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Risk Metrics Model in Purchasing Risk Measurement

Sheng[1]Yang, Xiao Wan [2]

School of Economics and Management, Beijing Jiaotong University, Beijing, China.

E-mail:wanx23@sina.com

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Abstract: VaR(Value at Risk)has been one of the most attractive risk management tools in recent years. As a quantitative model to measure and control financial risk, compared with traditional models, it is easy to understand and apply so as to have more practical and referential significance. However, the application of VaR method in the risk management of purchasing is limited. This paper analyzes the application of VaR Measurement Model in risk management of purchasing and set up a purchasing risk measurement model.

Key words: Purchasing risk measurement, Value at Risk, Risk Metrics

1. Statement of the Problem

It has been a widespread acknowledgement that the competition of companies is stepping into the era of supply chain competition. As the resource of companies' supply chain, purchasing is always the origin of companies' operation management, and the quality and price of the products are definitely determined by the quality of the raw materials. As we all know, the cost of raw materials occupies the first position of all the other costs, so any deviations emerged during the links of purchasing have an effect on the realization of the company's anticipated goal, and further will have an influence on the enterprise profit target. While abundant of potential risks and uncertainty exist in the whole process of purchasing in such a changeable environment of market economy. So how to control the risk of purchasing at a certain range has a significant meaning in increasing the enterprise' profits.

The measurement of supply chain risk, major identification methods include Delphi, the flow chart, decomposition analysis, fault tree analysis, risk questionnaires, scenario analysis, Etc(Ruijiang,2012)As the above discussed, we use Risk Metrics model to fit the series sequence of yield price variance, and build the purchasing risk measurement model finally.

2. Principle and Theory of VaR Model

2.1 Definition of VaR method

VaR simply means the value of risks, and it represents the quantity of losing capital next phase of investment portfolio. In another words, it means the maximum losing value of a portfolio under a certain probability. [7]There are many definitions of VaR at present; we use the definition from Philippe Jorion's[5]: VaR means the maximum losing value of an investment portfolio under a certain holding period and confidence level. It is always presented by α- quartile of profit & Loss distribution of an investment portfolio mathematically.

$$Pr\left[\Delta p(\Delta t) \le -VaR\right] = \alpha \,. \qquad (2\text{-}1)$$

$\Delta p(\Delta t)$ stands for the market value change of an investment portfolio p in a holding period of Δ t and confidence level of (1－α), the equation (2－1)express that the probability of which that the losing value is no less than VaR equals α.

For a specific investment portfolio, we assume P0 is the initial value, R is the return on investment during the holding period, u is the expected value, σ is the standard deviation. At the end of the holding period, the value of the investment portfolio can be stated as follows:

$$P = P_0(1+R) \;. \qquad (2-2)$$

We assume the minimum value of the investment portfolio under a certain confidence level is:

$$P^{'} = P_0\left(1 + R^{'}\right) \quad . \tag{2—3}$$

$R^{'}$ is the minimum return on investment during this period.

So, the relative VaR can be expressed below:

$$VaR_R = E(P) - P^{'} = -P_0\left(R^{'} - \mu\right) \tag{2—4}$$

The absolute VaR is:

$$VaR_A = P_0 - P^{'} = -P_0 R^{'} \quad . \tag{2—5}$$

It is obvious, the calculation of VaR equals to assessing the minimum $P^{'}$ or minimum $R^{'}$.[3]

R is assumed to be the standard normal distribution with 0 as mean value and 1 as standard deviation. Generally speaking, under the assumption of standard normal distribution, $R^{'}$ is negative, we assume:

$$-\alpha = \frac{\left|R^{*}\right| - \mu}{\sigma} \quad (\alpha > 0) \ . \tag{2—6}$$

$$1 - C = \int_{-\infty}^{P_0} f(P)dP = \int_{-\infty}^{-\left|R^{'}\right|} f(r)dr = \int_{-\infty}^{-\alpha} \Phi(\varepsilon)d\varepsilon \quad . \tag{2—7}$$

So, the calculation of VaR can be transformed into the problem which purpose is to find proper α to fit the equation above.

