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Abstract: Interest rate guides financial resources to effectively flow and allocate, which prompt economic structure adjusting and economic development. Risk-measurement of interest rate is the basis of the risk management. Thus, accurately measuring interest rate risk is extremely significant. Based on the inter-bank bond repurchase rate as the target, this paper uses value at risk (VAR) to quantify interest rate risk, and use adjusted-historical simulation to compute VAR. Finally failure rate is applied to verify the validity of VAR. The result shows that VAR can effectively measure interest rate risk and restrains the possible highest fluctuation of interest rate, real change of repurchase rate has a greater influence on the fluctuation of VAR. VAR can help risk manager forecast the trend of interest rate and avoid the risk by derivative instruments of interest rate.

Key Words: Interest rate risk, VAR, Adjusted-historical simulation

1. INTRODUCTION

Steady progress being made in interest rate marketization is an important content of China's financial reform. The sequence of Interest rate marketization is from money market and bond market to the deposit and lending interest rate; the people's bank made a decision that interbank lending market interest rates determined by the market capital supply and demand independently on June 1, 1996, which marked the marketization of interest rate took a pioneering step; and the inter-bank bond repurchase rate also got freedom On June 5, 1997. With the interest rate marketization pushing on, the extent and frequency of interest rate changing are increasingly violent, which brought the huge challenge to commercial banks in the operation and profit pattern. Microcosmic enterprises confront with the difficult choice of financing approach and structure. In the market system, up and down of basic interest rate mirrors circumstances of the supply and demand of capital, which is an indicator of economy. So it is necessary to quantify risk and forecast volatility to interest rate.

In 1993, G30 report firstly introduces VAR to quantify financial market risk, then VAR becomes a prevail method on international. VAR is the highest loss in market value over a given time period, such as one day or two weeks, that is exceeded with a small probability, such as 1%.VaR makes use of a simple and direct number to describe interest rate risk, which helps risk manager sufficiently understand and better manage risk. Thus, the paper uses VAR to measure the interest rate risk.

The paper is structured as follows. Section 2 reviews the existing literature. Section 3 describes the methodology and the data used. Section 4 presents the empirical results of VAR. Section 5 is the conclusions.

2. LITERATURE REVIEW

Interest rate risk refers to the change of price of financial instruments caused by interest rate volatility, and the uncertainty of the benefits to investors. The main methods of measuring interest rate risk are sensitive gap analysis, duration and convexity model, option adjust spreads(OAS) and VAR. Flannery &James and Meyer Selhansen constructed an model of gap analysis[1]; Zhou Yu and Jia Zhen & Ma Jie through comparative analysis, got conclusions that the advantages of sensitive gap analysis are easy to find the source of interest rate

risk, to operate and have simple model, the disadvantages are static analysis and ignores the time value of money [2][3]. Yang Wenhan put forward modified duration [4]; Chen Zugong & Cha Qifeng used duration model to measure interest rate risk, which is caused by mismatching structure of commercial bank assets and liabilities [5]. Duration only fit to analysis slight volatility of interest rate, when interest rate updates, duration underestimate the downward of bond price, and vice versa. So, convexity replaces duration to measure interest rate risk. When duration measures interest rate risk, one of assumption is that future discounted cash flows are fixed. However, for those embedded options bonds, OAS is an alternative method to measure interest rate risk. Based on convexity model, Wang Chunfeng & Zhang Wei researched problems of the bank's interest rate risk management under the implied options and concluded that convexity model adjusted by options effectively has measured the interest rate risk[6]; Yi Chuanhe & Liu Lian supported an idea that OAS is a compensation of options risk implied financial instruments[7]. OAS is difficult to develop a unified industrial standard in practical. VAR method to measure interest rate risk is a tried new method based on the above several kinds of the defects. Huang Hai & Lu Zudi elaborated three main methods of calculating VAR --parameters, historical simulation and Monte Carlo simulation, discussed their advantages and disadvantages [8]; Wang Beiqi applied VAR-GARCH model to risk management of stock index futures [9]; Song Yan & Xu Maoyuan used Monte Carlo simulation to analyze risk of loan interest rate marketization in our country [10]; Yang Shoulong employed the family of GARCH model for evaluating interest rate risk of commercial bank [11].

By comprehensive consideration, VAR uses numbers to reflect interest rate risk, which not only measures interest rate risk of a single asset, but also portfolio.

