficient) graph of Ping An Bank's logarithmic rate of return sequence, as well as the constraints of the ARCH model and the AIC values of different GARCH models that follow different distributions, select GARCH that follows the GED distribution (1, 1) The model. The model results are shown below.

Mean equation: $r_t = -0.000107 - 0.03841 r_{t-5} - 0.063 r_{t-6} + 0.076 r_{t-9} + a_t$

Variance equation: $\sigma_t^2 = 0.000061445 + 0.1999 a_{t-1}^2 + 0.6997 \sigma_{t-1}^2$

The initial fluctuation of the logarithmic rate of return sequence can be calculated $\sigma_0 = 0.024817$.At the same time, the standard deviation of the conditions in different periods can be obtained according to the above equation, and then substituted into the equation to obtain the absolute value of VaR in different periods under different confidence levels. With a confidence level of 99%, the average VaR is 0.053370.

(13) China Everbright Bank

According to the ACF (autocorrelation coefficient) graph and PACF (partial autocorrelation coefficient) graph of China Everbright Bank's logarithmic rate of return sequence, as well as the constraints of the ARCH model and the AIC values of different GARCH models that follow different distributions, select GARCH that follows the GED distribution (1, 1) The model. The model results are shown below.

Mean equation: $r_t = -3.2177 \times 10^{-8} + a_t$

Variance equation: $\sigma_t^2 = 0.00000653 + 0.1104 a_{t-1}^2 + 0.8671 \sigma_{t-1}^2$

The initial fluctuation of the logarithmic rate of return sequence can be calculated $\sigma_0 = 0.017931$.At the same time, the standard deviation of the conditions in different periods can be obtained according to the above equation, and then substituted into the equation to obtain the absolute value of VaR in different periods under different confidence levels. With a confidence level of 99%, the average VaR is 0.038355.

(14) Bank of Nanjing

ISSN: 2472-3703 DOI: 10.6911/WSRJ.202006_6(6).0030

According to the ACF (autocorrelation coefficient) graph and PACF (partial autocorrelation coefficient) graph of Bank of Nanjing's logarithmic rate of return sequence, as well as the constraints of the ARCH model and the AIC values of different GARCH models that follow different distributions, select GARCH that follows the GED distribution (1, 1) The model. The model results are shown below.

Mean equation: $$r_t = -0.000044438 - 0.0543r_{t-1} - 0.0218r_{t-2} - 0.0056214r_{t-3} - 0.0116r_{t-4} - 0.0331r_{t-5} - 0.0070923r_{t-6} + a_t$$

Variance equation: $\sigma_t{}^2 = 0.00003019 + 0.1309 a_{t-1}{}^2 + 0.7954 \sigma_{t-1}{}^2$

The initial fluctuation of the logarithmic rate of return sequence can be calculated $\sigma_0 = 0.024846$.At the same time, the standard deviation of the conditions in different periods can be obtained according to the above equation, and then substituted into the equation to obtain the absolute value of VaR in different periods under different confidence levels. With a confidence level of 99%, the average VaR is 0.048552.

(15) Bank of Beijing

According to the ACF (autocorrelation coefficient) graph and PACF (partial autocorrelation coefficient) graph of Bank of Beijing's logarithmic rate of return sequence, as well as the constraints of the ARCH model and the AIC values of different GARCH models that follow different distributions, select GARCH that follows the GED distribution (1, 1) The model. The model results are shown below.

Mean equation: $$r_t = -0.0348r_{t-1} - 0.012r_{t-2} + 0.0116r_{t-3} - 0.0109r_{t-4} - 0.0251r_{t-5} + 0.0048754r_{t-6} + 0.038r_{t-7} + a_t$$

Variance equation: $\sigma_t{}^2 = 0.00002031 + 0.17 a_{t-1}{}^2 + 0.7609 \sigma_{t-1}{}^2$

The initial fluctuation of the logarithmic rate of return sequence can be calculated $\sigma_0 = 0.019623$.At the same time, the standard deviation of the conditions in different periods can be obtained according to the above equation, and then substituted into the equation to obtain the absolute value of VaR in different periods under different confidence levels. With a confidence level of 99%, the average VaR is 0.040869.

