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Research on Quantitative Analysis Model of Financial Risk Value

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ABSTRACT
With the continuous improvement of theoretical and practical research on financial development, especially under the condition of further innovation of China's multi-level capital market system, there are more and more uncertain factors causing financial risk. It is very necessary to strengthen the research on the value of financial risk. This paper studies the quantitative model of financial value at risk from the perspective of factor pricing model and GARCH model. The research results can predict and prevent various risks in the process of financial development. The research results can also reduce the scope and degree of losses, and provide a more accurate reference basis for the construction and empirical analysis of the financial risk value quantitative model.

Keywords: *Quantitative analysis; model; financial risk; value-at-risk*

1. INTRODUCTION

Under the background of economic globalization, any portfolio management is not an isolated financial activity. The objective conditions such as time difference and location advantage among the world financial markets also determine some complex relations and nonlinear characteristics of asset price fluctuations to a certain extent. Quantitative analysis of financial value of risk is an integrated system engineering, and its practical application involves many aspects and stages. Only by carrying out complete macro-control of each stage, can financial risks be controlled more accurately and the actual effect of quantitative value of risk of financial can be brought into full play. Risk measurement plays an important role in financial risk management. It mainly relies on quantitative analysis method to measure the possibility of loss caused by various risks and the scope and degree of loss, so as to provide reliable quantitative basis for risk management.

The quantification of financial value of risk involves the basic theoretical knowledge of finance, theoretical econometrics, investment and other related disciplines, and relevant scholars have carried out certain research. It is pointed out that modeling the historical return of an asset as a univariate Generalized Autoregressive Conditional Heteroscedasticity (GARCH) process is often used as a basis for price discovery in illiquid derivatives markets. Heston's model is often used because it has a convenient closed-form solution. However, this generally applies to spot price dynamics. Therefore, subsequent scholars carried out a series of studies on the basis of Heston's model to supplement the shortcomings of the model [1]. Yang K et al fitted and analyzed the HFT data of Vanke A (000002) based on GARCH model and its derivative model [2]. Zolfaghari M et al predicted stock indexes by applying a hybrid model combining Adaptive Wavelet Transform (AWT), Long and Short Term Memory (LSTM) and ARIMAX-GARCH series models [3]. Venter P-J et al compared the model price with the market price to show the pricing performance, and studied the application of single-variable and multi-variable GARCH model in the pricing of bitcoin futures and options [4]. Wang X-C evaluated the options with the maximum or minimum of the two prices under the GARCH model [5].

It is particularly important to study the quantitative analysis model of financial risk value in the great era of the rise of China's financial industry. In the backdrop of the discipline overlapping, this study of factor pricing model, GARCH model, such as financial econometrics model analysis, from the Angle of multi-scale analysis and Bayesian learning, the Value-at-Risk (VaR) model of financial risk management is expanding in some relevant theory, and then found some new financial risk quantification and portfolio management theory angle of view and practical experience.

2. FACTOR PRICING MODEL

Capital Asset Pricing Model (CAPM) shows that the risk premium of a single asset is equal to the β times of the market risk premium, which measures the degree of covariance between the return of a single asset and the return of the market portfolio. Factor pricing model is the theoretical generalization of the capital asset pricing model, by means of wavelet multi-resolution analysis to study the effect of risk factors for a single asset price the value of the portfolio risk analysis is a very meaningful work, financial globalization has made a single asset and portfolio risk is affected by more factors, such as market risk, interest rate risk, exchange rate risk, etc.

2.1. Double Factor Pricing Model

Taking market risk and exchange rate risk as risk factors, this paper studies the double factor pricing model based on wavelet multi-resolution analysis and its application in portfolio value at risk measurement. In the double factor pricing model, the market risk is measured by the return of the market composite index, and the exchange rate risk is measured by the return of the exchange rate. Let $r_i(i=1,2,3,\cdots,m)$ represent return on assets, r_x represent return on portfolio, and portfolio weight vector is $X=(x_1,x_2,x_3\cdots x_m)$. r_w represents market index yield, s is exchange rate yield. ψ_1 and ψ_2 represent the covariance risk sensitivity of return on assets to risk factors, so the expected risk premium of assets is [6]:

$$E(r_i-r)=\psi_1\operatorname{cov}(r_i,r_w)+\psi_2\operatorname{cov}(r_i,s) \tag{1}$$

In Formula (1), the expected risk premium of visible assets is composed of market risk and exchange rate risk premium. The first item is similar to the market system risk premium of CAPM model, and the second item indicates that investors are concerned about the exchange rate risk premium of asset returns. By substituting the return rate sequence of the two risk factors into Equation (1), equations (2) and (3) can be obtained, and ψ_1, ψ_2 are obtained by further solving:

$$E(r_w)-r=\psi_1\operatorname{cov}(r_w,r_w)+\psi_2\operatorname{cov}(r_w,s)=\psi_1 Var(r_w)+\psi_2\operatorname{cov}(r_w,s) \tag{2}$$

$$E(s)-r=\psi_1\operatorname{cov}(s,r_w)+\psi_2\operatorname{cov}(s,s)=\psi_1\operatorname{cov}(s,r_w)+\psi_2 Var(s) \tag{3}$$

According to $\operatorname{cov}(r_w,s)=0$, this paper gets:

$$\begin{cases}\psi_1=(E(r_w)-r)/Var(r_w)\\ \psi_2=(E(s)-r)/Var(s)\end{cases} \tag{4}$$

Combining (4) with (1), a double factor asset pricing model is obtained as follows:

$$E(r_i-r)=\frac{(E(r_w)-r)}{Var(r_w)}\operatorname{cov}(r_i,r_w)+\frac{(E(s)-r)}{Var(s)}\operatorname{cov}(r_i,s) \tag{5}$$

That is, the following Formula (6) :

$$E(r_i-r)=\beta_{1i}(E(r_w)-r)+\beta_{2i}(E(s)-r) \tag{6}$$

In Formula (6), β_{1i} and β_{2i} are the sensitivity of a single asset I to market risk factors and exchange rate risk factors. Combined with equations (5) and (6), the expressions of β_{1i} and β_{2i} are as follows:

$$\begin{cases}\beta_{1i}=\operatorname{cov}(r_i,r_w)/Var(r_w)\\ \beta_{2i}=\operatorname{cov}(r_i,s)/Var(s)\end{cases} \tag{7}$$

The above Formulas (5) and (6) are the double factor pricing model including market risk factor and exchange rate risk factor.

2.2. Multi-Factor Pricing Model

The effective pricing of assets has always been the core problem in finance, and the exact relationship between asset return and risk is the different expression of this problem. On the basis of the double factor pricing model, related scholars also developed the multi-factor pricing model.

Fama proposed a three-factor model, which further clarified the relationship between excess return on assets and risk factors in 1993. Fama won the 2013 Nobel Prize in Economics for his outstanding contributions to asset pricing theory. Since then, many scholars have followed to explore the applicability of the traditional pricing model in different capital markets and come to different conclusions. It should be noted that the traditional asset pricing theory assumes that the distribution of asset return follows a normal distribution, which is inconsistent with the actual data. In many literatures, it is found that the characteristics of return on financial assets are inconsistent at different frequencies, so different models need to be built to describe the characteristics of real data. For example, Z-B Li et al. analyzed the Sinicization of FF5 model with 21 years' monthly data of China's A-share market as samples. After analyzing different samples in different periods, they found that the five-factor model had stronger explanatory ability than the single-factor model, three-factor model and four-factor model [7]. In the framework of FF5 model analysis, W-W Du improved the construction method of HML factor and established a multi-factor pricing model more in line with market characteristics [8]. L. Wang introduced GC Forest algorithm on the basis of multi-factor model to explore stock selection strategies and excess returns in the stock market. Through empirical analysis and research comparison, L. Wang found that in the robust trend of CSI 300 index, and Gc Forest strategy has a better effect in controlling the prediction of retracting [9]. It is found that the idiosyncratic volatility is an independent risk factor that needs to be priced, which can describe the return characteristics of stocks to a certain extent and improve the explanatory power of the model.

