



Covariance Estimation and Algorithm Implementation of Hedge Fund Distribution Replication Model Based on AHP Algorithm

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Abstract. Covariance estimation of hedge fund distribution replication model can help people identify relevant financial risks, so as to prevent and control them. In order to achieve this purpose, based on the hedge fund distribution replication model, this paper discusses the feasibility of AHP algorithm in model covariance estimation, and then introduces the algorithm implementation method. The research shows that AHP algorithm has obvious advantages in the covariance estimation of hedge fund distribution replication model, and accurate results can be obtained under reasonable application.

Keywords: AHP algorithm · Hedge fund distribution replication model · Estimation of covariance

1 Introduction

Hedge fund is a kind of fund different from the traditional mutual economy. It has the characteristics of high profit and high risk, so it attracts many "activist" investors. With the help of these investors, hedge fund began to be popular around the world. This background, the effects of high risk hedge funds increasingly obvious, and the types of hedge funds, so the influence of the high risk also increases gradually, so the people began to think of the problems of how to should hedge fund risk, thus was born the hedge fund distribution replication model, the main function of the model by means of covariance estimates for a hedge fund project, evaluating the risk so that investors can make accurate decisions according to their own situation. Although this can't completely eliminate risk, it can at least reduce the influence of risk and make the characteristic of high profit of hedge funds more prominent, which is conducive to the development of hedge funds. Because hedge funds distribution replication model is put forward by means of covariance estimation results, so the accuracy of the estimation results are very important, to ensure the accuracy, put forward a lot of fields related to covariance estimation algorithms, including AHP algorithm has been widely attention, think the results of this algorithm can well improve the accuracy, therefore, in order to understand the application method of AHP algorithm in the covariance estimation of hedge fund distribution replication model, this paper will carry out relevant research.

2 Basic Concept of AHP Algorithm

In real life or work, people often encounter a problem with multiple decision-making objectives. For example, in financial investment, people have to make joint decisions on the level of risk and profit of investment projects [1-3]. This kind of problem is called multi-decision objective problem. Concept in multiple decision objective problems early, it was found that there is almost no good method to provide help to the person, then solve these problems mainly rely on experience and subjective idea, but it also caused the attention of the related fields, and then through the study put forward some special algorithms for such problem, the AHP algorithm which is one of the representative algorithms. The core idea of AHP algorithm is: Will much decision goal is regarded as a system, namely the decomposition problem of all the decision goal, each decision target as a hierarchy, and find the relationship between the level, again according to the relationship between combination, of which each level contains the different index system, can adopt the qualitative index fuzzy quantification method for its calculation, get any level of weight, the hierarchy is sorted according to the weight, so that the importance degree of each decision-making objective in the problem can be known [4]. The decision-making focuses on the target with the highest importance degree for consideration, and finally obtains the optimal result. Figure 1 is the topology of the AHP algorithm.

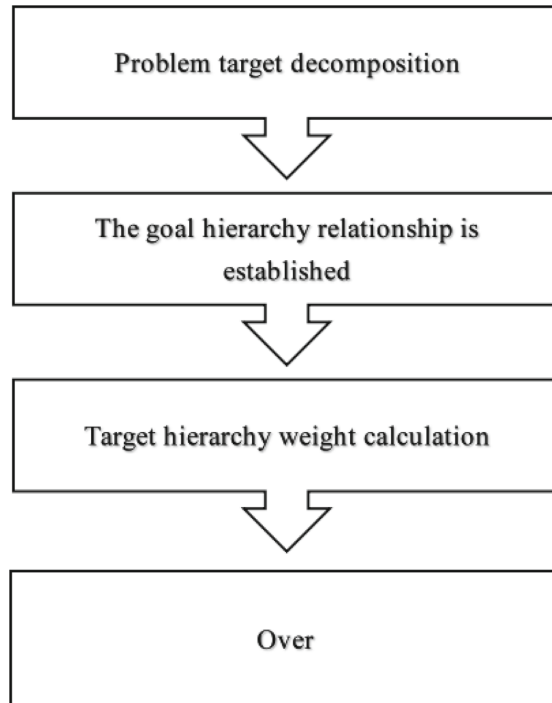


Fig. 1. Topology of AHP algorithm

It can be seen that the AHP algorithm is a kind of algorithm that builds the hierarchical model after the problem is decomposed, and then builds the judgment matrix of the model to solve the matrix eigenvector [5–7]. The results can show the correlation degree between different elements in different levels and an element in the previous level, so as to establish the relationship and distinguish the weight. These characteristics make AHP algorithm have a wide range of applications, basically any problem with hierarchical staggered evaluation index, but the target value is not qualitative index fuzzy quantitative description can be solved by AHP algorithm, this is due to the different functions of AHP algorithm, Table 1 is the functional characteristics of AHP algorithm in different problems.

