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Solving multi-objective portfolio optimization problem using invasive weed optimization

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ABSTRACT

Portfolio optimization is one of the important issues for effective and economic investment. There is plenty of research in the literature addressing this issue. Most of these pieces of research attempt to make the Markowitz's primary portfolio selection model more realistic or seek to solve the model for obtaining fairly optimum portfolios. In this paper, *P*/*E* criterion and Experts' Recommendations on Market Sectors have been added to the primary Markowitz mean-variance model as two objectives. The *P*/*E* ratio is one of the important criteria for investment in the stock market, which captures the current expectations of the market activists about different companies. Experts' Recommendations for different Market Sectors, on the other hand, captures the experts' predictions about the future of the stock market. There are many solving methods for the portfolio optimization problem, but almost none of them investigates Invasive Weed Optimization algorithm (IWO). In this research, the proposed multi-objective portfolio selection model has been transformed into a single-objective programming model using fuzzy normalization and uniform design method. Some guidelines are given for parameter setting in the proposed IWO algorithm. The model is then applied to monthly data of top 50 companies of Tehran Stock Exchange Market in 2013. The proposed model is then solved by three methods: (1) the proposed IWO algorithm, (2) the Particle Swarm Optimization algorithm (PSO), and (3) the Reduced Gradient Method (RGM). The non-dominated solutions of these algorithms are compared with each other using Data Envelopment Analysis (DEA). According to the comparisons, it can be concluded that IWO and PSO algorithms have the same performance in most important criteria, but IWO algorithm has better solving time than PSO algorithm and better performance in dominating inefficient solutions, and PSO algorithm has better results in total violation of constraints.

1. Introduction

The development and preservation of financial power in every society is directly related to the reasonable and appropriate investment of that society; thus, organizations and people try to dedicate a part of their money or properties to investment. Investors are always trying to find an appropriate spot to invest, and they choose different ways for investment. One of these ways is investing in stock exchange markets and making portfolios. There are a lot of methods for making an appropriate portfolio; some of these methods are quantitative and some are non-quantitative. The major evolution in portfolio selection was presented by Markowitz in 1952 [1]. He minimizes the correlation between assets, which defines the risk of portfolio subjected to the given level of portfolio return value expected by the investor. His solving method is called Critical Line Method (CLM), that is not effective in models with large sizes [2]. He presented his Critical Line Method more comprehensively in another article in 1956 [3], and in 1959, he published a book which was about his own and other researchers' achievements in portfolio selection and solving methods [4]. To continue his work, researchers have always tried to make mathematical models of portfolio selection closer to reality, and help investors reach their objectives. They have also tried to reduce the impact of market volatility in order to reduce the negative effect on the investor and portfolio. To reach these purposes, researchers have used many approaches such as adding more objectives, adding more constraints, implementing robust optimization in the model, implementing fuzzy theory, etc.

In this study, it has been tried to make the model closer to reality through addition of two more objectives to Markowitz basic mean-variance model. These two objectives affect the model by involving the *P*/*E* criterion and recommendation of stock exchange market experts for market sectors into the model. The

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new multi-objective model is solved by three algorithms: Particle Swarm Optimization (PSO), Invasive Weed Optimization (IWO) and Reduced Gradient Method (RGM). In this study, Invasive Weed Optimization algorithm has been used for the first time to solve the portfolio selection problem, and its performance has been analyzed.