Under the condition of standard normal distribution, when given the confidence level of 95%, α=1.65, then the corresponding $R^{'}$ and VaR can be assessed.

The minimum return on investment $R^{'}$ can be calculated as follows:

$$R^{'} = -\alpha\sigma + \mu \ . \tag{2—8}$$

We assume the time period is Δt, rate of vibration is $\sigma\sqrt{\Delta t}$, the relative VaR will be:

$$VaR_R = -P_0\left(R^{'} - \mu\right) = P_0\alpha\sigma\sqrt{\Delta t} \quad . \tag{2—9}$$

The absolute VaR will be:

$$VaR_A = -P_0 R^{'} = P_0\left(\alpha\sigma\sqrt{\Delta t} - \mu\Delta t\right) \quad . \qquad (2-10)$$

We can find that the method contains three main factors according to the definition of VaR:

1. Holding period [0,T]

Holding period is the overall length of time to assess the rate of vibration and correlation of return, and the data selection time range. In order to overcome the effects of cyclical changes in market economy, it is better to choose longer history data during the holding period.

2. Confidence level 1-α

If the confidence level is too low, the extreme event in which the losing value exceeds VaR may have a high probability of happening, and this will cause a high cost of investment. If the confidence level goes too high, the extreme event in which the losing value exceeds VaR may have a low probability of happening, while in such a situation, the data in statistical sample which reflects the extreme events will become more and more less. Low investment costs will also make it difficult to control the market risks in time.

3. ROI distribution characteristics

It is the most important factor in VaR method. It stands for the probability distribution of ROI in a certain holding period. Different assessing methods have different probability distribution, and then cause different VaRs of the same investment portfolio.

2.2 The classification of VaR method

Based on different ways to predicting the market factors changing, VaR can be divided into three kinds: Historical Simulation, Variance-CoVariance and Monte Carlo Simulation.

(1). Historical Simulation

Historical Simulation carries on the calculation directly according to the definition of VaR, using the present portfolio proportion in chronological true historical data of asset returns, and then put the profits and losses of the assets into a probability distribution, and then the value of risks can be calculated.

(2). Variance-CoVariance

Variance-CoVariance simplifies the calculation of VaR via using the approximate relationship between the values of the portfolio function and the market factors. And it is divided into Delta-Model and Gamma-Model according to the different forms of the portfolio function.

In Delta-Model, the portfolio function takes first-order approximation. But the statistical distribution assumptions of market factors are different. For instance, Delta- Normality Model assumes that the change of market factors obey the multivariate normal distribution. Delta-Weighted Gaussian Model uses WTN to evaluate the covariance matrix of the return of market factors. Delta-GARCH Model uses GARCH Model to describe the market factors.

As Delta -Model is based on the linear form, it can't identify nonlinear risks. In order to solve such a problem, researchers propose Gamma-Model. In this model, the portfolio function takes second-order approximation. Gamma-Normality Model assumes that the change of market factors obey the multivariate normal distribution. Gamma-GARCH Model uses GARCH Model to describe the market factors. And JP Morgan’s Risk Metrics brings in both the Gamma-CF Model and Gamma-Johnson Model.

(3). Monte Carlo Simulation

Monte Carlo Simulation repeatedly simulates the random process which determines the value of financial assets. Each simulation will get a possible value of portfolio in the final of holding period. If we carry out a large number of simulations, the portfolio value simulation will converge to the real distribution, and then we will get the real VaR.

From the view of statistical, the models to assess VaR can be divided into two kinds: parametric model and nonparametric model. Parametric model evaluates VaR through assuming the yield of securities portfolio obey to a certain distribution, such as JP.Morgan’s Risk Metrics and GARCH; Nonparametric model need no assumptions about the distribution of the yield of securities portfolio. It evaluates

VaR via analyzing and simulating the historical data. Historical Simulation and Monte Carlo Simulation are typical examples of nonparametric model.[4]

2.3 Comparison of different VaR methods

As there are so many methods to calculated VaR, the one which should be employed in practice is subject to whether the portfolio contains large amount of share options or financial instruments with embedded options, the situation of data collection, the complexity of method implementation, counting speed, the difficulty in explaining to senior management, market stability and the capacity for inspecting other hypotheses. Comparison will be made between these 3 models in terms of their operability, reliability and flexibility.