(16) Bank of Ningbo

According to the ACF (autocorrelation coefficient) graph and PACF (partial autocorrelation coefficient) graph of Bank of Ningbo's logarithmic rate of return sequence, as well as the constraints of the ARCH model and the AIC values of different GARCH models that follow different distributions, select GARCH that follows the GED distribution (1, 1) The model. The model results are shown below.

Mean equation: $$r_t = 0.000121 - 0.0529r_{t-1} - 0.0549r_{t-2} - 0.0216r_{t-3} - 0.0651r_{t-4} - 0.0635r_{t-5} - 0.051r_{t-6} + a_t$$

Variance equation: $\sigma_t{}^2 = 0.00001242 + 0.0633 a_{t-1}{}^2 + 0.9086 \sigma_{t-1}{}^2$

The initial fluctuation of the logarithmic rate of return sequence can be calculated $\sigma_0 = 0.022375$.At the same time, the standard deviation of the conditions in different periods can be obtained according to the above equation, and then substituted into the equation to obtain the absolute value of VaR in different periods under different confidence levels. With a confidence level of 99%, the average VaR is 0.050007.

In summary, the maximum value, minimum value, average value and ranking order of VaR of different banks in different periods under 99% confidence are shown in Table 4.

ISSN: 2472-3703 DOI: 10.6911/WSRJ.202006_6(6).0030

Table 4. VaR values ($\times 10^{-2}$)

Bank	VaR maximum	VaR minimum	VaR mean	VaR mean ranking
ICBC	12.9544	1.6541	3.0883	14
Construction Bank	14.5560	1.8073	3.4238	13
Bank of China	14.7403	1.6817	2.9547	16
Bank of Communications	13.0254	1.9916	3.4445	12
ABC	11.0487	1.5118	2.9983	15
China Merchants Bank	10.2627	2.3038	4.1414	7
CITIC Bank	14.4963	2.4733	4.4814	6
Industrial Bank	54.1179	1.8837	4.7524	4
Shanghai Pudong Development Bank	25.2127	2.3699	4.0895	8
Minsheng Bank	17.2870	1.7663	3.9489	10
HSBC Bank	27.2064	2.0335	4.4868	5
Ping An Bank	59.4279	3.4814	5.3370	1
China Everbright Bank	13.5013	1.9079	3.8355	11
Bank of Nanjing	53.2142	3.0316	4.8552	3
Bank of Beijing	21.2413	2.2695	4.0869	9
Bank of Ningbo	18.9579	2.9519	5.0007	2

From Table 4, it can be obtained that with a 99% confidence level, the average VaR of the three types of commercial banks ranges from small to state-owned commercial banks, joint-stock commercial banks, and urban commercial banks. That is to say, the average VaR of the state-owned commercial banks is the smallest, and its stability is the best, that is, the ability to deal with its own risks is the best. Although the average value of VaR of Ping An Bank ranks first among all banks in the joint-stock commercial banks, the stability is poor. However, the average VaR of these banks is in the middle, and their robustness is also in the middle of the three types of commercial banks. In addition to the Bank of Beijing's VaR, which ranks 9th and has a good degree of stability, the other two banks in the city commercial banks are less stable. The overall stability of this type of commercial banks is poor, that is, their ability to deal with their own risks is weak. Similarly, in the maximum value of VaR, Industrial Bank, Bank of Nanjing and Ping An Bank are significantly larger than other banks, and the logarithmic yield sequence peak of these three banks is also significantly larger than other banks. Therefore, it can be seen from the side that the VaR value estimated in this paper has a greater degree of credibility.

