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A Deep Dive into Portfolio Optimisation

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Abstract

Background: Selecting an optimal portfolio allocation across a universe of assets is a central problem in investment management. While mean-variance optimisation, first proposed by Markowitz (1952), provides a theoretically principled framework, its out-of-sample performance has proven disappointing in practice. This study empirically compares four portfolio strategies to assess whether model sophistication translates into superior investment performance.

Methodology: This study implements and compares four portfolio strategies: equal weight, Markowitz mean-variance, Black-Litterman and Risk Parity applied to an 18-asset UK multi-asset portfolio comprising 15 FTSE 100 equities, a UK government bond ETF, a gold ETC and a broad commodities ETF, over the period January 2015 to December 2025. Strategies are evaluated using a monthly rebalancing framework and assessed across annualised return, volatility, Sharpe ratio, maximum drawdown and portfolio turnover.

Results: We find results broadly consistent with DeMiguel et al. (2009), with the naive benchmark proving difficult to displace on a risk-adjusted basis over the full sample period. The optimisation strategies exhibit meaningfully different risk profiles, however, suggesting that Sharpe ratio alone does not fully capture the practical trade-offs between approaches.

Key words: Portfolio optimisation ; mean-variance ; Black-Litterman ; Risk Parity ; backtesting

1 Introduction

1.1 The Portfolio Allocation Problem

The portfolio allocation problem is the fundamental question in investment management. It asks: How should capital be distributed across available investment opportunities to best achieve an investor's objectives?

The problem was intractable until 1952, when Harry Markowitz published *Portfolio Selection* in the *Journal of Finance* and turned it into a clean optimisation problem, and the "efficient frontier" gave investors a principled answer. Markowitz's mean variance model minimises portfolio variance for a given level of expected return. It was revolutionary in the consideration of variance as the risk, standing as a hallmark of modern portfolio theory. In practice however, the model has proven difficult to implement reliably.

Michaud (1989) challenged this view directly, arguing that small estimation errors in expected returns produce wildly unstable portfolio recommendations.

In 2009, DeMiguel et al. delivered a provocative result: he found that even sophisticated strategies incorporating shrinkage estimators and Bayesian methods failed to consistently outperform 1/N out-of-sample, suggesting that estimation error dominates theoretical optimality for typical portfolio problems. This tension between the theoretical elegance of optimisation and its empirical fragility motivates the present study.

1.2 Background and Research Objectives

This study addresses three main questions:

i. Do optimisation models outperform a naive 1/N benchmark out-of-sample, applied to a multi-asset UK portfolio over a ten-year period?
ii. Which model offers the best risk-adjusted performance, as measured by the Sharpe ratio?
iii. How does model performance vary across distinct market regimes: the Brexit referendum (2016), the COVID-19 crash (2020), and the 2022 rate-hiking cycle?

1.3 Summary of Findings

1.4 Structure of the Report

The remainder of this report is organised as follows:
Section 2 reviews the theoretical foundations of each model and derives their key mathematical results. Section 3 describes the data, implementation choices, and backtesting framework. Section 4 presents

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Key Points

- Key finding or takeaway 1.
- Key finding or takeaway 2.
- Key finding or takeaway 3.

Figure 1. Descriptive caption for your figure.

Table 1. Descriptive caption for your table.

Category	Metric 1	Metric 2	Metric 3
Group A	0.00	0.00	0.00
Group B	0.00	0.00	0.00
Group C	0.00	0.00	0.00

Note: Explain any specific details about the data in the table.

the empirical results, including full-period performance metrics and a breakdown by market regime. Section 5 discusses the findings and their practical implications. Section 6 concludes.

2 Methodology

This section details the design of your study, the data used, the models applied, and the analytical framework. The goal is to provide enough detail for another researcher to replicate your work.

2.1 Data Acquisition and Processing

Describe the data you used, where you got it from (e.g., Bloomberg, Refinitiv, web scraping), and any steps you took to clean, process, or transform it. Mention the time period and frequency of the data.

2.2 Analytical Models

Describe the quantitative or qualitative models used in your analysis. Include mathematical formulations if applicable. For example, if you are using a regression model, you would specify it here:

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \epsilon \tag{1}$$

Explain the variables and the assumptions of the model.

2.3 Backtesting or Validation Framework

If you are testing a strategy, describe the backtesting framework. Mention key parameters like rebalancing frequency, transaction cost assumptions, and performance metrics used.

3 Results and Discussion

This section presents the key findings from your analyses and interprets their significance. Use figures and tables to present your results clearly.

3.1 Primary Findings

Present your main results. This could be in the form of tables summarizing statistical outputs, or charts showing trends and relationships.

3.2 Interpretation of Findings

Discuss what your results mean. How do they relate to your initial research question? Are they consistent with existing literature? What are the implications of your findings?

4 Conclusion and Future Work

Summarize the main conclusions of your research. Reiterate the key insights and their importance.

Future work could include:

- Exploring alternative methodologies or datasets.
- Addressing limitations of the current study.
- Expanding the research to a different market or asset class.

5 Declarations

5.1 Author Contributions

Briefly describe the contribution of each author to the research and writing of the report. For example: "A.B. designed the research. C.D. collected the data. E.F. performed the analysis. All authors contributed to writing the report."

5.2 Competing Interests

The authors declare that they have no competing interests.

5.3 Funding

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5.4 Acknowledgements

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