1. Operability

The Variance-CoVariance analysis method is based on the assumption that the market factor is subject to multivariate normal distribution. Choose normal models with different parameters according to the form of portfolio's value function and the model of market factor. The calculation can be greatly simplified by utilizing the statistical property of normal distribution, so the Variance-CoVariance analysis method is widely used.

The historical simulation method is easy and most understandable and frequently used. But the method requires complete data of the observation period, thus, workload for data importing will be increased if the portfolio is sensitive to most of market factors; or the method may become valid if the finance market of the country is underdeveloped, because in this case, most of data may be unavailable or distorted.

Monte Carlo simulation method requires knowledge of probability statistics and financial derivative instruments. A large amount of random numbers simulating amount of asset portfolio will be produced in calculation, so its calculation process is more complex and involves more calculation workload.

2. Reliability

In practice, the possibility that the results of the Variance-CoVariance analysis method deviate from the mean value is usually higher than expected. In such case, appropriate modification should be made to the estimated relevant coefficient and standard deviation to avoid the invalidity of the estimation of VaR value.

The historical simulation method relies too much on historical data. So when the observation period lacks representativeness, the VaR value obtained through the method may not well reflect the market value. Although the Variance-CoVariance analysis method and Monte Carlo simulation method also rely on historical data of the observation period, the impact of data with less representativeness on the results of these two methods is less serious.

Because the Monte Carlo simulation method requires suitable distribution patterns, so if the actual distribution is different with the assumed one due to different reasons, the reliability of VaR value may reduce greatly.

3. Flexibility

VaR method is to estimate the market risks given that the market is under normal condition. If risk manager thinks that great change may happen in future market, he/she should modify the estimated value according to his own judgment for better estimation of risks. The analysis method and the Monte Carlo simulation method are more flexible so the user can ignore estimated value of parameters and use rational data to measure market risks neglecting. The historical simulation method is less flexible because it directly relies on historical data to make simulation.

Table 2-1 Comparison of Different VaR methods

	Historical Simulation	**Variance-Covariance**	**Monte Carlo Simulation**
Status of The Data Collection	Difficult	Easy	Easy
Difficulty Level of Implementation	Relatively Easy	Easy	Difficult
The Speed of	Quick	Quick	Relatively

Computation			Slow
Difficulty Level of Explanation to senior Managers	Easy	Relatively Easy	Difficult
Volatility of Market	The result will show bias.	The result will show bias unless other standard deviation and correlation coefficient used.	The result will show bias unless other distribution parameters used.
Testing Other Hypothesis	N/A	Applicable only on other standard deviation and correlation coefficient hypothesis but other distributions.	Applicable

2.4 Application of VaR methods

Due to its advantages, VaR method has been widely used in recent ten years by securities companies, investment banks, commercial banks, pension funds and other non-financial business. After the G-30 group released report in 1994, 43% derivative dealers announced that they were using VaR method to measure market risks, 3% of dealers said that they would adopt VaR method by the end of 1995; A investigation in 1995 made by the Wharton School found that 29% of non-financial enterprises of US surveyed use VaR method to estimated the risk of their derivatives. According to a survey in 1995 of Institute Investor journal, 32% of surveyed companies had used VaR method; the investigation in the same period conducted by NY University found that 60% of surveyed pension funds have adopted VaR method. The proportion is on rise as time goes. At present, the application of VaR is not only limited to measure risks of financial market, it is gradually adopted to judge credit risk, liquidity risk and operational risk.

