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Portfolio Optimization using Modern Portfolio Theory

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ABSTRACT

In a world of countless investment choices and ever-present risk, the scientific construction of efficient, diversified portfolios is one of the most important tasks in investment management. Modern Portfolio Theory (MPT), developed by Harry Markowitz, provides the foundational framework for this task by showing how the combination of imperfectly correlated assets can reduce risk for a given level of return. The present study applies this framework to the securities of three leading financial-sector companies — Goldman Sachs, HSBC, and HDFC Bank — to construct and evaluate an optimised portfolio.

The study adopts an analytical and quantitative research design based on secondary data, namely the annual returns of the three stocks over the five-year period 2021 to 2025. Average returns, variances, standard deviations, covariances, and correlations of the stocks were computed, and mean-variance optimization was applied to construct the minimum-risk and maximum-Sharpe (optimal) portfolios and the efficient frontier, with performance evaluated using the Sharpe ratio.

The findings reveal that Goldman Sachs gave the highest average return (32.34%) but also the highest risk, while HDFC Bank, with a low correlation to the other stocks, served as an effective diversifier. The equal-weighted diversified portfolio achieved a risk of 13.27%, significantly lower than the weighted-average risk of the individual stocks (16.64%), and the optimal portfolio achieved the best risk-adjusted return with a Sharpe ratio of 1.19. The hypothesis test confirmed that optimization significantly reduced risk, leading to rejection of the null hypothesis. The study concludes that portfolio optimization using Modern Portfolio Theory is an effective tool for constructing efficient portfolios, and offers suggestions on diversification, risk-adjusted selection, and use of the efficient frontier for investors.

Keywords: Portfolio Optimization, Modern Portfolio Theory, Markowitz Model, Mean-Variance Optimization, Efficient Frontier, Diversification, Sharpe Ratio, Risk and Return.

1. Introduction

Every investor, from the individual saver to the largest institution, faces the same fundamental problem: how to allocate a limited pool of money among many possible investments so as to earn the highest possible return for the least possible risk. The systematic, scientific answer to this problem is the subject of portfolio optimization, and the theory that first made such optimization possible is Modern Portfolio Theory (MPT).

A portfolio is a collection of financial investments such as shares, bonds, mutual funds, and other assets held by an investor. Portfolio optimization is the process of selecting the best combination and proportions (weights) of assets in a portfolio so as to maximise return for a given level of risk, or minimise risk for a given level of return. Modern Portfolio Theory was developed by the economist Harry Markowitz, whose seminal paper 'Portfolio Selection', published in 1952, earned him the Nobel Prize in Economics in 1990. Markowitz's revolutionary insight was that what matters is not the risk and return of each security in isolation, but the risk and return of the portfolio as a whole, and that the way securities move in relation to one another is decisive.

The central idea of MPT is the power of diversification: by combining assets whose returns do not move perfectly together, an investor can reduce overall portfolio risk without necessarily sacrificing return. Risk is measured by the variance (or standard deviation) of returns, and return by the expected (mean) return — hence MPT is often called the mean-variance model. Plotting every possible portfolio on a risk-return graph traces the efficient frontier, the set of portfolios offering the highest expected return for each level of risk. When a risk-free asset is combined with risky portfolios, the tangency point with the efficient frontier identifies the optimal risky portfolio, and performance is

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judged using risk-adjusted measures such as the Sharpe ratio.

The relevance of portfolio optimization has grown enormously with the development of financial markets, including in India, as retail and institutional investing, mutual funds, portfolio management services, and computing power have made scientific portfolio construction both possible and necessary. MPT does rest on assumptions — rational, risk-averse investors, normally distributed returns, and stable correlations — that do not always hold, particularly during market crises when correlations tend to rise; later developments such as post-modern portfolio theory and behavioural finance address these limitations, though MPT remains the indispensable foundation.

The present study applies Modern Portfolio Theory to the optimization of a portfolio constructed from the securities of three leading financial-sector companies — Goldman Sachs, HSBC, and HDFC Bank. Using historical annual return data over 2021–2025, the study computes the returns, risks, and correlations of the selected stocks, constructs an optimised portfolio using the mean-variance framework, and evaluates its risk and return, thereby demonstrating the practical application and benefits of portfolio optimization using MPT for investors constructing efficient, diversified portfolios.

2. Literature Review

The following review of recent research (2015–2025), including Indian studies, examines portfolio optimization, the Markowitz model, the efficient frontier, and risk-return analysis, providing the foundation for the present study.

1. Application of Markowitz Mean-Variance Model in Portfolio Optimization (2025), International Journal of Creative Research Thoughts, 13(11). Applied the Markowitz mean-variance model to construct optimal portfolios from NSE/BSE-listed companies, computing return, risk, covariance, and the efficient frontier, and demonstrated that mean-variance optimization helps balance risk and return in a volatile market.

2. Optimization of Portfolio using Markowitz's Modern Portfolio Theory (2024), International Journal of Scientific Research in Engineering and Technology, 12(5). Applied Markowitz's MPT using real-world stock data and Python, generating random portfolios and using quadratic programming to trace the efficient frontier, showing how computational methods identify risk-minimising or return-maximising portfolios.

3. Sen, A., & Sen, J. (2024). Application of the Markowitz Model in Portfolio Optimization: A Study of Selected NSE Sectors. Compared equal-weight, minimum-risk, and optimum-risk portfolios across thirteen NSE sectors and found that optimised portfolios offer a better risk-return trade-off than naive equal-weight portfolios.

4. Verma, A., & Srivastava, T. (2024). Two-Asset Portfolio Optimization Using MPT on BSE 100 Stocks. Constructed optimal two-asset portfolios from ten BSE 100 large-cap stocks, identifying low-correlation pairs to maximise diversification and confirming that combining low-correlation stocks reduces portfolio risk.

5. A Study on Portfolio Management and Optimization with Reference to Selected Stocks (2023), International Journal of Research Publication and Reviews. Examined portfolio optimization using selected stocks and found that a diversified, optimised portfolio reduces risk relative to investing in individual stocks.

6. Construction of Optimal Portfolio Using Sharpe's Single Index Model (2023), International Journal of Creative Research Thoughts, 11(4). Constructed an optimal portfolio using the excess-return-to-beta ratio and cut-off rate of Sharpe's Single Index Model, an approach closely related to MPT.

7. Risk and Return Analysis of Selected Stocks for Portfolio Construction (2024), International Journal of Research Publication and Reviews. Found that the risk of a diversified portfolio of selected stocks was lower than the weighted-average risk of the individual stocks, confirming the diversification benefit central to MPT.

8. A Comprehensive Survey of Modern Portfolio Optimization: From Traditional Risk Analysis to Machine Learning (2025), ResearchGate. Surveyed portfolio construction among six listed Indian companies using the Markowitz model and confirmed that efficient diversification is achievable in the Indian market.

9. Muller, H. H. Modern Portfolio Theory: Some Main Results, ASTIN Bulletin. Presented the main theoretical results of MPT, deriving the Capital Asset Pricing Model from the Markowitz approach and providing a rigorous theoretical foundation for portfolio optimization.

10. Practical Application of Modern Portfolio Theory, DiVA Portal finance research thesis. Illustrated the construction of the efficient frontier and demonstrated the practical benefit of diversification across more than one stock.

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11. Portfolio Optimization and the Efficient Frontier: A Practical Approach. Explained the Maximum Sharpe Ratio Portfolio within the mean-variance framework and set out the mathematical formulation used in constructing optimal portfolios.

12. A Study on Construction of Optimal Equity Portfolio of Selected Companies (2022), International Journal of Creative Research Thoughts. Found that an optimised equity portfolio, built using mean-variance analysis, achieved a better risk-return position than the individual constituent stocks.

13. Portfolio Optimization Using the Markowitz Model: Evidence from the Indian Stock Market (2023), International Journal for Multidisciplinary Research. Applied the Markowitz model to Indian stocks and confirmed that it produces efficient, diversified portfolios that lower risk for a given return.

14. Application of Sharpe Ratio and CAPM in Portfolio Performance Evaluation (2023), International Journal of Research Publication and Reviews. Applied the Sharpe ratio and CAPM to evaluate portfolio performance, showing that risk-adjusted measures are essential for assessing optimised portfolios.

15. Diversification and Risk Reduction in Equity Portfolios: An Empirical Study (2024), International Journal of Creative Research Thoughts. Empirically showed that combining stocks with low or negative correlations lowers overall portfolio standard deviation, providing direct support for MPT's central principle.

16. Markowitz Meets Bellman: Portfolio Management Using the Efficient Frontier (2024), arXiv. Set out the full mathematical formulation of the Markowitz efficient frontier in a modern computational setting, reinforcing the mathematical foundation of portfolio optimization.

17. Mean-Variance Optimization and Portfolio Selection: A Review (2022), International Journal of Research Publication and Reviews. Traced the mean-variance approach from Markowitz's 1952 work to its modern applications, reviewing the roles of expected return, variance, and covariance.

18. A Study on Optimal Portfolio Construction Using Selected Banking Stocks (2023), International Journal of Creative Research Thoughts. Found that a diversified portfolio of banking-sector stocks reduced risk relative to individual stocks, directly relevant to the present financial-sector portfolio.

19. Risk-Return Trade-off and Efficient Portfolio Construction in Indian Markets (2024), International Journal for Multidisciplinary Research. Applied mean-variance analysis to Indian stocks, constructing the efficient frontier and confirming the applicability of MPT to Indian equity portfolios.

20. Markowitz, H. (1952). Portfolio Selection. The Journal of Finance, 7(1), 77–91. The foundational paper that introduced the mean-variance framework, established the principle of diversification and the efficient frontier, and earned Markowitz the Nobel Prize in 1990; the foundational reference for the present study.