Table 1. Functional characteristics of AHP algorithm in different problems

Type of problem	Functional features
Super multilevel problem	Build simplified models to improve efficiency
Some target values are not quantitatively described	Other target values of the system are described by fuzzy quantitative qualitative indicators to ensure the whole-body coordination of the target values
Staggered evaluation index relationship	Establish accurate index relation model and improve the transparency of results

3 Feasibility and Implementation Method of AHP Algorithm in Model Covariance Estimation

3.1 Feasibility Analysis

In order to verify the feasibility of AHP algorithm in covariance estimation of hedge fund distribution replication model, its advantages and disadvantages will be discussed below.

Advantages, AHP algorithm has very strong systemic, through analysis, comparison, judgment, comprehensive thinking ways of making decisions, the process does not give a combination of the relationship between, any combination of the factors will directly or reference effects on the final results, at the same time because of the fuzzy quantitative, so the final result has definite numerical value characteristic, It is very clear, so the AHP algorithm can give accurate and clear results in the covariance estimation of hedge fund distribution replication model. Compared with other algorithms, AHP algorithm is more concise in the covariance estimation of hedge fund distribution replication model, that is, AHP algorithm is not a pure mathematical method, and relevant theories tend to define it as an analytical method that combines qualitative and quantitative logics to calculate problems systematically. In short, is the thinking process of people thinking about the problem of mathematics, systematization, only in the final simple mathematical calculation, so that the form of the result is more accurate, so the AHP algorithm is more

concise, use, operation difficulty is relatively small [8–10]. Finally, in the covariance estimation of hedge fund distribution replication model, other algorithms generally need a large amount of data support, but the AHP algorithm needs less data and generally only contains basic data information, such as the transaction amount of the fund, etc.

In terms of disadvantages, many modern fields will choose intelligent algorithms when solving problems, such algorithms can constantly give workers the choice of new solutions in decision-making, while AHP algorithm does not have this function, can only give the optimal results on the basis of existing data, so it may not be able to meet people's special needs. The AHP algorithm does not need too much data in the covariance estimation of the hedge fund distribution replication model, which makes the algorithm can give the answer quickly, but also leads to the lack of credibility of the answer given by the AHP algorithm. The AHP algorithm contains all the factors involved in the problem and the relationship between the combination of factors, so if faced with complex problems, there will be too many indicators, resulting in the weight is difficult to define the problem.

Combined with the advantages and disadvantages of AHP algorithm, first of all, the advantages of the algorithm also indicate the function of the algorithm, which indicates that it can be used in the decision of complex problems, and the covariance estimation of hedge fund distribution replication model is a typical complex problem, so the AHP algorithm has a good application value in the covariance estimation of hedge fund distribution replication model. Second hedge fund distribution copying model covariance estimation, will not affect mostly the drawback of AHP algorithm: first, the hedge fund distribution copying model covariance estimation, people do not need to get support of the new project, you just need to know details risk according to the covariance, therefore AHP algorithm cannot provide defect will not affect some of the new project; Secondly, AHP algorithm answer low credibility of defects can be eliminated by deduction method, namely AHP algorithm's answer itself although do not have too much credibility, but because the answer contains the whole development process, risk risk development process, so as long as the observation to determine whether a process is the same as the process description of the answer, if it is the same, it means that the results are still credible. Different representative processes have changed. Re-calculate and repeat this process to avoid the defect of insufficient credibility of the answer. Third, there are many improved AHP algorithms in modern times. The biggest difference between these algorithms and the classical AHP algorithm is that they can simplify the model. Therefore, the use of such algorithms can avoid the problem that the index is too complex and the weight is difficult to define. It can be seen that although the AHP algorithm has some disadvantages, they can be avoided by other methods, and the advantages represent that the algorithm is required by the covariance estimation of the model. Therefore, the AHP algorithm has good feasibility in the covariance estimation of the hedge fund distribution replication model.

3.2 Implementation Method

As for the implementation method of AHP algorithm in the covariance estimation of hedge fund distribution replication model, it is mainly divided into two steps, namely, the establishment of hedge fund distribution replication model and the estimation of AHP covariance. The specific contents are as follows.