2.3. Application of Factor Pricing Model

2.3.1. Factor to pick stocks

The factor pricing model is often used in the stock market for stock selection. Its main step is to include the factors that may affect or explain the expected rate of return of stocks into the model. Generally, the commonly used factors include the size of listed companies, asset liability ratio, roe, ROA, etc. at the same time, select appropriate stock data and analyze them with measurement methods. Firstly, filtering the factors and using the effective factors is helpful for the next analysis, such as FF three factor model. The factor selected by the model - the market value of listed companies. Through the model analysis, it is found that the expected return on assets of listed companies with small market value is relatively high, so they should sell the stocks of listed companies with small market value in order to obtain excess returns. In addition to selecting the underlying stocks, in recent years, investors have used the multi factor model to predict the buying, rising and falling times of stocks, and its steps are roughly similar to the stock selection steps.

2.3.2. Hedging

The factor pricing model can also be used to hedge risks, mainly in tracking various Index ETF funds. The assets that can be traded in these markets have unique advantages as factors. Its operating principle is mainly separation. It can be inferred from Formula (5) that the intercept term should be 0, but if the intercept term is not 0 and positive for some reasons, The corresponding part can be sold by buying assets, which will be separated by this method. Because the return difference between assets and asset portfolio is very small, the two prices will be relatively close. So the cost of holding a portfolio short and an asset long at the same time will be very small.

2.3.3. Statistical arbitrage

Statistical arbitrage is different from arbitrage. Statistical arbitrage realized by multi factor model refers to using statistical analysis tools to find out the long-term stable quantitative relationship between interrelated asset prices. If asset prices change and deviate from this long-term stable relationship in the actual process, corresponding operations can be carried out to predict that this deviation will disappear. Therefore, this statistical arbitrage method is risky. The operation step of statistical arbitrage is to calculate the return rate of each stock in the past period. If the actual return rate of a stock exceeds the expected return rate, it can be judged that the stock is growing too fast during this period, and the growth rate may decline in the future, so that the return rate of the whole process meets the expectation. Therefore, this stock should not be bought in the future, on the contrary, it should be bought, Similarly, we should be aware that such methods are not absolute.

3. GARCH MODEL

From the perspective of market microstructure, traders always put their own interests first, hoping to maximize the economic profits of enterprises through the lowest capital cost. In the field of behavioral finance, this paper makes an in-depth analysis of traders' behavior, combines various types of traders' investment behavior, observes the local fluctuation characteristics in their development process, and establishes GARCH model on this basis, which can not only show the analytical role of the original model, but also expand the original model. It can capture the impact of transaction information contained in different transaction cycles on the volatility of asset return.

3.1. Basic GARCH Model

When constructing the GARCH model, this paper should take into account the multi cycle trading behavior of investors, clarify the asset price formation mechanism contained in the multi cycle trading behavior, put forward the GARCH model from the perspective of wavelet multi-scale analysis, optimize and prove the GARCH model according to the reasonable regulation of relevant data, and verify the statistical characteristics on the basis of comprehensive index return, further ensure the authenticity and reliability of GARCH model, and provide a basic guarantee for the quantitative analysis of financial value at risk. The expression of the basic GARCH model is:

$$\begin{cases} r_t = \mu_t + \varepsilon_t \\ \varepsilon_t = \sigma_t Z_t \\ \sigma_t^2 = w + \alpha r_{t-1}^2 + \beta \sigma_{t-1}^2 \end{cases} \tag{8}$$

In Formula (8), μ_t represents the expected return; and ε_t is the residual term, that is, the nonprofitable item; and z_t is the nonprofitable item index; and w is a constant term; and r_{t-1}^2 is the ARCH term, and uses the lag of the square of the perturbation term of the mean equation to measure the information of volatility obtained from the previous period; and σ_{t-1}^2 is the prediction variance of the previous period, representing GARCH term.