In addition to the wide application in measuring risks, VaR method is also extensively used in risk management. For example, a comprehensive consideration is given to benefit and risk by introducing VaR method in performance evaluation, the employment of returns with risk-adjusted performance measures (namely RAPMs) has changed the traditional evaluation of performance simply based on benefit, thus the excessive speculation has been avoided. To use RAPMs index-RAROC to replace ROC (RAROC=ROC/VaR). So, even if the VaR value is very high due to engagement of high-risk investment project, the performance evaluation would not be high.

The great advantage of VaR method in risk measurement and management has been recognized and acknowledged by international financial supervising and managing authorities, many financial regulation bills and rules have fully highlighted VaR-based risk supervising methods, the typical ones include Core Principles for Effective Banking Supervision issued by the Basel committee on banking supervision, EU capital adequacy directive, Pre-commitment Act of The United States Federal Reserve Board, FAS119 enacted by FASB and Derivatives market risk disclosure requirements of SEC. Those bills and regulations rule require financial institutions to determine the demand of internal capital risks, internal risk control and information disclosure on the basis of VaR method. For example, the method to judge the capital adequacy of market risk on a certain date t of a financial institute with Basel internal model approach is to take the larger one between the VaR value of the previous day and several times of the mean VaR value over the previous 60 days. Namely that capital adequacy of market risk of the day t requires that MRC, is:

$$MRC_t = \max\left[k \times \frac{1}{60}\sum_{i=1}^{60} VaR_t - iVaR_t - 1\right] \qquad (2\text{-}11)$$

Wherein, K stands for a prudence multiplier stipulated by supervising authorities.

3. Risk Metrics Model of VaR Method in Purchasing Risk Measurement

First of all, according to the original definition of VaR in financial market, we define VaR of purchasing risk measurement as: the maximum expected amount of loss caused by the fluctuations in the prices of raw materials in a probability during a specified period. [1]

3.1 Introduction

The independently and identically normal model is a common model in financial asset returns. Many models such as CAPM require and imply this assumption in financial economics. Since fully describing the overall situation of objective phenomenon, normal distribution is in the core position of statistics. Central Limit Theorems proved by P.S.Laplace shows that distribution tends to normal distribution with the number of observed increase. And distribution tends to smooth normal distribution while the number becomes greater.

The following analysis in this article is built on the basis of the assumption that price yield a normal distribution.

Probability density function of single normal distribution is:

$$f(x) = \frac{1}{\sigma\sqrt{2\pi}} e^{-\frac{(x-\mu)^2}{2\sigma^2}} \qquad (x \in (-\infty,+\infty)) . \tag{3－1}$$

μ, σ stand for the mean value and the standard deviation of single normal distribution.

Probability density function of multivariate normal distribution is:

$$f(x) = \frac{1}{(2\pi)^{m/2} |V|^{1/2}} e^{-\frac{1}{2}(X-\mu)' V^{-1} (X-\mu)} \quad . \tag{3－2}$$

μ is mean vector, V is covariance matrix, V=AA'，A is the matrix of rank m.

At present, arithmetic yield and geometric yield are the mainly two definitions of yield calculation. The definitions are as follows:[6]

1. Arithmetic yield: $r_t^A = {(p_t - p_{t-1})} / {p_{t-1}}$, t=1,2,… (3－3)

2. Geometric yield: $r_t^G = \ln\left({p_t}/{p_{t-1}} \right) = \ln p_t - \ln p_{t-1}$ t=1,2,… (3−4)

pt-1 and pt stand for the market value at the beginning and the end of the investment portfolio period.

We will use geometric yield when it comes to the VaR model.