4. CONCLUSION

VaR considers the maximum possible loss of a financial institution in a certain period of time under a certain probability level, which provides a reference for the risk management of financial institutions to a certain extent. The following conclusions can be drawn from the above results:

(1) The logarithmic yield data of 16 listed commercial banks in China generally have the phenomenon of "spikes and thick tails" possessed by financial time series. Among them, Industrial Bank, Ping An Bank and Bank of Nanjing performed the most. The "peak and thick tail" phenomenon of state-owned commercial banks among all banks was relatively slight. In addition, these 16 commercial banks all exhibited a volatility aggregation effect. Large fluctuations often followed large fluctuations, and small fluctuations followed small fluctuations.

(2) In the maximum VaR and the average VaR, Industrial Bank, Bank of Ningbo, Bank of Nanjing and Ping An Bank are significantly larger than other banks, and the logarithmic return sequence peak of these three banks is also significantly larger than other banks. This shows that the risks of these four banks are the greatest to some extent.

(3) VaR indicates the robustness of the organization, that is, its ability to handle its own risks. On average, among the three types of commercial banks, state-owned commercial banks have the smallest risk value, followed by joint-stock commercial banks, and urban commercial banks have the largest. And because the Bank of Communications has carried out mixed ownership reforms, this has made the Bank's VaR value the largest among the five state-owned commercial banks.

REFERENCES

[1] X. Zhang (2016). Research on Financial Risk Measurement Based on VaR and CVaR. Technology and Management, vol.18, no.4, p.62-68.

[2] T.S. Beder(1995). VAR:Seductive but Dangerous. Financial Analysts Journal, vol.51, no.5, p.12-24.

[3] P.T. Kupiec(1995). Techniques for verifying the accuracy of risk measurement models.The Journal of Derivatives, vol.3, no.2, p.73-84.

[4] P.R. Jorion(1996). Risk:measuring the risk in Value at Risk.Financial Analysts Journal, vol.52, no.6, p.47-56.

[5] M. Billio and L.Pelizzon(2000). Value-at-Risk:a multivariate switching regime approach.Journal of Empirical Finance, vol.7, no.5, p.531-554.

[6] W.T. Zheng (1997). VaR method of financial risk management and its application. International Finance Research, vol.9, p.58-62.

[7] N.K. Gu (1998). VaR: a new tool for market risk measurement and management. Guangdong Finance, vol.1, p.9-10.

[8] G. Yao (1998). Analysis on the Method of Measuring the Risk Value. Economic Science, vol.8, no.1, p.55-60.

[9] Y.F. Liu (1999). VaR model and its application in financial supervision. Economic Science, vol.6, no.1, p.39-50.

[10] G.Q. Dai, L.B. Xu and R. Lu (2000). Reference and Application of VaR Method to Chinese Financial Risk Management. Financial Research, vol.7, p.45-51.

[11] H.T. Du (2000). Application of VaR model in securities risk management. Securities Market Herald, vol.8, p.57-61.

[12] Y. Fan (2000). The VaR method and its application in stock market risk analysis. China Management Science, vol.3, no.5, p.26-32.

[13] M.J. Wang and H. Wang (2002). Risk Analysis of Shanghai Stock Market Based on GARCH-t. Quantitative Economic Technical Economic Research, vol.28, no.3, p.106-109.

[14] S. Jin and L. Liu (2011). The Application of GARCH Model in the Measurement of Financial Risk——Taking the Shanghai and Shenzhen Index from 2005 to 2010 as an Example. Finance Teaching and Research, vol.3, p.55-58.

[15] S.D. Chen and S.D. Yu (2002). Analysis of Chinese Stock Market Based on VaR Method of GARCH Model. Journal of Social Science of Jilin University, vol.2, no.4, p.11-17.

[16] Q.F. Xu, J.X. Zhang and C.X. Jiang (2014). Multi-stage VaR measurement based on support vector quantile regression.Journal of Systems Engineering, vol.29, no.2, p.202-214.

ISSN: 2472-3703 DOI: 10.6911/WSRJ.202006_6(6).0030

[17] X.Q. Liu and Y. Zhou (2015). Application of Weighted Compound Quantile Regression Method in Dynamic VaR Risk Measurement.Chinese Management Science, vol.23, no.6, p.1-8.