The Engineering of China Commercial Bank Operational Risk Measurement

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Abstract

Drawing specific reserve separately for operational risk is the requirement of the New Basel Capital Accord. Since 1990, as serious loss incidents in operation risk often happened all over the world, operational risk is taken account into the risk management framework for the first time in New Basel Capital Accord, becoming the three main risk get along with credit risk and market risk that bank may take. In the paper, the data of Chinese commercial bank operational risk is analyzed by Monte Carlo simulation empirically. Research shows that China commercial bank should allocate 15 billion capital for its operational risk, capital reserve fund rate is about 4.79%.

Keywords: Operational risk; Engineering of capital measurement; Monte Carlo simulation

1. Introduction

Operational risk is one of important issues in commercial bank operation, which means unexpected loss resulted from inaccurate operation of staff, failure of system, inadequate control and procedure, unauthorized activity or external event. In some business, operational risk is more important than credit risk and market risk. Many banks in the world don’t allocate any capital for operational risk, this also happens in China commercial banks. The reason is not that operational risk is not important, but that we don’t know how to measure and manage operational risk. One article of Euro Money in December 1996 once said “Banks measure credit risk and market risk and allocate capital for them. The reason is not that credit risk and market risk is the biggest risk they face but that they can do. In fact, operational risk is more important, more dangerous, but no one knows exactly how to deal with it.”[1] As a result, Basel committee decided to include operational risk in the capital allocation framework. The measurement of the operational risk is the process of quantification of operational risk. At present, domestic article such as L.Zhang [2] and C.Fan [3] mainly focus on studying the quantification of the operational risk of single commercial bank, and the main method is the basic indicator approach and the income model method. Basing on the research of scholars [4-8], the paper tries to study the overall operational risk of commercial bank industry. The loss amount of operational risk of the whole commercial bank industry is estimated with Monte Carlo simulation.
2. The capital for commercial bank operational risk

Risk capital, also known as economic capital, is the capital that company or organization use to prevent or ease the nonpayment crisis caused by unexpected loss [9]. The economic capital for operational risk means to prevent the payment difficulty caused by operational risk loss. Economic capital is calculated according to the risk level of commercial bank capital. The premise of calculating the economic capital is that bank must quantitative the risk. Similarly, allocating the capital for operational risk is also based on the quantitative of operational risk. This is the most difficult problem in the management of operational risk.

3. The approach of measurement of capital for operational risk

Three methods of measurement of capital for operational risk are provided in the new Basel Capital. They are the basic indicator approach, standardized approach and advanced measurement approach respectively. Among them, (1) basic indicator approach: capital requirement is equal to a fixed ratio of gross activity indicator such as overall income. (2) standardized approach: use the basic indicator approach for every product line, then sum up and get the capital requirement for operational risk. (3) advanced measurement approach: it includes internal measurement approach, loss distribution approach and scorecard method. Internal measurement approach: use internal loss data to estimate probability of loss event (PE) of combination of different types of product line, the loss generated from expected risk (LGE). Multiply PE, LGE and risk exposure indicator EI to get the expected loss. And multiply expected loss and a fixed ratio and get capital requirement. Loss distribution: use the data of risk loss to simulate its frequency and loss amount and get the specific probability distribution. Calculate VaR, and sum up to get capital requirement. Scorecard method: use loss data and forward-looking risk indicator to assess the risk and measure the relative level of risk [10].

4. The approach of measurement of capital for operational risk that this paper used

Every method measuring operational risk has advantage and disadvantage. Data about the operational risk event are not sufficient, therefore operational risk can only be estimated. The aim of estimation is to determine reserve for operational risk. Operational risk has the character of low frequency, broad range of loss amount distribution and heavy tail. It is difficult to directly use some traditional parameter or non-parameter estimating method. To overcome the lack of data and based on the research experience of other scholars, this paper uses Monte Carlo simulation to calculate the capital for operational risk.

Monte Carlo simulation, also known as statistic test method, is a method using the statistic value to calculate parameters in the random process. It is too complex to formulate a precise mathematical model with character of high reliability when the stability of every unit in this system is known. Then this method will approximate the expected value of the system reliability. With the increase in simulation times, its accuracy is also expected to gradually increase. The empirical analysis will directly use Monte Carlo simulation.

Monte Carlo simulation to measure the risk capital of our commercial banks has two advantages: (1) we can overcome the disadvantage of lack of data, and get more precise data with simulation. (2) because the result of Monte Carlo simulation is the distribution of loss amount of operational risk, we can easily get the quartile at different level from the distribution, and then use the frame of VaR to measure the risk of commercial banking.

5. The measurement of China commercial bank operational risk the research data and description
Because inside data of commercial bank operational risk loss are not available for us, we try our best to collect information about commercial bank operational risk loss from the media and academic papers [12]. And we finally get 443 loss events involving 13 commercial banks, including ICBC, CCB, CB, ABC and so on. The time span is from 2000 to 2009, and the maximum loss to the bank is 2.19 billion yuan, while the minimum is 6 yuan. In every loss, we record the time and the type of the loss event, the amount of loss and the business sector. We refer our classification of loss events to the 7 categories of operational risk defined by Basel committee.

5.1 The idea and the method of Monte Carlo simulation

1) The basic idea of measurement of capital for operational risk with Monte Carlo simulation

Two properties of operational risk are the frequency of loss events and the amount of the loss. If the frequency of our country commercial bank loss risk events and the amount of loss are known every year, then the total amount of loss caused by operational risk is available. Assuming that frequency and statistical distribution of amount of loss do not change in short term, then the historical data about the distribution loss, the joint distribution function and the future loss of operational risk are available. This is the basic idea of measurement of capital for operational risk with Monte Carlo simulation.

2) Steps of measurement of capital for operational risk with Monte Carlo simulation

Step 1. The 184 operational risk events with loss data in the 443 events from 2000 to 2009 are used in this paper as our sample. The key statistics include the name of the commercial bank, the occurrence time of the operational risk events and the amount of loss and the type of risk events.

Step 2. Assuming that frequency of loss event and loss amount obey the known distribution function, then the parameters in the distribution function can be estimated. That is, we simulate the frequency of operational risk loss event and the amount of loss with the software Matlab7.8.

Step 3. After we get the loss event frequency distribution function, we carry out the simulation n times, then we get n random numbers which conform with the distribution function, \( Q_1, Q_2, \ldots, Q_n \).

Step 4. Assuming that the \( Q \) values \( Q_1 \), that is, operational risk loss event maybe happen \( Q_1 \) times over the period. So we can simulate the amount of loss \( Q_1 \) times, then we get \( Q_1 \) loss amount: \( L_1, L_2, \ldots, L_{Q1} \), they represent every loss amounts over the period.

Step 5. Sum up the \( Q_1 \) loss amounts, a possible value of the operational risk is available.

\[
L = \sum_{i=1}^{Q_1} L_i
\]

Step 6. Repeat step 4 and step 5 5000 times. And we get 5000 possible values of the operational risk.

Step 7. The distribution of the operational risk is available with the 5000 possible values.

Step 8. The value of operational risk is determined by value of VaR model.

5.2 The measurement of our commercial bank’s operational risk with Monte Carlo simulation

1) Preliminary statistic of operational risk events

The histograms of the frequency and the loss amount of the operational risk events have been draw for readers’ understanding of the operational risk events.
From Figure 1, the earliest event happened in 2000, and the latest happened in 2009. The number of operational risk events between 2007 and 2009 is very small compared with the data from 2000 to 2006. The reason is that the disclosure of operational risk events have certain time lag and they may be disclosed after several years since they have happened. So there must be else operational risk events between 2007 and 2009. They are just not disclosed now.

Because the amplitude of loss amount is relatively large, if we directly estimate its probability distribution, the effect may be less than ideal. According to the experiences and convenient of previous researchers [11-12], we take the amount of loss on the base 10 logarithm, then we consider the possible distribution of the logarithm of loss amount. Figure 2 is the histogram of the logarithm of loss amount.

2) Simulate the possible distribution of loss event frequency

After we have intuitive understanding of the histogram of the distribution of operational risk loss event frequency, this paper uses engineering software Matlab 7.8 to simulate their possible distribution function. Distribution result is recorded under every Matlab default distribution model. Then the goodness of fit of these distributions are tested with Kolmogorov-Smirnov test approach (K-S test for short) and the distribution is chosen with the best goodness of fit.