3.2 Overview of Risk Metrics model

Risk Metrics model fits the yield variance under normal distribution and is based on a kind of moving average method——Exponentially Weighted Moving Average Model. It's basic ideas are as follows: First, we get the sensitivity coefficient of the income of the portfolio on the risk factors from the valuation model. Then we use the historical data to determine the coefficient of variation and the correlation coefficient of the risk factors. So we can get the main parameters——mean value, variance and covariance matrix. And we can get the portfolio income distribution by multiplying the sensitivity coefficient and the variance matrix. Next, the threshold which reflects the degree of deviation from the mean of the distribution in certain confidence interval can be obtained under the premise that the major market parameters follow a normal distribution. Finally we can derive the VaR value by establishing contact with the venture capital.[2]

It should be noted that the return on assets tend to have different distributions, such as the time-varying characteristics of variance. And moving average method is most commonly used as a financial estimate technology to estimate time-varying variance (volatility). The basic principle is as follows: We select historical data window of a certain length and calculate the arithmetic mean value. The average we obtained can be used for variance estimate and projection.

The fundamental difference between the exponentially weighted moving average model and the simple moving average method is that they take unequal weights of time series data. Different weights are respectively assigned according to the distance between historical data and current time. The distance is shorter means that it contains more information and it is more important. And greater weights will be assigned. If the distance is long, the weights will be small as the function is also small. To make this principle simple, a parameter λ is introduced into the exponentially weighted moving average model to decide the weight coefficient of each historical observation. λ is called attenuation factor (Decay Factor) and the value is between 0 and 1. The size of the value describes the attention degree of historical information in considering the size of the financial market volatility.

The EWMA formula in n phase of a time series {xi} is:

$$EWMA_n = \frac{x_{t-1} + \lambda x_{t-2} + \lambda^2 x_{t-3} + ... + \lambda^{n-1} x_{t-n}}{1 + \lambda + \lambda^2 + ... + \lambda^{n-1}} \quad . \qquad (3-6)$$

$n \to \infty$, the denominator in the above formula converges to $1/(1-\lambda)$. So the EMWA of infinitely long period of history will be:

$$EWMA_n = (1-\lambda)\sum_{i=1}^{\infty} \lambda^{i-1} x_{t-i} \quad . \qquad (3-7)$$

The variance of yield in Risk Metrics model when it comes to t moment can be described as follows:

$$\sigma_t^2 = (1-\lambda)\sum_{i=1}^{t} \lambda^{i-1} \left(r_i - \bar{r}\right)^2 \quad . \qquad (3-8)$$

We assume the historical data is infinite. $\sigma_{t+1/t}^2$ stands for the estimate of variance at t+1 moment when we have known the information at t moment. $\varepsilon_t = r_t - \bar{r}$. We can get the result as follows according to the exponentially weighted moving average model.

$$\begin{aligned} \sigma_{t+1/t}^2 &= (1-\lambda)\sum_{i=0}^{\infty} \lambda^i \varepsilon_{t-i}^2 = (1-\lambda)\varepsilon_t^2 + (1-\lambda)\sum_{i=1}^{\infty} \lambda^i \varepsilon_{t-i}^2 \\ &= (1-\lambda)\varepsilon_t^2 + \lambda\left[(1-\lambda)\sum_{i=0}^{\infty} \lambda^i \varepsilon_{t-i-1}^2\right] = (1-\lambda)\varepsilon_t^2 + \lambda\sigma_{t/t-1}^2 \end{aligned} \quad . \qquad (3-9)$$

$$\sigma_{t+1}^2 = (1-\lambda)\varepsilon_t^2 + \lambda\sigma_t^2 \quad . \qquad (3-10)$$

We usually take λ=0.94 in Risk Metrics model.[6]

3.3 VaR model in purchasing risk measurement based in Risk Metrics

We assume that enterprise need n species raw material in the manufacturing process. The purchase combination is $\omega = (\omega_1, \omega_2, \cdots \omega_n)$. $\omega_i (i = 1,2,\cdots n)$ stand for the value weight of material i in the purchase combination. $\sum_{i=1}^{n} \omega_i = 1$. P0 is the initial purchase price and it becomes Pt at t moment. According to the assumption, the geometric yield of the purchase price change obeys normal distribution. The price of continuous compounding is Pt at t moment. $P_t = P_0 \left(\omega_1 e^{r_1} + \omega_2 e^{r_2} + \cdots + \omega_n e^{r_n} \right)$. ri is the geometric yield of price change of material i at t moment. $r_i = \ln\left(p_i \big/ p_0 \right)$. Pit and Pi0 是 are the price of raw material i at t moment and the beginning of the period. The accumulative return rate of the whole purchase can be described as $r_\omega = \ln\left(\sum_{i=1}^{n} \omega_i e^{r_i} \right)$。

