International Journal of Applied Metaheuristic Computing
Volume 15 • Issue 1 • January-December 2024

Optimizing Stock Portfolio Using the Particle Swarm Optimization Algorithm and Assessing PSO and Other Algorithms

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ABSTRACT

When it comes to making financial decisions, choosing stocks is crucial to building a successful portfolio. Stocks are evaluated according to lower risk, and the best stocks are chosen to produce assets that are then utilized to construct the portfolio. In this study, we have compared the integrated particle swarm method to four other algorithms for stock selection and optimization: the genetic algorithm, the Pareto search algorithm, the pattern search algorithm, and quadratic programming in the Matlab toolbox. Six particular stock firms are taken into consideration for this reason during a given time period. First, we will use the aforementioned Matlab toolbox techniques to conduct Markowitz's mean variance model. Additionally, the usual embedded particle swarm methodology and the penalty function approach will be used to create this model. The difference between the averages at ten distinct levels of predicted values will be examined in the next research based on the returns in the chosen portfolios. Statistical tests will be employed to differentiate noteworthy distinctions between the suggested approach and the alternative algorithms. MSC: 65K10,91B05.

KEYWORDS

Markowitz's Model, Quadratic Programming, Genetic Algorithm, Particle Swarm Algorithm, Pareto-Search Algorithm, Pattern-Search Algorithm

1. INTRODUCTION

Numerous models have been developed throughout the course of the twentieth century in an attempt to guide investigators toward the right approach to modelling investments. Sector diversity and stock portfolio optimization have evolved into ideas that are used as tools for decision-making and the growth of financial markets. Since Markowitz's model was released, it has been applied as a useful tool for stock portfolio optimization and has brought about a number of adjustments and advances in the way researchers view investing and stock portfolios. While it may appear straightforward to minimize risk and maximize investment returns, creating an ideal portfolio really involves a number of techniques. Markowitz presented contemporary portfolio theory as a mathematical formula that

DOI: 10.4018/IJAMC.362001

embodies a classical approach (Markowitz 1952). His mean-variance approach gives information about a portfolio's risk by displaying the average anticipated return and variance. A lot of individuals have attempted to expand and alter Markowitz's concept. In the area of stock portfolio optimization, several studies have been conducted using a variety of models as well as numerical and clever techniques. See Kalayci et al. (2019); Ponsich et al. (2012); Thakkar and Chaudhari (2021); Zanjirdar (2020), for an outline of some of these examples. Articles Aranha and Iba (2009); Bazrkar and Hosseini (2023); Chang et al. (2009); Coello et al. (2007); Erwin and Engel- brecht (2023); Lin and Liu (2008); Wright (2006) (also see reviewer articles and books in Goldberg (1989); Gunjan and Bhattacharyya (2022); Zanjirdar (2020)) discuss the use of genetic algorithms, or GA, in stock portfolio optimization. As you shall see below, GA may be used to solve the constrained optimization problem as it is currently integrated into the Matlab toolbox. Furthermore, this software has other algorithms that can address the Markowitz portfolio optimization issue, including pattern-search, Pareto-search, and quadratic programming, or QP for short. However, when it comes to the PSO algorithm, the Matlab toolbox has just one unconstrained optimization toolbox.

When there are no linear restrictions, pattern search automatically searches for a minimum based on an adaptive mesh that is aligned with the coordinate directions. Pattern-search (see the algorithm in Audet and Dennis Jr (2002)) locates a series of locations $x_0, x_1, \ldots$ that converge to a minimal point.

The Pareto-search method iteratively looks for non-dominant points by applying pattern-search to a group of points. In every iteration, the Pareto-search meets all linear bounds and restrictions. The method should theoretically converge to locations around the actual Pareto front. See Custódio et al. (2011) for a discussion and proof of convergence, where the proof is used for Lipschitz continuous objective and constraint problems.

Recently, Kennedy and Eberhart (1995) presented a heuristic method called particle swarm optimization. While some PSO research has been done, virtually none of it addresses portfolio optimization for the mean-variance Markowitz model (Cura (2009)). For a complete overview of PSO applications in portfolio optimization, Thakkar and Chaudhari (2021) is a useful resource. Also, refer to recent advancements and applications of PSO in the works Bazrkar and Hosseini (2023); Erwin and Engelbrecht (2023); He and Huang (2014); Kuo and Chiu (2024); Liu and Li (2024); Song et al. (2023).

The suggested method's steps—data selection, data cleaning and preparation, objective function determination, stock portfolio selection based on GA, pattern search, Pareto search, and QP—are used in this article. These may be found in the Matlab toolbox, and the penalty function mentioned in Section 3 was used to create the PSO algorithm in Matlab. We employ non-parametric statistical tests to examine the numerical findings and present the optimal methods in Section 4. Using the Kruskal-Wallis test, the significance of the lack of differences between solutions produced by these algorithms has been investigated.

The paper presents a comprehensive analysis of portfolio optimization methods using various algorithms. Below are the main findings highlighted throughout the research:

1. Optimizing the stock portfolio using the penalty function method and PSO algorithm.
2. Optimization Algorithms Performance:
    - Algorithm Comparison: The study compares the performance of five algorithms: Particle Swarm Optimization (PSO), Quadratic Programming (QP), Genetic Algorithm (GA), Pareto Search, and Pattern Search.
    - Statistical Testing: The Kruskal-Wallis test was employed to statistically compare the performance of the algorithms against QP, showing no significant difference among the top-performing algorithms (PSO, Pareto Search, and Pattern Search) at a 1% significance level.
    - Effective Algorithms: PSO, QP, and Pareto search algorithms demonstrated superior performance in achieving optimal risk-return ratios compared to GA and Pattern Search.

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