For the simulation of possibility distribution of loss event frequency, there are exponential distribution, gamma distribution, generalized extreme value distribution, lognormal distribution, weibull distribution, Nakagami distribution (also known as the m distribution), negative binominal distribution, Rayleigh distribution, Rice distribution and the log-logistic distribution. The software calculates parameters of all the distributions respectively, and we use “ks test” order to carry out the K-S test for each distribution, and the result is that H equals 0, that is, the data is consist with the original hypothesis of exponential distribution, P equals 0.93, therefore, exponential distribution is selected as the possible distribution of loss event frequency.

The distribution function of exponential distribution is just as follow:

\[
F(x) = \begin{cases} 
1 - e^{-\lambda x} & x > 0 \\
0 & x \leq 0 
\end{cases} \quad (2)
\]

The result of the simulation shows that the parameter \( \lambda \) of exponential distribution is 18.4.
3) Simulate the possible distribution of loss amount
   
   It’s the same as the approach of simulating the possibility distribution of operational risk frequency, at first, calculate the parameters of the distribution that Matlab provided, then carry out the K-S test. For simulation of possibility density distribution of loss amount, the Matlab provided extreme value distribution, generalized extreme value distribution, normal distribution, logistic distribution and t distribution. The K-S tests show that only the generalized extreme value distribution passed the test, return value of H is 0, and P is 0.859. Therefore we take generalized extreme value distribution as the possibility distribution of operational risk loss amount.

   The distribution function of generalized extreme value distribution is as follow:
   \[ G(x) = \exp \left\{-\exp \left[1 + \gamma \left(\frac{x - \mu}{\sigma} \right)^\gamma\right]\right\} \]  
   \[ (3) \]

   The result of simulation shows that \( \gamma = -0.43, \mu = 1.70, \sigma = 2.17 \)

4) Simulation
   
   After the possibility density distribution of loss event frequency and loss amount are carried out, the simulation can be done. The specific approach is as follow:
   
   So i takes 1-5000 \( \{(\text{simulation time. The i indicates some year in the future. Each calculation produces the number of loss events in i year. Make } n = \text{round (NumOperation(i))}, \text{that is, value the number of loss event in the year we calculated. Then j takes 1-n. Then we carry out the loss amount Loss that is consistent with generalized extreme value distribution for each loss event, then we sum up all the Losses and we can get a Total Loss, that is total amount of loss that caused by the operational risk in the year. We calculate 5000 times, then we get 5000 operational risk loss amount. Graph 1-5 shows the distribution of the total loss amount.}

   \[ \text{Graph 1-5 shows the distribution of the total loss amount.} \]
At the same time, some very important statistic data is gained from the result of the simulation: the average value of loss amount is 38.151 million yuan, the standard deviation is 3904.8 million yuan. For the convenience of calculation, we take the average value on logarithm, the multiply the values under different points digits and we finally get the value of VaR. If the point digit is 90%, the loss amount is 362.0838 million yuan. If the point digit is 99%, the loss amount is 628.5433 million yuan. The maximum of operational risk loss is 1.5162020 billion yuan.

5) Capital measurement of the operational risk

Operational risk loss can be classified into three kinds: expected loss, unexpected loss and catastrophic loss. Operational risk management should be strengthened in the daily operation and operational risk reserve should be drawn to guard against the expected loss. Because commercial bank can’t estimate or anticipate the catastrophic loss, they use insurance and release technology to handle this problem. For the unexpected loss, the commercial bank should draw specific operational risk capital. From the result of the simulation, the operational risk capital that China commercial bank should draw is 1.5162020 billion yuan minus 38.151 million yuan equals 1.4780510 billion yuan, that is about 1.5 billion yuan. It is about 4.79% of the total loss amount (31.3 billion yuan) in the 10 years. So commercial bank should draw 4.79% of its capital to guard against the operational risk loss.

6. Conclusion

This paper shows that China commercial bank should draw 1.5 billion yuan for operational risk and the capital rate is 4.97%. Because the authority data is unavailable, the result of capital measurement engineering is not very precise. A precise operational risk loss event data base needs to be constructed, then deeper study can be insured.

References