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The Measurement of Operational Risk Based on CVaR: a Decision Engineering Technique

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Abstract

In recent years, operational risks in Decision Engineering attract so much attention from the bank industry that Basel Committee includes it in the risk capital and considers it as a part of inspection criteria. According to its own traits, Conditional-Value-at-Risk model based on Peak Value Method of Extreme Value Theory is employed in the measurement of operational risks. Based on these results, strategies such as the provision of risk reserves, the allocation of economic capital, insurance and outsourcing are adopted in the control and management of operational risks.

Keywords: CVaR, Operational Risks, Measurement; Decision Engineering

1. Introduction

Operational risks have been in financial institutions for a long time. But the understandings of operational risks diverse among financial institutions. As defined in *Basel New Capital Accord(2003)*, operation risks are risks caused by incomplete or ineffective intra program, staff, and system, or extra events. At the same time, in the new accord, Basel Committee proposed three approaches for the calculation of operational risk regulatory capital requirement: Basic Indicator Approach, Standardized Approach and Advanced Measurement Approach.

After the announcement of this new capital accord, the operational risk management, especially the measurement models, are studied and researched by many international scholars. The models such as VaR, Extreme Value method and Bayesian networks are adopted in the measurement of operational risks. Many more advanced statistical and analytical techniques start to be applied by the bank industry. And new kinds of measurement methods are developed and employed. Giulio Mignola, R.Ugoccioni(2005)used Extreme Value Theory to carry out empirical analysis on operational risks and believed that the measurement of operational risks depended on the shape, scale and position characteristics of the loss distribution[1]. P. Embrechts, H. Furrer and R. Kaufmann (2003)developed a method, which is now widely used, to employ VaR and Extreme Value Theory in the calculation of operational risks [2]. Since 2004, some scholars have tried to make some modifications on Extreme Value Theory

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to get a closer and more precise value on the operational risk extremes and to calculate operational risk regulatory capital. Moscadelli (2004) derived the actual distribution function of operational losses over certain critical level, and the expected loss over expected threshold was calculated from sample mean extra function and adjusted coefficients, which was the reference of operational risk capital[3]. Tom Wilde (2005) employed credit risk model in the quantitative analysis of operational risks[4].

Recently in the wake of the booming cases concerning operational risks of commercial banks in China, the bank industry and academe pay more attention on operational risks. ZHONG Wei(2006) analyzed and believed that the main reasons for the frequent happenings of operational risk cases were issues concerning the high level management of banks, the report process of operational risks, operation flow and system construction[5]. Some scholars studied the management methods of operational risks and proposed that loss database should be constructed as soon as possible so that the accumulated loss data can be the foundation of operational risks' precise measurement[6]. Income model and securities factor model were used to make empirical analysis on operational risks of national joint-stock commercial banks. Bayesian network model was proposed in the management of operational risks. Monte Carlo techniques and loss distribution method, owing to the incomplete operational loss data, were employed in the measurement of operational risks in the commercial banks[7,8,9].

The study of CVaR abroad started from the end of 20_{th} centuries. CVaR risk measurement approach was firstly advanced by the Americans Rockafellar and Uryasev(1999), who described a new investment portfolio optimum method, called Conditional Value-Risk (CVaR), and firstly illustrated the definition of CVaR[10]. Later, some scholars studied mean-CVaR. Pflug(2000) discussed the optimum issues of CVaR[11]. Fredrik Anderson, Helmut Mausser, Dan Rosen and Stanislav Uryasev(2001)successfully introduced CVaR in the measurement of credit risks, in which random values were generated by Monte Carle method to stimulate return distribution of bonds, then the measurement of credit risks was transformed to linear programming to get the weights in portfolios so as to get the minimum CVaR[12]. Till now, CVaR is a method to measure not only market risks but also all kinds of risks, whose frame has been further expended. Based on the traits of operational risks, VaR model can be introduced to the management of operational risks. But due to the innate limitations, VaR model failed to get a scientific, reasonable, and relatively precise calculation on operational risks. However, CVaR makes up the faculties of the loss of information on the tails, and can be used as a satisfied instrument on the calculation of operational risks.