The price change is generally small during a very short period in normal. And its geometric variation of the yield is also smaller. We can obtain the result below by first order expansions of Taylor approximation.

$$e^{r_i} = 1 + r_i \quad . \tag{3－11}$$

$$r_\omega \cong \ln\left[\sum_{i=1}^{n} \omega_i (1 + r_i) \right] = \ln\left(1 + \sum_{i=1}^{n} \omega_i r_i \right) \cong \sum_{i=1}^{n} \omega_i r_i \ . \tag{3－12}$$

We can know that geometric yield obeys random process according to the assumption. We can get combined variance from the variance of random variable linear function.

$\sigma_\omega^2 = \omega^T \sum \omega$, $\omega^T = |\omega_1, \omega_2, \cdots \omega_n|$ is the transposed matrix of ω. Σ is the variance-covariance matrix of vector quantity ri. $r_i = (r_1, r_2, \cdots r_n)$.

$$\sum = \begin{vmatrix} \sigma_1^2 & \rho_{12}\sigma_1\sigma_2 & \cdots & \rho_{1n}\sigma_1\sigma_n \\ \rho_{21}\sigma_2\sigma_1 & \sigma_2^2 & \cdots & \rho_{2n}\sigma_2\sigma_n \\ \vdots & \vdots & \ddots & \vdots \\ \rho_{n1}\sigma_n\sigma_1 & \rho_{n2}\sigma_n\sigma_2 & \cdots & \sigma_n^2 \end{vmatrix}$$

We can know that r_ω obeys normal distribution according to the behavior characteristics of financial assets price. $r_\omega \sim N(\mu_\omega, \sigma_\omega^2)$, μ_ω and σ_ω^2 are the mean value and the variance of r_ω. The standard normal distribution is: $\frac{r_\omega - \mu_\omega}{\sigma_\omega} \sim N(0,1)$. r_ω^* is the minimum yield of in confidence coefficient(1－α). $\frac{r_\omega^* - \mu_\omega}{\sigma_\omega} = -C$, $\Phi(-C) = 1 - \alpha$. $r_\omega^* = \mu_\omega - C\sigma_\omega$.

The bottom price is $P_t^* = P_0(1 + r_\omega^*)$ at t moment. $VaR = E(P_t) - P_t^* = P_0(1 + \mu_\omega) - P_0(1 + r_\omega^*) = P_0(\mu_\omega - r_\omega^*)$, $r_\omega^* = \mu_\omega - C\sigma_\omega$. VaR can be calculated by:

$$VaR = P_0 C\sigma_\omega. \tag{3－13}$$

We should pay attention to the adjustment principle of time square root when total the yield of independent identical distribution. We can adjust the different volatility according to this factor of time square root when yield obeys the same distribution.

$$VaR = P_0 C\sigma_\omega\sqrt{\Delta t}. \tag{3－14}$$

We estimate the standard deviation and correlation coefficient with EWMA method. Different weights will be assigned by the distance between historical data and current time. The weight will be greater if the distance is short. Attenuation factor λ decides weights assignment. Its value is between 0 and 1. The exponential moving estimation formula of n-period variance of a square return sequence $\left\{\varepsilon_i^2\right\}$ is:

$$\hat{\sigma}_n^2 = \frac{\varepsilon_{t-1}^2 + \lambda\varepsilon_{t-2}^2 + \lambda^2\varepsilon_{t-3}^2 + \cdots + \lambda^{n-1}\varepsilon_{t-n}^2}{1+\lambda+\lambda^2+\cdots+\lambda^{n-1}} \quad . \tag{3-15}$$

The recursive form is:

$$\hat{\sigma}_t^2 = (1-\lambda)\varepsilon_{t-1}^2 + \lambda\hat{\sigma}_{t-1}^2 \quad . \tag{3-16}$$

The starting point of iterative computations is:

$$\hat{\sigma}_{t0}^2 = \frac{1}{M}\sum_{i=0}^{M-1}\varepsilon_{t0-i}^2 \quad . \tag{3-17}$$

Recursive form of correlation estimates is:

$$\hat{\sigma}_{12,t} = (1-\lambda)\varepsilon_{1,t-1}\varepsilon_{2,t-1} + \lambda\hat{\sigma}_{12,t-1} \quad . \tag{3-18}$$

The steps of purchasing risk measurement model based in Risk Metrics are as follows:

1.Data reduction

The logarithmic yield of raw material i at t moment can be calculated by the formula $r_{it} = \ln\left(P_{it} / P_{i(t-1)}\right)$. Pit stands for the price of raw material i at t moment. And we can get the time series of logarithmic yield of raw material i which is described as $\{r_{it}\}$.

2. Description of data statistics

Description of data statistics has five indicators which includes mean, median, standard deviation, skewness and kurtosis:

Mean: the data average value of time sequence.

Median: the mediate data of time sequence in ascending order.

Standard deviation: a measurement of the degree of fluctuations in time sequence. The formula is:

$$\hat{s} = \sqrt{\frac{1}{N-1}\sum_{i=1}^{N}(y_i - \bar{y})^2} \quad . \tag{3—19}$$

N is the sample number. y_i is the value of sample i. $\bar{y}$ is the sample mean.

a) Skewness: the non-symmetry of that the time sequence distribution with respect to the mean value. The formula is:

$$S = \frac{1}{N}\sum_{i=1}^{N}\left(\frac{y_i - \bar{y}}{\hat{\sigma}}\right)^3 \quad . \tag{3—20}$$

The skewness of symmetric distribution is 0, such as normal distribution. Positive skewness of the distribution of the time series has a long right tail. And negative skewness means a long left tail.

b) Kurtosis: the measure of the spikes or flat peak of time series distribution. The formula is:

$$K = \frac{1}{N}\sum_{i=1}^{N}\left(\frac{y_i - \bar{y}}{\hat{\sigma}}\right)^4 . \tag{3—21}$$

Kurtosis of the normal distribution is 3. If the kurtosis of time sequence is greater than 3, it means that it is the peak of the normal distribution. If the kurtosis of the time series is less than 3, which means that it is the flat peak of normal distribution.

3. The standard deviation $\hat{\sigma}_i$ of time series $\{r_{it}\}$ which stands for the logarithmic yield of raw material i can be calculated by formula（3-16）and（3-17）. The attenuation factor λ is 0.94 according to the RMSE. M is decided by the size of sample.

4. Correlation coefficient ρij of raw material i and j can be calculated by formula（3-18）. The attenuation factor λ is 0.94.

5.The expected maximum amount of the loss is limited to Lmax. $VaR = P_0 C\sigma_{\omega}\sqrt{\Delta t} = L_{\max}$. Procurement value weighting vector ω of n kinds of raw material can be obtained if we know P0 and Δt.

In addition, if enterprise takes single raw material procurement, sourcing mix dimension will be 1. And the formula (3-3) can be simplified as $VaR = P_0 C\sigma\sqrt{\Delta t}$. σ is the standard deviation of raw material yield. We can get P0 according to the formula after estimating the σ. $VaR = P_0 C\sigma\sqrt{\Delta t} = L_{\max}$. We can decide how much to invest in spot market when enterprises take single purchase of raw materials, in order to avoid the loss due to fluctuations in raw material prices.

4. Conclusion

As the above discussed, we can know the VaR model is not only easy to understand and operate, but also applied in a wide range. Of course, there are many practical issues of VaR method, such as income distribution fitting. We need to constantly refine and improve. We believe VaR approach will have broad prospects in purchasing risk measurement in China.

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