With the help of GARCH model, this paper makes a quantitative analysis of financial value at risk, further defines the important role of value at risk in financial development, and summarizes the corresponding statistical description test characteristics. The standard deviation of GARCH model will change with the change of scale. The larger the scale, the value of standard deviation will increase. In other words, investors face different investment risks within a certain range. If investors want to ensure their economic benefits, they must formulate corresponding development strategies from different time scales. Moreover, the statistical description skewness of different scales will also change with the change of return. Generally, the peak of each scale is greater than three, and is positively correlated with the scale. The peak characteristics of the distribution of Shanghai stock index return in the sample period change significantly with the scale.

3.2. Multivariate GARCH Model

In the financial market, great progress has been made in the research of its volatility, but there are a variety of assets in the financial market. When making financial asset portfolio investment, it will face the problems of multiple assets, multiple profits and multiple risks. At the same time, in the context of economic globalization, the financial markets of various countries are interrelated and affect each other. The study of the linkage between the stock markets not only has great reference significance for individual investors and institutional investors in risk management, but also has great reference value for the government in financial supervision and the formulation of stock market policies. In view of this, many scholars have improved and expanded on the basis of GARCH model and formed a series of multivariate GARCH models [10]. The CCC- GARCH model is formulated as follows [11]:

$$\Sigma_t = D_t R D_t \tag{9}$$

In Formula (9), *R* is the constant correlation matrix of ϵ j, T_j (estimated using historical data). The diagonal matrix D_t takes the following form:

$$D_t = \begin{pmatrix} \sqrt{h_1, t} & 0 & \cdots & 0 \\ 0 & \ddots & & \\ \vdots & & \ddots & \\ 0 & & & \sqrt{h_N, t} \end{pmatrix} \tag{10}$$

The conditional variance of each asset is assumed to be consistent with Equation (11).

An obvious shortcoming of the CCC-GARCH model is the assumption of constant correlation. To address this problem, Engle extended the model to incorporate dynamic conditional correlation (DCC). The DCC-GARCH model is formulated as follows:

$$\Sigma_t = D_t R_t D_t \tag{11}$$

In Formula (11),

$$R_t = diag(Q_t)^{-\frac{1}{2}} Q_t diag(Q_t)^{-\frac{1}{2}} \tag{12}$$

In Formula (11), $diag$ is the diagonal matrix symbol, Q_t is modelled using an autoregressive process:

$$Q_t = (1 - \theta_1 - \theta_2)\overline{Q} + \theta_2 Q_{t-1} \tag{13}$$

It can be seen that the estimation of CCC-GARCH model is mainly divided into two steps: the first step is to estimate the conditional variance D_t of a single asset by equation (10); The second step is to estimate the correlation matrix R of multidimensional assets according to equation (12), and then obtain its dynamic covariance matrix Q_t according to equation (13). For CCC-GARCH model, the conditional variance of a single asset is estimated by univariate GARCH model, which is relatively simple to estimate; however, for the correlation matrix *R*, when the asset dimension considered is high and the amount of data is large, its estimation becomes more difficult.

4. CONCLUSION

It can be seen from the above analysis that it is of great significance to construct a more perfect value quantification model on the basis of Value-at-Risk. Mathematical modeling is carried out from the perspective of factor pricing model and GARCH model, including analysis of four models including double-factor pricing model, multi-factor pricing model, basic GARCH model and multi-CCC-GARCH model, to further clarify the important role of value-at-risk in financial management and financial development. The calculation method of financial risk management tool is extended, which can provide a certain reference for the similar research of quantitative analysis model of financial risk value.

AUTHORS' CONTRIBUTIONS

This paper is independently completed by Zhaowei Chen.

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