In China the study of CVaR has just started. A small number of papers focus on the definition of CVaR, optimum method and assessment method. HU Jie, GUO Xiaohui and QIU Yaguang(2005) compared the application of VaR and CVaR in commercial banks' risk measurement[13].TANG Xiangjin, TONG Shikuan(2005) suggested the conditions and methods of risk capital deployment under CVaR limitations[14].

Therefore, the traits of operational risks make its measurement difficult. A reasonable and precise model and technique to measure operational risks is incumbent in the face of rampant operational cases in China. Operational risk management mainly includes the assessment and disposal of risk loss. Based on the scientific and reasonable calculation of operational risks, the strategies such as the provision for risk reserves , the allocation of economic capital, insurance and outsourcing should be employed.

2. The Definition and Application of CVaR

2.1. The Application and Limitation of VaR

G-30 report published in July, 1993 defined Value at Risk (VaR) as " at a certain confidence interval and a certain target range, the maximum expected loss". In 1994, J.P. Morgan firstly promoted a risk measurement system based on VaR-Risk Metrics. It indicated VaR has formally become a tool for risk measurement and management. Since then, the obvious merits of VaR obtained the wide acceptance of global finance industry. But VaR initially measures market risks under certain premises. There are at least two issues in the usage:

- It only measures the percentages of loss distribution, but ignores the loss over a certain level. As a result, the loss on the tail is often neglected.
- For it is not a coincidence indicator, VaR cannot be added. But Conditional-Value-at-Risk, as a measurement of financial risks, preserves even better virtues that VaR. Although it has not yet been the criterion of financial industry, CVaR has been widely adopted in insurance and credit risk measurement.

2.2. The Basic Model and Advantages of CVaR

- The basic model of CVaR. CVaR is a risk measurement tool proposed by Rockafeller and Uryasev, which means the mean loss over VaR. Conditional-Value-at-Risk can also be called as Mean Excess Loss, Mean Shortfall, and Tail Valk. It is a better embodiment of potential risk of assets than VaR. In the process of calculation of CVaR, VaR can also be obtained.

The mathematics meaning of CVaR is that under the normal market condition and a certain confidence interval, at a certain time span, the conditional mean of the loss over VaR. It is the average of excess loss. It is supposed that the random loss of asset portfolio is X, VaR α is VaR value under confidential level α , F_x is accumulated distribution function of X , so CVaR can be presented as:

$$CVaR\alpha(X) = E(X \mid X \geq VaR\alpha) = \frac{1}{1-\alpha} \int_{VaR}^{+\infty} x f(x) dx \qquad (1)$$

In formula (1), $f(x)$ is the probability density function of random variable X .

- The advantages of CVaR. In the mathematic point of view, CVaR is a conditional expectation, is the mean extreme loss over VaR, reflects the possible average potential losses when losses exceed VaR threshold value. It presents a better prediction of potential risk value. Lots of theory studies and empirical researches have proved that CVaR has better mathematic merits and operability. The advantages are as follow: firstly, CVaR is sub-additive and convex, is a coincidence indicator. Sub-additivity means the dispersion of asset portfolios can decrease the overall losses. As for the abnormal distribution, CVaR is convex. So the optimum solution can be obtained. Secondly, CVaR is the mean of tail losses, reflecting losses exceeding VaR. In the measurement of CVaR, the measurement of tail losses of loss distribution is relatively sufficient and complete, especially when loss distribution is not a normal distribution, CVaR can present a better and more precise mathematic characteristics of loss distribution. In addition, as for the calculation of CVaR is based on VaR, CVaR and VaR can be got at the same time. It is a double measurement for risks, and is easy for mutual checks.

Regulatory capital of banks is the sum of expected and unexpected losses. Otherwise, the lowest regulatory capital is calculated by minimum unexpected losses. But it is necessary for the banks to calculate precise expected losses in the inner business. In the calculation of minimum regulatory capital, different assessments of operational risks should be added. But it should be proved that correlation coefficients the system allocates are correct and precise in the calculation of operational losses, then the inner confirmed correlation coefficients can be used. However, the unexpected and expected losses can be obtained simultaneously in the usage of CVaR.