2. Literature review

2.1. Portfolio selection

Yoshimoto has added transaction costs to Markowitz's basic model and has solved it with non-linear programming techniques; the results of his analysis indicate that the portfolio selection model is not effective without considering transaction costs [5]. Konno and Suzuki incorporated skewness into Markowitz model, which was involved in assets rate of return, that affects portfolio selection a lot [6]. The addition of Cardinality Constraints by Chang et al. has been one of the major changes in the portfolio selection problem. Cardinality constraints limit the kinds of existing assets in the portfolio; they used genetic algorithm, simulated annealing, and tabu search for solving their proposed models with five sets of data. The results indicate that each algorithm shows excellence with particular sets of data [7]. Soleimani et al. added market sectors to Markowitz model as a constraint for the first time. In their research, cardinality constraints and minimization of transaction costs have been considered [8]. Oh et al. have also utilized market sectors in their model of portfolio selection, but their main effort was on Beta portfolio selection [9]. Golmakani and Fazel have used market sectors, too, and solved their model with Particle Swarm Optimization (PSO) [10]. Fuzzy theory has been involved in the portfolio selection problem, and plenty of research has been conducted on this subject. Fuzzy theory was introduced by Zadeh in 1965 [11]; he developed this theory also in 1978 [12]. Katagiri and Ishii used fuzzy theory in the portfolio selection problem for the first time [13]. Robust Optimization approach has also been included in the portfolio selection problem; Soyster introduced Robust Optimization approach in 1973 [14]. For the first time, Goldfarb and Iyengar used Robust Optimization approach in the portfolio selection problem [15]. Sadjadi et al. implemented Robust Optimization approach in Markowitz model with cardinality constraints, and solved their model with genetic algorithm [16]. Ghahtarani and Najafi incorporated Robust Optimization approach and Goal Programming in the multi-objective portfolio selection problem [17]. Most of the introduced models are multi-objective models. Thus, multi-objective solving methods are very common in the portfolio selection problem. It is almost impossible to find the optimized solution to existing models of portfolio selection in a large scale. Therefore, researchers tend to

Table 1
The most basic important developments of the portfolio selection problem.

Author(s)	Development	Year
Konno and Suzuki	Assets skewness	1995
Yoshimoto	Transaction costs	1996
Katagiri and Ishii	Using fuzzy method in Markowtiz model	1999
Chang et al.	Cardinality constraints	2000
Goldfarb and Lyengar	Using robust optimization approach in Markowtiz model	2003
Oh et al.	Beta portfolio selection	2006
Soleimani et al.	Sector constraint	2009

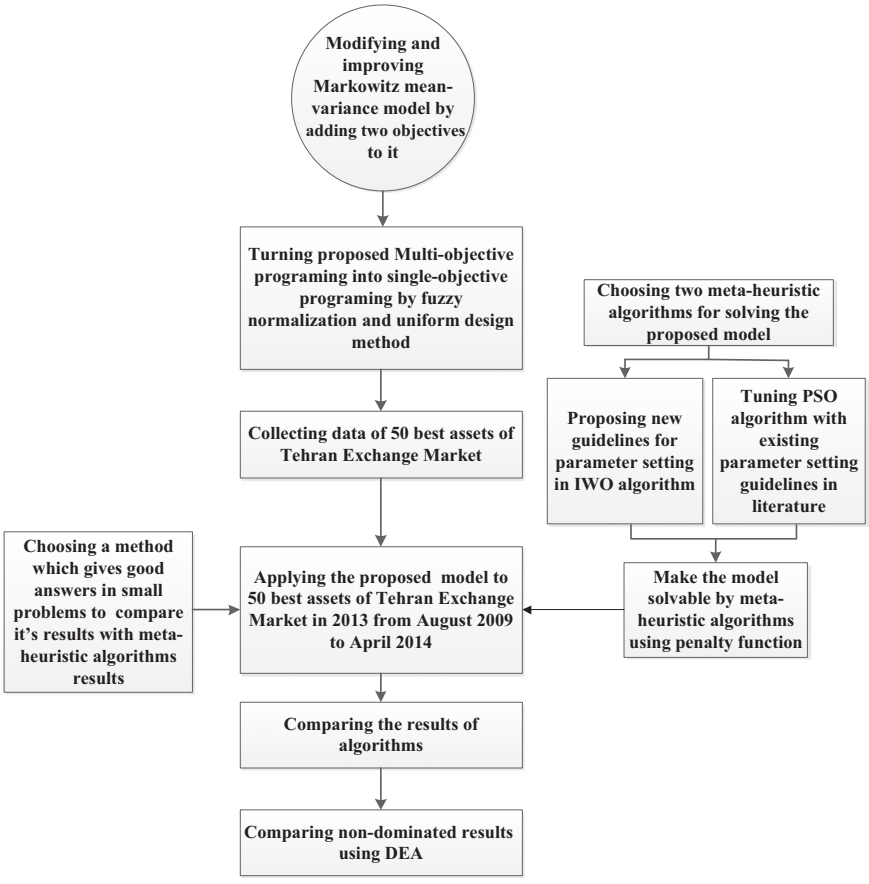

Fig. 1. The diagram of research outline.