3.2.1 Establishment of Hedge Fund Distribution Replication Model

In the establishment of hedge fund distribution replication model, a basic dynamic portfolio model should be established first, as shown in Formula (1).

$$\begin{cases} \pi_t = \sigma'(t)^{-1}\varphi_t \\ \varphi_t = \frac{\theta_t}{H_t}E[H_T f'(L_T)] \end{cases} \quad (1)$$

where t is the investment time, H is a random vector, where the combination with t represents the state price density process, T is the change node of investment time, $f'(L_T)$ is the end return, and the remaining elements are determined functions of t .

On the basis of formula (1), the establishment of hedge fund distribution replication model can be further divided into three steps, as shown in Fig. 2.

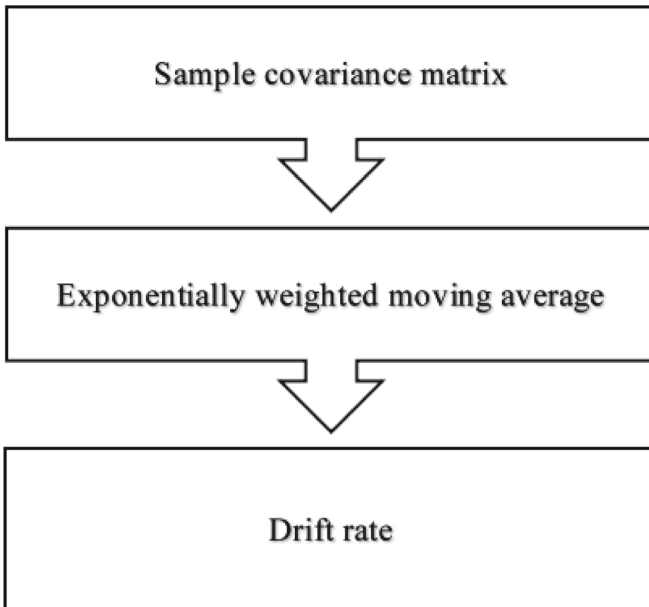


Fig. 2. Steps of establishing hedge fund distribution replication model

Build the sample covariance matrix, the definition of risk assets in a moment of the day logarithm yield, confirm the assets from one moment to any other moment, logarithm

yield vector, and then by counting yield variance calculation, the results represent the risk, according to the known risk assets which belong to the risk assets, aimed at this kind of risk to establish covariance matrix, see formula (2).

$$\sum_t = \left(\sum_t ij \right) n \times n \quad (2)$$

where i is the asset, j is the daily log rate of return, and n is the change vector of the daily log rate of return at two time points.

Second for index weighted moving average operation, first set up an assumed time series, and then take the index weighted moving average method to calculate the mean value of the sequence, the average according to the analysis of characteristics of time series data, if features preset standards, means you can continue, in contrast to change the time sequence, repeat the process.

Finally, the drift rate is confirmed, and the volatility of the hedge fund project can be calculated on the basis of formula (2). According to the daily logarithmic return series of the volatility risk asset and the assumed time series, the index weighted moving average method is used to calculate again, and the result is the drift rate of the project investment amount on the dynamic basis.

3.2.2 AHP Covariance Estimation

Combined with the hedge fund distribution replication model, covariance can be estimated in two directions: factor and contraction, but only factor direction is suitable for AHP algorithm, so this paper only considers the hedge fund distribution replication model in factor direction.

The hedge fund distribution replication model in the factor direction is characterized by a covariance definition structure, so the data dimension is less. The multi-level model can be decomposed into several single-factor models, and then the AHP algorithm is used to estimate the covariance. Applied to confirm the factor loading vector and the factor of intercept vector in this dimension, the residual vector, so that the full variance diagonal principle, after the completion of the combination of asset market index returns, assumes that the residuals are independent and normal distribution, can get covariance matrix, see formula (3), in the type into risk assets return, return time length can be estimated results.

$$\sum_t^{(1)} = \sigma_{market}^2 \beta \beta' + \Delta \quad (3)$$

where market is the return of asset market indicators.

3.3 Filter Establishment

Above plan basic function can let the AHP algorithm, its output hedge fund distribution replication model covariance estimation results, but must pay attention to the noise problem in actual applications, the large scale of financial data, and numerous sources, this leads to the financial data itself has no quality guarantee, which are likely to have a lot of data noise problem, For example, some complex data have irregular structure,

which will have a certain impact on the result of AHP algorithm covariance estimation. Facing this problem, it is necessary to build a filter for denoising before data mining. In this paper, the mean filter is selected, and the denoising process of the filter is shown in Fig. 3.