3. METHODLOGY AND DATA

Historical simulation (HS) is a typical no-parameter model and overcomes the disadvantage of parameter and semi- parameter model, which is assumption of return distributions, such as normal distribution and so on. HS compute VAR through the actual distribution, however, traditional HS doesn't consider the influence of volatility, and various observations endow uniform weight. All these aren't accurately describe and forecast the fluctuations of interest rate. This paper adjusts the HS from volatility and weight perspective and use failure rate to verify the validity of VAR.

A basic assumption of using HS is that the future is the continuation of history. HS forecast the possible degree of interest rate by scenario simulation, then calculate VAR. Specific steps as follows [12]:

Firstly, mark the scenarios i ; compute the change of interest rate, indicator Δr_i ; use exponential weighted moving average model compute the variance and volatility, which can respectively be written as

$$\sigma_i^2 = (1-\lambda) * \sigma_{i-1}^2 + \lambda * (\Delta r_{i-1})^2 \qquad (3.1)$$

$$\sigma_i = \sqrt{\sigma_i^2} \qquad (3.2)$$

Where λ equals to 0.97, when i equals to 1, then σ_0 is given by

$$\sigma_0^2 = \sum_{i=1}^{n} (\Delta r_i)^2 \Big/ n \qquad (3.3)$$

The weight of observations presents exponential decline, which according to

$$w_i = \lambda^{n-i} * (1-\lambda) \Big/ (1-\lambda^n) \qquad (3.4)$$

Where λ equals to 0.99, and illustrate the speed of exponential decline.

Secondly, forecast the fluctuation of interest rate for each scenario, indicator Δr_i can be written as

$$\Delta r_i = \Delta r_n * \sigma_i / \sigma_n \qquad (3.5)$$

fidence level, the corresponding Δr_i is VAR, otherwise, use linear interpolation to get VAR.

Inter-bank bond market has vast preponderances, such as abundant participants, active trading, strong liquidity, relatively reasonable term structure of bond, and price can more accurately reflect market supply and demand of funds. Because pledged repo trading is the largest, the paper selects pledged repo rates as sample [13], takes the seven-day repo rate data between "11/1/2011" and "11/28/2013" from China money. Eviews6.0 and Excel are used to analyze the data.

4. RESULTS OF INTEREST RATE RISK VAR

4.1 Descriptive analysis

The feature of pledged repo rates is showed as figure 1, figure 2, and table 1. It is concluded that repo rates present strong volatility-clustering, namely, the volatility is high in some time, and shows low in other time. Skewness equals to 2.435, which is more than zero. Kurtosis is 12.825 and surpasses 3.Jarque-Bera equals to 2610.393, all which show that rate distribution submits to right- skewness and high- kurtosis, belong to typical sharp peak and heavy tail, not normal distribution.

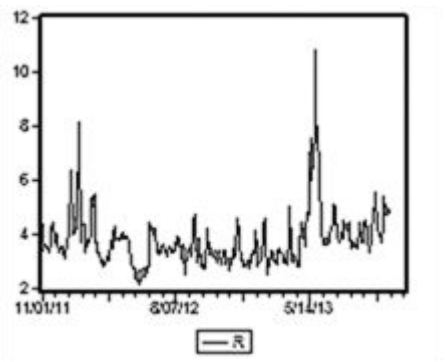

Figure 1. Time series of

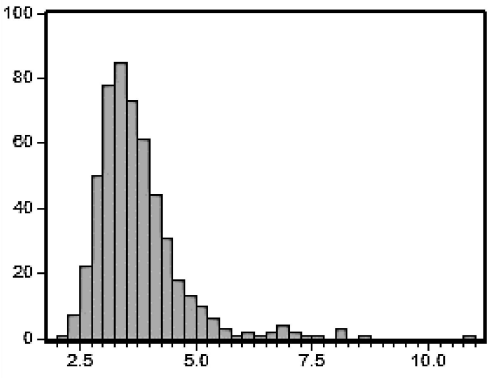

Figure 2. Frequency histogram

Table 1. Descriptive statistics

	Mean	Median	Std.	Skewness	Kurtosis	Jarque-Bera	p
r	3.739	3.541	0.955	2.435	12.825	2610.393	0.00

4.2 Empirical results

The process of interest rate VAR on November 1, 2013 is showed as table 2, and the rest can be done in the same manner and listed in table 3.

