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Particle swarm optimised analysis of investment decision

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Abstract

A portfolio forecasting model based on particle swarm optimization (PSO) algorithm with automatic factor scaling is proposed in this Article to effectively improve the accuracy of related analysis model in portfolio application. Firstly, the portfolio problem is analyzed and a hybrid constraint portfolio model is obtained by improving portfolio model with consideration of general portfolio model and combination of market value constraint and upper bound constraint according to Markowitz's theory. Secondly, PSO algorithm is introduced during analysis on portfolio model and solution is found with the hybrid constraint portfolio model of PSO on portfolio. In addition, in order to further improve the performance of PSO in model solution, automatic factor scaling is used for adaptive learning on parameters associated with PSO, to improve convergence of the algorithm. At last, simulation experiments show that the algorithm proposed can obtain a more ideal investment portfolio scheme, thereby reducing investment risks and obtaining greater investment returns.

Keywords: Wealth effect; Consumer behavior; Individual investment; Decision analysis; PSO

1. Introduction

In 1980s, the financial sector was rapidly developed, and the process of innovation, freedom, and integration continued to deepen. However, the risk in financial sector increased, especially in the investment field. The financial sector has been increasingly concerned with the prediction and control of risks and has become a hot topic of research. It is of great practical significance to realize accurate pre-control of financial risks (Brown, Bulte, & Zhang, 2015).

The core of managing financial risks is how to quantitatively predict and analyze potential financial risks. In order to improve the performance of portfolio analysis method, the Literature (Lucas & Moll, 2014) proposes a model of risk value (investment decisions for individuals with consumer behaviors), which gradually becomes the main calculation model for risk management and control in financial sector. However, after a long period of theoretical and practical verification, it shows that there are certain shortcomings when applying investment decision model of individual with consumer behaviors to financial risk management and control. Among them, additivity is an important attribute of financial risk management and control, but investment decision model of individual with consumer behaviors do not have additive features. At the same time, when tail risk occurs in financial sector, the investment decision model of individual with consumer behaviors cannot clearly define the loss caused by the incident. In this regard, the Literature (Sexton & Sexton, 2014) proposes a consistent measurement improvement method for the defects of investment decision model of individual with consumer behaviors, which can determine the risk

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boundary in financial risk management and control interval. To solve this problem, some scholars have proposed a risk-constrained value model. The model can effectively represent the average degree of loss in financial risk over the rated level, prevent financial risk of small odds events, and measure the degree of risk. It is recognized as a more mature and effective model to represent financial risk. Although the construction of model has relative advantages, the parameter setting of model is another important factor to test the accuracy of model. In particular, some of key parameters in the model, such as expected return, have a very high sensitivity to the accuracy of investment decision model for individuals with irrational consumer behavior. For this situation, an effective means is to use robust optimization methods to set parameters. For example, Literature (Berger Guerrieri, Lorenzoni, & Vavra, 2015) uses box-like attributes for robust portfolio optimization based on uncertainty in investment returns, which enables the control of robust optimization processes. The Literature (Schmutte, 2015) analyzes and studies the portfolio problem based on uncertainty sets. The uncertainty set used is an uncertain set in the form of Ellipsoid. Literature (Brooks Huang, Kearney, & Murray, 2014) shows certain non-equilibrium and extremum situations in process of portfolio returns, and in the process of long-term and short-term investment, there will be a certain peak tilt. Recently, the Literature (Kapeliushnikov, 2015) studies show that there is non-equilibrium in the process of portfolio investment, with a multi-distribution nature. The above research shows that forecasting of portfolio risk is a valuable research direction.

The problem with above literature is that the uncertainty sets used are all symmetric, that is, taking into account the equilibrium returns of asset investment, which is different from the real situation. In this regard, a conjugate gradient optimization model for investment decision of individual with irrational consumer behaviors considering the unbalanced returns of assets is proposed in this Article, and a conjugate gradient algorithm is introduced to optimize the investment decision portfolio model of individual with irrational consumer behaviors. Empirical analysis is carried out to verify the effectiveness of the proposed portfolio analysis method.

