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Research Paper

# Applying Verbal Decision Making and Multi-objective Fuzzy Optimization Approach in Portfolio Selection[1]

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## INTRODUCTION

Portfolio theory and the selection of the optimal stock portfolio, after the first efforts of Markowitz (1952), have always been one of the attractive research fields for researchers and investors in financial markets. One of the first criteria used by Markowitz in the traditional portfolio model is the expected rate of return and variance of the portfolio rate of return. The logic used in this model is the use of variance as a measure of the portfolio's risk. One of the newest and most effective risk measures is the Average Value at Risk (AVaR) measure. After the introduction of Value at Risk (VaR), AVaR was developed by Rockefeller and Yuriasov (2000). Despite the advantages it has in risk reporting, VaR has disadvantages such as not providing any information about the severity of losses greater than the desired probability level. Another weakness of this measure is not taking into account the diversification effect, and for this reason, it cannot be used as a consistent risk index (Artzner et al., 1999). AVaR is one of the most modern risk measures and is introduced as a consistent risk measure.

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Although Markowitz focused a lot on how to choose the optimal portfolio from among the various available assets, and the application of the mean-variance model in investments seems logical from a theoretical point of view, there are some problems in its practical application. The Markowitz model's lack of attention to investors' views in choosing the optimal portfolio is one of the most important problems that this research seeks to cover. Verbal Decision Analysis (VDA) is a new methodological method for making decision-making methods. This approach is based on cognitive psychology, applied mathematics, and computer science.

The purpose of this research is to design and use a multi-objective mathematical programming model to optimize the stock portfolio with risk criteria based on the qualitative opinions of investors. For this purpose, the parameters used in this research, such as the expected rate of return of the assets, are considered as fuzzy. Also, to achieve more realistic results, the consistent risk measure AVaR is used. On the other hand, by calculating the official quality index obtained from the ZAPROS III method, the investors' qualitative opinions are also added as a goal to the mentioned model. In addition to the main limitations in the portfolio optimization problem, other limitations such as the minimum and maximum amount of investment in assets and the minimum and maximum number of stocks in the portfolio were also considered.

In the end, to show the practical applicability of the model in the real investment environment, the model developed from the companies present in the Tehran Stock Exchange was used, and considering the nonlinear and multi-objective nature of the problem, the particle swarm optimization algorithm was used for solving. Multi-objective (MOPSO) is used for solving.

## RESEARCH METHODS

Among the features of this research, which distinguishes it from previous studies in the field of portfolio optimization, are the following:

1. The use of the average value-at-risk criterion, as a consistent risk criterion.
2. The inclusion of subjective judgments of investors using the ZAPROS III method as a goal.

The modeling process of this research is based on two main parts. The first part involves solving the verbal decision analysis problem with the ZAPROS III method, while the second part involves solving the multi-objective optimization problem, which consists of four steps. In the first step, the goals and indicators of the portfolio optimization problem are identified. Then, these goals and indicators are examined

based on the background of the research and the practical nature of the problem, and finally, after careful examination, the main indicators are selected. In the second step, using the principles of fuzzy credit theory, for the case where the expected rate of return of stocks is a triangular fuzzy number, each of these goals and limits are obtained under uncertainty. In the third step, based on the selected criteria, a fuzzy multi-objective model is designed, and in the fourth step, a suitable meta-heuristic method is used to solve and explain the problem.

Verbal Decision Analysis (VDA) is a new method that aids the decision-making process to provide a complete and satisfactory result. In this research, the ZAPROS III method was used, which is also one of the ZAPROS methods.

In this section, the method of solving the stock portfolio optimization model is presented. First, the multi-objective problem is solved with the MOPSO meta-heuristic algorithm, and the set of optimal solutions is obtained. Since the analytical solution of the model with the presence of fuzzy variables is difficult, the model is first transformed into a deterministic model. Then, considering that the model consists of several objectives, the problem can be solved through the multi-objective optimization algorithm, using Matlab software.

## RESULTS AND DISCUSSION

The output of this model will be a set of Pareto solutions, from which the investor can choose one or a set of those solutions as a suitable strategy for the model based on his subjective preferences. Figure 1 shows the optimal portfolios and the amount of objective functions of each portfolio in the portfolio model resulting from the implementation of the MOPSO algorithm.

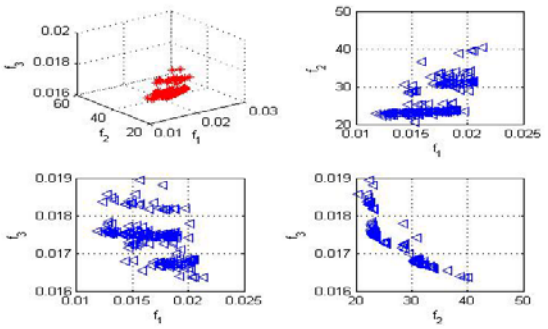


**Figure 1.** Pareto front resulting from the implementation of MOPSO algorithms

## CONCLUSION

The designed model has three goals, two of which are minimization and one is maximization. It also has limits on the maximum and minimum amount of investment in one share and the maximum and minimum number of shares that can exist in the desired portfolio. The MOPSO meta-heuristic algorithm was used to solve the model and obtain the Pareto front. Additionally, the results of running the algorithm and creating optimal portfolios were compared with the portfolios obtained from random weights, which showed a higher level of satisfaction of the objectives of the problem in all three objectives of the model. To compare the portfolios formed from the research with other portfolios, a random portfolio was created, and it was concluded that the obtained model is at a higher level than the random models in terms of the satisfaction of the goals. Of course, other criteria can be used for comparison, and naturally, the results may differ. Moreover, the results demonstrate that the use of multi-objective algorithms produces more diverse results in terms of criteria than the single-objective mode. Consequently, the use of the proposed methods in portfolio selection and optimization has been approved and is recommended. For future research, it is suggested to use other intelligent methods, such as the ant algorithm, colonial competition, and a combination of them, which are known as hybrid methods.

**Keywords:** Multi-objective Optimization of Portfolio, Credit Theory, ZAPROS III Method, MOPSO Algorithm.

**JEL Classification**: G11, G32, C02, D53.

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