3. The Empirical Analysis of Operational Risk Measurements Based on CVaR

3.1. The Construction of CVaR Measurement Model

When Extreme Value Theory is adopted to calculate VaR, only the tail is considered into the calculation, instead of the whole distribution. Usually, the economic capital preserved by banks based on this way of calculation is relatively low, accurate, and sufficient. Therefore, as a way to inspire the staff on operational risk management, the banks incline to choose this method. However, the loss range considered by VaR is relatively narrow, unable to reflect the real condition of operational risks facing the banks. As a result, the lack of reasonable estimation of extreme losses may cause pitfalls in risk management of banks. Therefore, CVaR should be employed to solve above issues.

- The parameters in CVaR measurement model based on peak value method. Although there are three important parameters: holding period, confidential level, and VaR in the definition of CVaR, VaR for each portfolio at a given holding period and confidential level, is confirmed. Therefore, VaR is endogenetic. CVaR should be obtained under the given holding period and confidential level. Below will illustrate the important influential factors of these two parameters.

①The choice of confidential level. The choice of confidential level depends on the following needs: the examination of CVaR, the requirement of inner risk capital, regulatory requirements and the cross comparison between different institutions. At the same time, normal distribution or other distribution with relatively good virtues may also affect the choice of confidential level. Effective factors are shown in Figure 1.

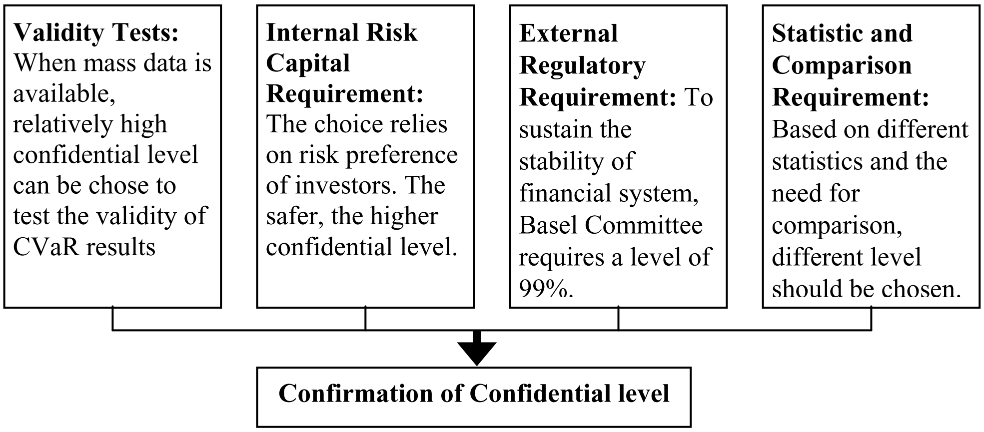

Figure1 Effective Factors on Confidential Level

As discussed above, different confidential level is chose for diverse purposes: to get a valid CVaR, relatively low confidential level should be preferred; while internal risk requirements and external risk regulatory requirements demand relatively high confidential level; in addition, as for statistics and comparison, medium or high level is required. Therefore, the confidential level of CVaR in this paper is chosen at 95% and 99%.

②The choice of holding period. Holding period is the time range selected in the calculation of CVaR. Owing to the positive correlation between volatility and time span, CVaR increases in the wake of the increase of holding period. The common hold period is one day or one month. But some financial institutions choose it as one quarter or one year. The following four effective factors should be considered in the selection of holding period: liquidity, normality, position adjustment, data limitations. Shown as Figure 2.