2. Description of investment decision model of individuals with irrational consumer behavior.

2.1. Related definitions

We assume $\boldsymbol{x}$ as a decision vector in process of portfolio risk decision in investment decision of individual with irrational consumer behavior, with $\boldsymbol{x} \in X$, and $\boldsymbol{x} \in R^n$ is a feasible solution in process of decision making, $\boldsymbol{y} \in R^n$ as a vector formed by random uncertain elements in process of portfolio risk decision in investment decision of individual with irrational consumer behavior. We set $\boldsymbol{y}$ probability density to be expressed as probability density. For all $\boldsymbol{x}$, the loss of corresponding output $\boldsymbol{y}$ is $f(\boldsymbol{x}, \boldsymbol{y})$, we can express the probability that $f(\boldsymbol{x}, \boldsymbol{y})$ is less than the set threshold as:

$$\psi(\boldsymbol{x}, \alpha) = \int_{f(\boldsymbol{x},\boldsymbol{y}) \leqslant \alpha} p(\boldsymbol{y}) d\boldsymbol{y} \tag{1}$$

We assume that $\boldsymbol{x}$ is preset and can be expressed as a function with α as parameter, and $\psi(\boldsymbol{x}, \alpha)$ is the loss distribution associated with parameter $\boldsymbol{x}$. For set confidence level $\beta \in (0, 1)$ and preset $\boldsymbol{x} \in X$, the calculation form of $VaR_\beta(\boldsymbol{x})$ is as:

$$VaR_\beta(\boldsymbol{x}) = \min\{\alpha \in R : \psi(\boldsymbol{x}, \alpha) \geqslant \beta\} \tag{2}$$

Investment decision of individual with consumer behaviors refers to a minimum loss value when the probability that the loss value is greater than set value α is $(1 - \beta)$. In contrast, the process of portfolio risk decision in investment decision of individual with irrational consumer behaviors uses the average loss, then the form of $CVaR_\beta(\boldsymbol{x})$ is:

$$CVaR_\beta(\boldsymbol{x}) = (1 - \beta)^{-1} \int_{f(\boldsymbol{x},\boldsymbol{y}) \geqslant VaR_\beta(\boldsymbol{x})} f(\boldsymbol{x}, \boldsymbol{y}) p(\boldsymbol{y}) d\boldsymbol{y} \tag{3}$$

Therefore, $CVaR_\beta(\boldsymbol{x}) \geqslant VaR_\beta(\boldsymbol{x})$. Then, based on above analysis, the difference between process of portfolio risk decision in investment decision of individual with irrational consumer behaviors, and that of individual with consumer behaviors is that, the former considers tail loss and has a consistent characteristic. The actual situation is, the calculation taking $CVaR_\beta(\boldsymbol{x})$ for risk forecasting is very difficult, the solution is to use auxiliary function F_β constructed and solved by $X \times R$ to improve the calculation of $CVaR_\beta(\boldsymbol{x})$. Specific definition form of F_β is:

$$\min_{\boldsymbol{x} \in X} \phi_\beta(\boldsymbol{x}) = \min_{(\boldsymbol{x}, \alpha) \in X \times R} F_\beta(\boldsymbol{x}, \alpha) \tag{4}$$

2.2. Solution of investment decision model of individuals with irrational consumer behavior

Actually, $p(\boldsymbol{y})$ is generally unknown, and there may be S group of sample portfolio $Y = \left(\boldsymbol{y}_{[1]}, \boldsymbol{y}_{[2]}, \cdots, \boldsymbol{y}_{[S]}\right)$, which is available by simulation. With sample Y, we can solve $F_\beta(\boldsymbol{x}, \alpha)$ as follows:

$$F_\beta(\boldsymbol{x}, \alpha) = \alpha + (1 - \beta)^{-1} \sum_{k=1}^{S} \pi_k \left[f\left(\boldsymbol{x}, \boldsymbol{y}_{[k]}\right) - \alpha \right]^+ \tag{5}$$

In which, $\boldsymbol{y}_{[k]}$ is sample k in financial portfolio, S is the number of samples in the portfolio, π_k is the probability of sample $CVaR_\beta(\boldsymbol{x})$ in the portfolio. If the constant value of π_k is S^{-1}, then the Eq. (6) can be rewritten as: