### Analysis of Implementation: Evaluation of the portfolio on unseen "future" data

Your implementation correctly applies the weights derived from the GA optimization to both the training data (2017-2022) and the unseen future data (2023) to evaluate how the portfolio performs on new data compared to the historical data it was trained on. By calculating the Sharpe ratio for both periods, you've provided a clear metric for comparing performance across the two datasets.

Sharpe Ratio Calculation: The Sharpe ratio is a measure of risk-adjusted return, and higher values generally indicate better performance relative to the risk taken. It is calculated as the ratio of the excess return of the portfolio over the risk-free rate to the standard deviation of the portfolio returns. In your case, you've simplified the calculation by not subtracting a risk-free rate, which is a common approach for relative comparisons when the risk-free rate is assumed constant or negligible.

Training Data Sharpe Ratio (0.0753): This value suggests that, for the historical period, the portfolio was generating returns at a certain level of risk. The Sharpe ratio here serves as a benchmark for what was achieved with the training data.

Test Data Sharpe Ratio (0.1486): The higher Sharpe ratio on the test data indicates that the portfolio, when applied to the unseen data of 2023, performed better in terms of risk-adjusted returns compared to the training period. This suggests that the portfolio not only managed to capture some of the positive dynamics of the market but also did so at a level of risk that was well-compensated by the returns.

Portfolio Performance on Unseen Data

Given that the Sharpe ratio for the test data is approximately double that of the training data, it indicates that your portfolio is doing well on unseen "future" data. This improvement could be due to several factors:

Market Conditions: The market conditions in 2023 might have been particularly favorable for the asset mix in your portfolio. This could mean that the sectors or specific stocks chosen had a good year relative to their historical performance.

Diversification Benefits: The diversification strategy embedded in your GA-optimized weights might have effectively capitalized on the positive movements of certain assets while mitigating risks from others.

Robust Optimization: The GA optimization process may have found a set of weights that not only performed well historically but also were robust enough to adapt to changing market conditions, emphasizing the optimization's effectiveness.

### Comparison of the evolved portfolio with balanced and random portfolios

|  |  |  |
| --- | --- | --- |
| WEIGHT CONSTRAINED TO 1 | **TRAINING DATA (2012 TO 2016)** | **TEST DATA (2017)** |
| **Sharpe Ratio for GA-evolved Portfolio** | 0.1005712 | 0.2026602 |
| **Sharpe Ratio for Balanced Weighted Portfolio** | 0.09305794 | 0.2045046 |
| **Sharpe Ratio for randomly weighted Portfolio** | 0.08884422 | 0.1912457 |
|  |  |  |
| **Sharpe ratio for GA-preselected weights** | 0.1099059 | 0.1464304 |

#### Observations for balanced weighted portfolio:

Training Period Performance: During the training period (2018-2022), your GA-evolved portfolio outperformed the balanced portfolio with a Sharpe ratio of 0.0753 compared to 0.065. This suggests that the GA optimization was effective in selecting a set of weights that provided a better risk-adjusted return than simply distributing the weights evenly across all assets.

Test Period Performance: Interestingly, in the test period (2023), the balanced portfolio achieved a slightly higher Sharpe ratio of 0.151652 compared to 0.1486 for the GA-evolved portfolio. This reversal indicates that, for the specific period of 2023, a simple balanced approach managed to slightly outperform the more sophisticated GA-optimized portfolio in terms of risk-adjusted returns.

Analysis and Implications:

Adaptability and Market Conditions: The performance of the balanced portfolio in the test period suggests that market conditions in 2023 might have favored a more diversified approach without heavy weighting toward specific assets. It underscores the importance of adaptability in investment strategies, as market dynamics can shift, altering the effectiveness of previously optimized portfolios.

Both your GA-evolved and balanced portfolios have their merits, with the GA approach showing strength in the historical period and the balanced approach edging out in the future period. This comparison highlights the nuanced nature of portfolio optimization and the difficulty of predicting future market movements. It suggests a potential avenue for further exploration, perhaps by incorporating mechanisms to adjust portfolio weights dynamically in response to changing market conditions or by exploring hybrid approaches that combine elements of both strategies.

#### Observations for randomly weighted portfolio:

During the training period, your GA-evolved portfolio outperformed the average randomly generated portfolio. The higher Sharpe ratio indicates that, relative to its risk, the GA-evolved portfolio achieved a better return. This suggests that the optimization process effectively identified a set of weights that capitalized on the available returns more efficiently than what could be expected from random allocation on average.

Test Period (2023)

GA-evolved Portfolio Sharpe Ratio: 0.1486

Average Random Portfolio Sharpe Ratio: 0.0922

For the test period, the GA-evolved portfolio significantly outperformed the average randomly generated portfolio. The improvement in Sharpe ratio from the training to the test period for the GA-evolved portfolio not only shows that the portfolio was well-optimized for unseen data but also that it was able to generalize beyond the specific market conditions of the training period. The random portfolio's Sharpe ratio also improved in the test period but not nearly as much as the GA-evolved portfolio's, further underscoring the effectiveness of the optimization process.

Comparison Summary

Effectiveness of GA Optimization: The comparison highlights the effectiveness of the genetic algorithm in optimizing the portfolio's weights to achieve a superior risk-adjusted return. While random portfolios provide a baseline for what might be expected from non-strategic allocations, the GA-evolved portfolio demonstrates the value of systematic optimization.

Generalization to Unseen Data: The significant improvement in the Sharpe ratio for the GA-evolved portfolio during the test period (2023) suggests that the optimization process has not only tailored the portfolio to the historical data but also equipped it to perform well under different market conditions. This is an important quality of any investment strategy, indicating robustness and adaptability.

Insights on Portfolio Construction: The comparison offers valuable insights into portfolio construction. While randomness can sometimes capture favorable allocations, a systematic approach like GA optimization is more likely to consistently identify efficient risk-return trade-offs. This becomes particularly apparent when comparing the performance improvements from the training to the test period.

**Comparison between Manaully selected assets and GA-evolved**

**Training Data Performance:**

Manually Selected Portfolio: Sharpe Ratio = 0.1005712

GA Selected Portfolio: Sharpe Ratio = 0.1099059

Insight: The GA-selected portfolio outperforms the manually selected portfolio during the training period, albeit by a modest margin. This suggests that the GA, with its objective of maximizing historical returns, was able to identify a combination of assets that, at least historically, offered a slightly better risk-adjusted return than the manually chosen set. This improvement, while not dramatic, illustrates the potential of using algorithmic methods to enhance portfolio selection based on past performance.

**Test Data Performance:**

Manually Selected Portfolio: Sharpe Ratio = 0.2026602

GA Selected Portfolio: Sharpe Ratio = 0.1464304

Insight: During the test period, the manually selected portfolio significantly outperforms the GA-selected portfolio in terms of Sharpe Ratio. This indicates that the manually selected portfolio was better positioned to capitalize on the market conditions present during the test period, offering a higher risk-adjusted return. This divergence could suggest several things, such as the GA-selected portfolio being more tailored to the historical data at the expense of generalizability, or the manually selected portfolio incidentally comprising assets that performed particularly well during the test period.