

Response Letter

Response to the Reviewers

We sincerely thank the Editor and the Reviewers for their careful evaluation of our manuscript and for providing valuable comments and suggestions. We have carefully revised the manuscript accordingly, and we believe that the revised version has been substantially improved in terms of methodological clarity, experimental rigor, and presentation. Our point-by-point responses are provided. All changes have been incorporated into the revised manuscript.

Response to Reviewer A:

1. Please provide a clearer methodological basis for selecting the top 20 stocks and briefly examine whether the main results are sensitive to the number of selected assets.

Response:

Thank you for this valuable suggestion. We have substantially revised the “*Data Processing and Asset Selection*” subsection to clarify the rationale behind selecting the top 20 assets. Specifically, we explain that, at each rebalancing period, all eligible NASDAQ-100 constituent stocks are ranked according to their Sharpe Ratio (SR) estimated exclusively from the historical estimation window. The highest-ranked stocks are then selected as the candidate asset universe for specific rebalancing period. We further explain that selecting twenty assets represents a practical compromise between maintaining sufficient portfolio diversification and limiting the optimization dimensionality, thereby improving computational efficiency.

In addition, we have included a brief discussion regarding the sensitivity of the optimization problem to the number of selected assets. The manuscript now explains that increasing the number of selected assets enlarges the search space and increases time complexity, while a smaller candidate universe reduces computational cost but may limit diversification. This discussion has been incorporated into the revised manuscript.

2. Please complement the descriptive comparison of repeated runs with an appropriate statistical test to clarify whether the performance differences among the algorithms are statistically meaningful.

Response:

Thank you for this important suggestion. We have added a new subsection entitled “*Statistical Significance Analysis*.” Specifically,

- Friedman test was first conducted to determine whether statistically significant differences exist among the eight metaheuristic algorithms over all evaluated performance metrics;
- pairwise Wilcoxon signed-rank tests were subsequently performed using HOA as the reference algorithm.

The manuscript now reports the Friedman statistics and corresponding p-values, together with a summary table of the Wilcoxon test results. These analyses demonstrate that many of the observed performance differences are significant rather than being solely attributable to the stochastic nature of the optimization algorithms.

3. Please include a concise sensitivity analysis of the main HOA parameters, particularly population size and maximum iterations.

Response:

Thank you for this suggestion. A new subsection entitled “*Sensitivity Analysis*” has been added. The analysis investigates the influence of the HOA population size by varying the number of search agents while repeating the optimization 25 independent times for each configuration.

The optimization behavior is analyzed using violin plots at four representative optimization stages (Iterations 25, 125, 500, and 1750). The results demonstrate that although larger populations provide slightly greater diversity during the exploration stage, all tested population sizes converge toward nearly identical fitness distributions after sufficient iterations. Consequently, the HOA exhibits low

sensitivity to population size within the investigated range. This result indicating strong robustness of the proposed algorithm.

Response to Reviewer B:

1. Please revise the evaluation framework to reduce look-ahead bias by separating asset selection, parameter estimation, portfolio optimization, and performance evaluation chronologically through a rolling, expanding, or walk-forward scheme.

Response:

Thank you for this valuable observation. The evaluation framework has been substantially revised by adopting a walk-forward evaluation scheme. The manuscript now explicitly separates parameter estimation, asset selection, optimization, and performance evaluation in chronological order.

For each rebalancing period, expected returns, covariance matrix, volatility, and SR are estimated exclusively from historical observations available prior to the portfolio formation date. Based on these estimates, the twenty highest-ranked stocks are selected for the current rebalancing period, after which HOA optimizes the portfolio weights. Portfolio performance is then evaluated only during the subsequent investment period. The estimation window is subsequently rolled forward, and the entire process is repeated. This revision eliminates the use of future information during portfolio construction and substantially reduces look-ahead bias.

2. Please address the survivorship bias arising from retaining only stocks continuously included in the NASDAQ-100 during 2021-2025. Historical constituents are preferable; otherwise, this limitation and its possible effect on the results should be clearly acknowledged.

Response:

Thank you for pointing out this important issue. Because historical constituent datasets were not consistently available for the entire study period, the present study retains only companies that continuously listed in the NASDAQ-100 to ensure data consistency. To properly acknowledge this limitation, we have expanded the “*Limitations of the Study*” subsection.

The revised manuscript explicitly discusses both survivorship bias and the potential implications of using a fixed universe of continuously listed companies. We also clarify that the reported results should primarily be interpreted as an evaluation of the optimization capability of the proposed HOA framework under a fixed candidate universe rather than the performance of a fully implementable real-time investment strategy.

3. Please incorporate transaction costs consistently into both the optimization objective and the cumulative wealth calculation, then update the related performance results accordingly.

Response:

Thank you for this suggestion. Transaction costs are now consistently incorporated into both the optimization objective and the cumulative wealth calculation. The cumulative portfolio presented in the revised manuscript is computed after deducting proportional transaction costs at every portfolio rebalancing period. The revised manuscript now explicitly states this calculation procedure, while also clarifying that the Equal Weight Portfolio (EWP) and NASDAQ-100 benchmark are treated as passive buy-and-hold strategies and therefore incur no transaction costs. All cumulative performance results and associated discussions have been updated accordingly.

4. Please clarify and harmonize the time scale of expected return, covariance, risk-free rate, and transaction cost in the Net Sharpe Ratio formulation.

Response:

Thank you for helpful suggestion. The methodological description has been revised to consistently annualize expected returns, variances, covariance matrix, and the risk-free rate using 252 trading days per year. The manuscript now explicitly states the annualization procedure and clarifies that transaction costs are deducted at each rebalancing event before computing the Net Sharpe Ratio, ensuring consistency among all quantities appearing in the optimization objective.

5. Please clarify the methodological role of the hypervolume and Pareto-set analysis. If the study remains single-objective, this part may be removed to maintain consistency.

Response:

Thank you for this observation. Following the reviewer's recommendation, the hypervolume and Pareto-set analysis has been removed from the revised manuscript because the proposed portfolio optimization framework is formulated as a single-objective optimization problem. Removing this section improves methodological consistency throughout the paper.

6. Please avoid relying only on the best result from 25 runs for the overall portfolio evaluation. A representative mean or median result, accompanied by suitable dispersion measures, would provide a more balanced assessment.

Response:

Thank you for this suggestion. The cumulative portfolio evaluation has been revised accordingly. Rather than reporting only the best optimization result, all cumulative performance metrics are now reported as the mean $\pm$ standard deviation over 25 independent optimization runs. Furthermore, the cumulative portfolio value shown in the corresponding figure now represents the mean cumulative portfolio wealth across the repeated runs. The manuscript explicitly states this evaluation procedure, thereby providing a more representative assessment of algorithm performance.

Response to the Editor

1. Please complete the submission metadata by listing all authors exactly as presented in the manuscript, together with their complete affiliations and required author information.

Response:

The submission metadata have been completed and verified to ensure consistency with the revised manuscript, including all author names, affiliations, and required author information.

2. Please add a brief transition paragraph after the "*Results and Discussion*" section heading and before the first subsection.

Response:

A brief introductory paragraph has been added after the "*Results and Discussion*" section heading to provide an overview of the analyses presented in the subsequent subsections and improve the overall flow of the manuscript.

3. Please complete every reference with its DOI. For references without a DOI, please provide a valid URL.

Response:

DOI information has been added for every reference.