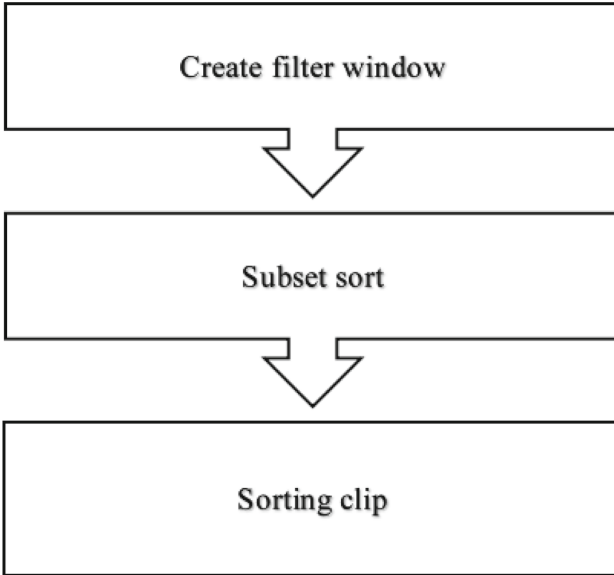


Fig. 3. Denoising process of mean filter

Combined with Fig. 3, the mean filter is first used for data cleaning, and several filtering Windows can be obtained in the process. Each window will have size differences according to the magnitude of internal data. Therefore, the subset sorting of filtering Windows is carried out according to the size differences to obtain the total sorting. According to the measurement results of the total ranking, the smallest and largest order is removed to complete the ranking pruning, and the noise input is also removed in synchronization, which can ensure the accuracy of the final results.

4 Conclusion

In conclusion, the characteristics of high profit, high risk of hedge funds that it is a “double-edged sword”, but if we can reduce the incidence of risk, you can pass this kind of financial product brings more benefits, and the AHP algorithm could copy for hedge fund distribution model is used to estimate covariance, the results can help people to identify risks, convenient rule, this point is reached, it shows that AHP algorithm is a feasible method for covariance estimation and has good application value.

References

1. An, T.N., Le, T.N., Quyen, H.A., et al.: Application of AHP algorithm to coordinate multiple load shedding factors in the microgrid. *IETE J. Res.* 1–13 (2021)
2. Lin, Y., Lin, F., Huang, D., et al.: Voltage sag severity analysis based on improved FP-Growth algorithm and AHP algorithm. *J. Phys. Conf. Ser.* **1732**(1), 012088(8p.) (2021)
3. Zhang, N., Chai, R., Zheng, J.: Economic evaluation of rock oil project based on AHP algorithm. *Arabian J. Geosci.* **14**(9), 779 (2021)
4. Ibrahim, M.R., Suseno, J.E., Surarso, B.: Emergency service search using ant colony optimization algorithm and AHP-TOPSIS method. *J. Phys. Conf. Ser.* **1943**(1), 012104(7p.) (2021)
5. Yuan, Z., Wang, J., et al.: An MTRC-AHP compensation algorithm for Bi-ISAR imaging of space targets. *IEEE Sens. J.* **20**(5), 2356–2367 (2019)
6. Li, Y., Wu, L., Han, Q., et al.: Estimation of remote sensing based ecological index along the Grand Canal based on PCA-AHP-TOPSIS methodology. *Ecol. Indic.* **122**(2), 107214 (2021)
7. Meng, F., David, S.: Analysis of the optimal time to withdraw investments from hedge funds with alternative fee structures. *IMA J. Manage. Math.* **2021**(2), 2 (2021)
8. Vrjitoru, E.S., Boscoianu, M., Boscoianu, E.C.: Aspects regarding a new methodology for active portfolio management of hedge funds alternative in emerging markets-the case of Romanian capital market in the actual context of post-crisis recovery. In: *International Conference Knowledge-Based Organization*. Walter de Gruyter GmbH (2021)
9. Zhang, Y.J., Wu, Y.B.: The time-varying spillover effect between WTI crude oil futures returns and hedge funds. *Int. Rev. Econ. Financ.* **61**(MAY), 156–169 (2019)
10. Li, Y., Holland, A.S., Kazemi H.B.: Duration of poor performance and risk shifting by hedge fund managers. *Global Financ. Journal*, 2019, 40:35–47