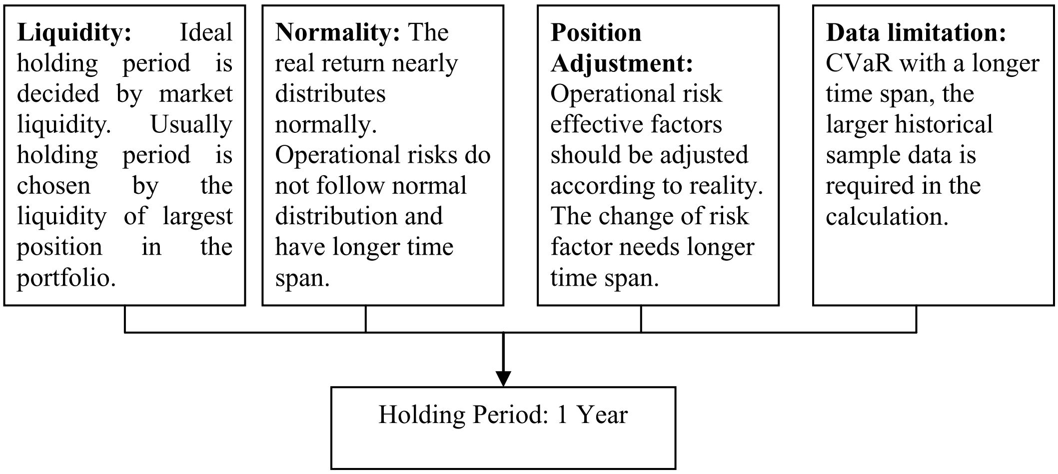

Figure2 Effective Factors on Selecting CVaR Holding Period

Therefore, in the calculation of CVaR, a relatively long holding period is preferred. This paper chooses 1 year as holding period.

- The construction of CVaR model based on peak value method. Based on Extreme Value Theory and CVaR studies, peak value method of Extreme Value Theory is chosen as the basis of model construction. This CVaR model is used to assess operational losses and to estimate great losses, non-great losses and extreme losses of unexpected operational losses.

①Operational loss intensity distribution based on Extreme Value Theory peak value method. Sample data is grouped and the largest figures are selected from each groups. The maximum series gradually follow generalized extreme value distribution (GEV). Then sample data is used to assess the parameters in generalized extreme value distribution to get the distribution of extreme losses.

The sample series are supposed to be $X_1,\ldots,X_n$, divided into *m* groups, each with *g* samples, and $g \geq 10$. Suppose that the residual of *n* divided by *m* is l. To make it simple, suppose $l = 0$, that is $X_1,\ldots,X_n = X_1,\ldots X_g, X_{g+1},\ldots X_{2g},\ldots,X_{(m-1)g+1},\ldots X_{mg}$. Then the maximum in each group is selected, $Y_i = (X_{i1},\ldots X_{ig}), i = 1,\ldots,m$, as for $Y_1,\ldots Y_m$, always exist $C_n > 0, d_n \in R$, so when $n \to \infty$, $\frac{Y_n - d_n}{c_n}$ converges to GEV distribution. For operational extreme loss distribution is a fat tail distribution similar to a power distribution, Frechet distribution is adopted. In a $\xi > 0$ GEV distribution, as for $Y_i = (X_{i1},\ldots X_{ig})$, exists $\sigma > 0$, $\mu \in R$, so the function of GEV distribution is

$$G_{\xi,\mu,\sigma(X)} = G_\xi(\frac{x-\mu}{\sigma}) = \begin{cases} \exp(-(1+\xi\frac{x-\mu}{\sigma})^{-1/\xi}) & \xi \neq 0 \\ \exp(-\exp(-\frac{x-\mu}{\sigma})) & \xi = 0 \end{cases} \tag{2}$$

While $\{1+\xi(\frac{x-\mu}{\sigma})\} > 0, \mu, \sigma(\sigma > 0), \xi$ is position parameter, scale parameter and form parameter respectively.

Maximum likelihood method is always adopted in parameter assessment of GEV distribution. Divided maximum series is supposed to follow generalized extreme value distribution. The distribution function is

$$F(y) = \exp(-(1+\xi\frac{y-\mu}{\sigma})^{-1/\xi}) \tag{3}$$

The distribution density is

$$F(y) = -\frac{1}{\sigma}(1+\xi\frac{y-\mu}{\sigma})^{-\frac{1}{\xi}-1}\exp(-(1+\xi\frac{y-\mu}{\sigma})^{-\frac{1}{\xi}}) \qquad \xi \neq 0 \tag{4}$$

Maximum likelihood estimated function is

$$L(\xi,\mu,\sigma) = \sum_{i=1}^{n}\left\{-\log\sigma - (1+\frac{1}{\xi})\log(1+\xi(\frac{y_i-\mu}{\sigma})) - (1+\xi(\frac{y_i-\mu}{\sigma}))^{1/\xi}\right\} \tag{5}$$

Maximize this function, Newton iteration is adopted to get the maximum likelihood solution of μ, σ, ξ.

②Operational loss frequency distribution based on Poisson distribution. The process of choosing maximum likelihood distribution can also be used in frequency model. According to the traits of operational risks, Poisson distribution is employed.

The possibility function of Poison distribution is

$$P(x = k) = \frac{e^{-\lambda}\lambda^k}{k!}, k = 0,1,\cdots\cdots$$

The accumulated distribution function can be obtained from below function

$$F(x) = e^{-\lambda t}\sum_{i=o}^{[x]}\frac{(\lambda t)^i}{i!} \tag{6}$$

③Solutions of VaR and CVaR of operational risks. After the calculation of loss intensity and loss frequency, overall loss distribution should be considered together with them to estimate operational loss at different confidential levels.

At *t*, the total loss is $X(t) = \sum_{i=1}^{N(t)} U_i$, with a distribution function as below

$$F_{x_{(t)}}(x) = P(X(t) \le x) = P(\sum_{i=1}^{N(t)} U_i \le x) \quad (7)$$

It is usually supposed that $\{N(t)\}$ and $\{U_n\}$ are statistically independent. From above formulas and total probability formula, below basic formula can be obtained

$$F_{X_{(t)}}(X) = \sum_{0}^{\infty} \frac{e^{-\lambda t}(\lambda t)^n}{n!} .P(\sum_{i=1}^{n} U_i \le x \big| N(t) = n) \quad (8)$$

For the differential of the explicit formula of $F_{X_{(n)}}(X)$ is hard to obtain at most times, approximation, extension, recursion or numerical algorithm should be adopted to solve above formula. If the frequency of operational risk cases is extremely large, central limit effect may be useful. An approximation of a large scale is similar to

$$F_{X_{(t)}}(X) \approx \varphi[\frac{x - E(X_t)}{\sqrt{Var(X_t)}}] \quad (9)$$

Above formula is a normally distributed approximation of large samples. $\Phi(x)$ is distribution function of standard normal distribution. $E(X_t)$ is expectation. $Var(X_t)$ is variance. The total intensity and frequency can be obtained from Turbo 2 programming.

$F_{X(t)}(x)$ is substituted by different confidential level *P*. Under different *P* value, from standard normal distribution function table $\Phi^{-1}(p)$ value can be obtained, then

$$VaR_P(t) = \Phi^{-1}(p)\sqrt{Var(X_t)} + E(X_t) \quad (10)$$

With this $VaR_P(t)$, $CVaR$ value can be derived. For

$CVaR = VaR + E(X_t - VaR \big| X_t > VaR)$, to get $CVaR$, $E(X_t - VaR \big| X_t > VaR)$ has to be solved. Suppose $VaR = u$, u is viewed as a critical value, and suppose excess loss is $Y = X - u$, which distribution is obtained from the tail of conditional distribution function F, that is

$$u \le y \big| X > u) = \frac{F(u+y) - F(u)}{1 - F(u)}, 0 \le y \prec \infty$$

(11)

When $u \to \infty$, the limit distribution of excess loss is generalized Pareto distribution. According to the form of Pareto distribution, suppose $\beta = \sigma + \xi(u - \mu)$, can get

$$G_{\xi,\beta(y)} \in \begin{cases} 1 - (1 + \xi \frac{y}{\beta})^{-1/\xi} & \xi = 0 \\ 1 - \exp(-\frac{y}{\beta}) & \xi \ne 0 \end{cases}$$

(12)

Where $$y \in \begin{cases} (0, \infty), \xi \ge 0 \\ (0, -\frac{\beta}{\xi}), \xi < 0 \end{cases}$$

Therefore, $E(X - u \big| X > u) = \frac{\beta + \xi}{1 - \xi}$, and $\beta = \sigma + \xi(u - \mu)$. Loss frequency still satisfies Poisson distribution. Suppose λ is the parameter of Poisson distribution, the expected excess loss Y can be obtained:

$$\lambda E\left|X-u\right|X>u\left|=\lambda\frac{\beta+\xi}{1-\xi}\right., \ \beta=\sigma+\xi(u-\mu), \text{ from } CVaR=VaR+E(X_t-VaR\left|X_t>VaR\right.),$$

CVaR value of operational risks can be obtained as

$$CVaR_p(t)=\Phi^{-1}(p)\sqrt{Var(X_t)}+E(X_t)+\lambda\frac{\beta+\xi}{1-\xi}$$

(13)

Till now, the derivation of VaR and CVaR formula of operational risks by peak value method has been completed. In the practical disposal, the way to group deserves further studies. The more is the number of data in each group, the fewer is the number of maximum series with larger data. As a result, the tail of the likelihood distribution is fatter, leading to a higher estimation of VaR and CVaR. The fewer is the number of data in each group, the more is the number of maximum series, which will cause some data cannot be dealt as extreme value. As a result, the tail of the likelihood distribution is not fat enough, leading to a lower estimation of VaR and CVaR.

3.2. The Calculations and Tests of VaR and CVaR

- The calculations of VaR and CVaR. From above derivation formula, the value of VaR and CVaR can be obtained. Divide the 363 operational losses of China's fourteen commercial banks from 1987 to 2009 into groups, and form them into 10, 12, 15, 17, 20, 25 and 30 groups, then choose the maximum in each group to fit a GEV distribution, and the maximum likelihood method is adopted to estimate parameters, as shown in Table 1.

Table1 Parameter Estimation

	10 Groups	12 Groups	15 Groups	17 Groups	20 Groups	25 Groups	30 Groups
μ	2823483	2749864	2568876	2432947	2340037	2150123	1985214
σ	856751	871346	862554	815718	789134	763514	563512
ε	0.91123	0.86421	0.86465	0.85934	0.86540	0.8312	0.6865

After the parameter estimation, from formula (10) and (13), VaR and CVaR value under the confidential level of 95% and 99% can be calculated respectively. The results are shown in Table 2.

Table2 Risk Estimation Value

	10 Groups	12 Groups	15 Groups	17 Groups	20 Groups	25 Groups	30 Groups
VaR_{95}	193.53	179.83	161.32	152.51	147.92	125.43	122.19
VaR_{99}	238.26	228.53	207.53	195.60	189.70	163.53	158.65
$CVaR_{95}$	1162.65	834.36	646.59	611.11	423.87	328.99	350.96
$CVaR_{99}$	9641.76	6519.04	6051.38	5432.47	5341.52	3771.75	1836.53

From the data in above tables, it can be drawn that in the same group format, VaR and CVaR increase in the wake of the raise of confidential levels. While at the same confidential level, VaR and CVaR decrease in the wake of the reduce of the number of data in each groups,. And CVaR is always larger than VaR. These results are reasonable on the surface. To verify their reasonability, backing tests should be took.

- Backing tests of CVaR. When peak value method is employed in empirical analysis, many kinds of grouping approaches can be tried to fit. By the comparison of backing tests, the best fitting could be confirmed. As for backing tests of CVaR, in the quantile violations, the gap between each violation figure and CVaR value should be considered, as well as the average gap. The test statistics can be shown as

$$LE = \frac{1}{n}\sum_{i=1}^{n} X_i - CVaR_p$$, where $X_i > CVaR_p$, n means the number of violating $CVaR_p$.

Therefore, each kind of group methods and violations under 95% confidential level as well as LE statistics can be obtained, as shown in Table 3.

Table3 Backing Test Result of CVaR

	10 Groups	12 Groups	15 Groups	17 Groups	20 Groups	25 Groups	30 Groups
Voilation	1	1	1	1	1	1	1
$LE_{0.95}$	-919.65	-591.36	-403.62	-368.11	-180.87	-85.99	-107.96

From above test results it can be drawn that the violation in each group is 1. It is because the sample number is a bit few. As the more the group number, the absolute value of $LE_{0.95}$ is lower, reaches the lowest at 25 groups, then rebounds. In comparison, the 10 groups' absolute value of $LE_{0.95}$ is largest, the 25 groups' is smallest. From the principles of backing tests, the fitting effect of 10 groups is worst with a over fat tail, while that of 25 groups is best.