Table 2. Interest rate VAR on November 1, 2013

Scenario	410	411	56	57	45	58	80	403	404	413	249	417
forecast	-11.19	-4.972	-3.981	-3.089	-2.985	-2.534	-1.528	-1.196	-1.123	-1.012	-0.998	-0.918
weight	0.0041	0.0041	0.0001	0.0001	0.0001	0.0001	0.0001	0.0038	0.0038	0.0042	0.0008	0.0044
cumulative weight	0.0041	0.0082	0.0083	0.0084	0.0085	0.0086	0.0088	0.0126	0.0164	0.0206	0.0214	0.0258
VAR												-0.9325

Interest rate VAR is equivalent to -0.9325, which means that the probability of seven-day repo rates downward exceeding 9.325 basic-points is 5%. The actual fluctuation of repo rates is -0.414, namely it declines 4.14 basic-points.

Figure 3 and table 3 reflect the rest rate risk information. It is obvious that VAR and real interest rate fluctuation are consistent initially by and large, however, as time goes, the difference between them is increasing. The real interest rate curve is flat, while VAR curve relatively is sensitive. In other words, the volatility of VAR is more than the real interest rate. When repo rate changes slightly, the volatility of VAR is severe, which accord with the feature of volatility clustering. Meanwhile, VAR always surpasses real change, which conformed to the definition of VAR. VAR is extremely sensitive to the real change of interest rate.

Figure 3. Real change and VAR

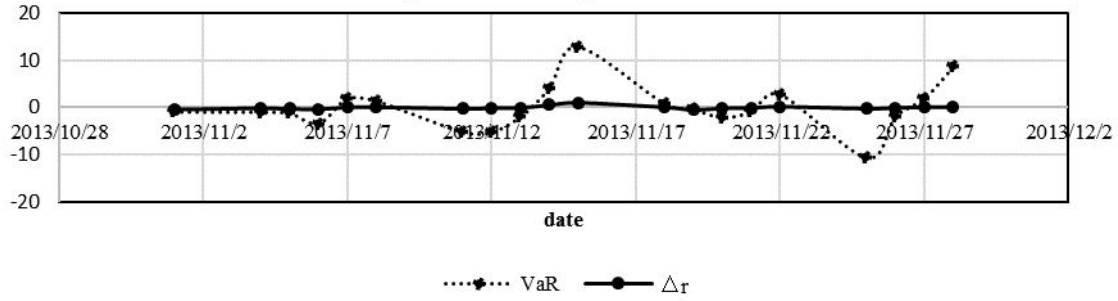

Table 3. VAR of interest rate risk

date	2014/11/1	2014/11/4	2013/11/5	2013/11/6	2013/11/7	2013/11/8	2013/11/11
Δr	-0.414	-0.126	-0.27	-0.36	0.07	0.09	-0.24
VAR	-0.9325	-1.0029	-1.1999	-3.4662	1.8459	1.3646	-5.2095
date	2013/11/12	2013/11/13	2013/11/14	2013/11/15	2013/11/18	2013/11/19	2013/11/20
Δr	-0.11	-0.03	0.57	1.07	0.1	-0.5	-0.13
VAR	-5.3019	-1.9941	4.0319	12.9283	0.8129	-0.4261	-2.1404
date	2013/11/21	2013/11/22	2013/11/25	2013/11/26	2013/11/27	2013/11/28	
Δr	-0.03	0.22	-0.22	-0.03	0.09	0.11	
VAR	-0.8793	2.7973	-10.733	-1.9544	1.9105	8.6412	

Failure rate is used to verify the validity of VAR. In 20 trading day, there was only one day that real fluctuation exceeded VAR. Failure rate equals to 5% which is consistent with significant level. All this demonstrate that VAR quantifying the interest rate risk is effective.

5. CONCLUSIONS

The fluctuation of interest rate has an effect on the transform between savings and investments, influences the development of economy. The paper uses VAR to measure the interest rate risk, and makes use of adjusted-historical simulation computing VAR. It is concluded that VAR is extremely sensitive to the real change of interest rate, and effectively restrains possible the highest extent of interest rate. The basic rate is object of reference for other kinds of rates, which keep a close watch on it and change.

The enlightenment to us is that in some extreme cases, VAR overestimates the interest rate risk, while in other cases, VAR underestimates the interest rate risk, all which perhaps lead to erroneous decisions. So, we must use like extreme value theory to analyze and measure the interest rate risk for extreme cases.

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