3.3. Conclusions of Empirical Analysis

- From the study of Extreme Value Theory and CVaR basic principles, CVaR theoretical derivation can be achieved by peak value method of Extreme Value Theory. After the groups of 363 data, Newton iteration is adopted to get the maximum likelihood solution of each parameter. It can be achieved by Matlab6.5.
- From the backing tests of CVaR, the best fitting effect is accomplished by 25 grouping method. Therefore, VaR and CVaR value is calculated by this grouping method.
- By using 25 grouping method, VaR value at 95% confidential level is ￥12.543 billion, CVaR is ￥32.899 billion. At 99% confidential level, VaR is ￥16.353 billion, CVaR is ￥377.175 billion.
- For operational risk is of a merit of low frequency but high danger, and the management of operational risks requires the study of case frequency and loss intensity at different time, to choose the biggest case in the given period (and to abandon many cases before in different managing environment) will simplify the judgment on bank asset quantity estimation. Therefore, the CVaR model based on Extreme Value Theory peak value method is helpful in the measurement of operational risks in commercial banks.

4. Management Strategies Based on CVaR of Operational Risks

4.1. Provision of Operational Risk Reserve—Losses within VaR Measurement Range

The same as other kinds of risks, operational risks also can be divided into expected and unexpected losses. Expected losses is that the banks already know in the business process certain losses must occur, such as mistake ratio, system failure etc. Expected Loss is the expectable mean loss of the bank during a certain period under a usual condition. This kind of losses should be covered by adjusted pricing and general reserve, and be included in current profit and loss in the financial accounting, and be deducted from business profit as a fee. There is a definite method of loss reserve for asset loss in China's commercial banks. While as for operational losses, there is no relative requirements. The method of loss reserve can also be used in the coverage of expected loses. As what Var is measured is the expected loss under a certain confidential level during a certain target period, based on VaR value, operational loss reserve can be preserved, and the possible loss can be covered by provision coverage method. In usual conditions, the actual operational losses should be less than operational loss reserves calculated from VaR

4.2. Allocation of Economic capital for Operational Risks—Losses within CVaR Measurement Range

Economic capital is a capital amount of a corporation or organization in a certain period to prevent or release (under a certain confidential level) unexpected losses. Correspondingly, economic capital for operational risks is to release unexpected operational loss and relative payment difficulties. While what CVaR measures is the unexpected losses in a given time, representing the average of excess losses. Therefore, the economic capital derived from CVaR value can cover the operational losses of low frequency but high danger. At the same time, for it is always true that $CVaR \geq VaR$, the allocation based on CVaR can reduce the capital pressure.

4.3. Outsourcing and Insurance Risk Release Techniques

The disastrous loss of unexpected loss in operational risks is seldom, the quantitative measurement will consider this kind of extreme events. In actual management, release techniques can be adopted. Basel committee recommends the banks could deduct equivalent amount to purchase insurance from operational risk capital, but the highest ratio should not exceed 20% of operational risk capital requirements.

Operational risk release technique is that based on the recognition and measurement of operation risks, together with the development stratigy, business scale and complexity, by release techniques such as outsourcing and insurance etc, the commercial banks transfer, disperse, avoid operational risks to lower the losses. By making relative policies, programs and processes, comprehensively and effectively using risk release tools to reduce risks, and adopting release techniques such as outsourcing and insurance etc aiming at different operational risk cases, the commercial banks release operational risks.

5. Conclusions

Operational risk management is a new research field. In China, the extra supervision is insufficient, the intra management method is deficient. At the same time, as for the complexity and dynamism of operational risk cases, and the absence of a unified statistical caliber, it makes the study of operational risks even harder. But nowadays, huge operational losses have already existed in commercial banks in China. The measurement and management of operational risks is incumbent. The CVaR measurement method can obtain a relatively precise operational loss value, by which economic capital can be allocated accordingly. However, as the capital ratio of most commercial banks in China is relatively low, if the operational loss is included in the denomination, a substantial pressure would be laid on capital ratio. Therefore, a comprehensive strategy to control and manage operational risks is essential, that is to cover expected operational losses by risk reserves, to allocate risk capital on the basis of unexpected operational losses, and to use insurance to lower capital demand, so as to reduce the pressure on capital ratio.

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