Taken together, this body of literature establishes that Modern Portfolio Theory, since Markowitz's foundational 1952 work, provides a consistently validated framework across global and Indian markets: diversification among imperfectly correlated assets reduces portfolio risk, mean-variance optimization identifies efficient portfolios, and risk-adjusted measures such as the Sharpe ratio are essential for evaluating performance. A research gap remains, however, in studies that combine major global investment banks with a leading Indian bank in a single optimised portfolio using recent five-year data — the gap the present study addresses.

3. Objectives of the Study

1. To study the concept of portfolio optimization and Modern Portfolio Theory.
2. To compute the risk and return of the selected stocks (Goldman Sachs, HSBC, and HDFC Bank) over the study period 2021–2025.
3. To construct an optimised portfolio of the selected stocks using the mean-variance framework and to evaluate its risk and return.
4. To offer findings and suggestions on portfolio optimization for investors.

4. Research Methodology

The study adopts an analytical and quantitative research design based entirely on secondary data — the annual returns of three leading financial-sector companies, Goldman Sachs, HSBC, and HDFC Bank, over the five-year period 2021 to 2025. Data was collected from stock exchanges (NSE/BSE, NYSE, and LSE), financial databases such as Yahoo

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Finance, Moneycontrol, and Investing.com, and the annual reports and investor-relations pages of the three companies. The analysis applies return and risk analysis, covariance and correlation analysis, mean-variance (Markowitz) optimization, and risk-adjusted performance measurement (the Sharpe ratio), computed in MS Excel.

Hypothesis: H_0 — Portfolio optimization using MPT does not significantly reduce risk (the optimised portfolio's risk is not lower than the weighted-average risk of the individual stocks). H_1 — Portfolio optimization using MPT significantly reduces risk, confirming the benefit of diversification.

5. Data Analysis and Interpretation

This section presents the analysis and interpretation of the secondary data for the construction and optimization of a portfolio of the securities of three leading financial-sector companies — Goldman Sachs (GS), HSBC, and HDFC Bank — by applying Modern Portfolio Theory over the five-year period 2021 to 2025. The annual returns of the three stocks were used to compute average returns, risks (standard deviation), covariances, and correlations, and the mean-variance framework was applied to construct an optimised portfolio and evaluate its risk and return.

Table 1: Annual Returns (%) of the Selected Stocks (2021–2025)

Year	Goldman Sachs (%)	HSBC (%)	HDFC Bank (%)
2021	45.00	1.50	-9.60
2022	-7.87	-1.00	6.23
2023	15.91	24.00	0.16
2024	52.03	25.00	-2.53
2025	56.64	38.00	21.16

Source: Compiled and computed from the historical share-price data of the companies (NYSE, LSE, and NSE).

Interpretation: Goldman Sachs delivered strong returns in most years (notably +52% in 2024 and +57% in 2025), HSBC delivered steady and rising returns, while HDFC Bank's returns were modest and volatile, including negative years, before recovering strongly in 2025 — the differing patterns underpin the case for diversification.

Table 2: Risk-Return Summary of the Stocks

Stock	Average Return (%)	Risk — SD (%)	Return per Unit of Risk
Goldman Sachs	32.34	24.60	1.31
HSBC	17.50	14.95	1.17
HDFC Bank	3.08	10.37	0.30

Source: Compiled and computed from the historical share-price data of the companies (NYSE, LSE, and NSE).

Interpretation: Goldman Sachs offers the highest average return (32.34%) but also the highest risk (24.60%), while HDFC Bank offers the lowest of both (3.08% and 10.37%). On a return-per-unit-of-risk basis, HSBC offers the best ratio (1.17), showing that the highest-return stock is not necessarily the most efficient once risk is taken into account.

Table 3: Correlation Matrix of the Stocks

	Goldman Sachs	HSBC	HDFC Bank
Goldman Sachs	1.00	0.59	0.07
HSBC	0.59	1.00	0.59
HDFC Bank	0.07	0.59	1.00

Source: Compiled and computed from the historical share-price data of the companies (NYSE, LSE, and NSE).

Interpretation: Goldman Sachs and HSBC show a positive correlation (0.59), while HDFC Bank shows a low correlation with both Goldman Sachs (0.07) and HSBC (0.59). This low correlation makes HDFC Bank an excellent

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diversifier, as combining it with the other stocks substantially reduces portfolio risk. The equal-weighted portfolio (one-third in each stock) accordingly achieved a risk of 13.27%, well below the weighted-average risk of the individual stocks of 16.64% — a diversification benefit of 3.36 percentage points.

Table 4: Optimised Portfolios using Mean-Variance Optimization

Optimised Portfolio	GS (%)	HSBC (%)	HDFC (%)	Return (%)	Risk (%)
Minimum-Risk Portfolio	15	0	85	7.47	9.79
Maximum-Sharpe (Optimal) Portfolio	65	35	0	27.15	19.53

Source: Computed by mean-variance optimization (risk-free rate assumed at 4%).

Interpretation: The minimum-risk portfolio allocates most weight to the lower-risk, low-correlation stocks, achieving the lowest possible risk of 9.79%. The maximum-Sharpe (optimal) portfolio — allocating 65% to Goldman Sachs and 35% to HSBC, with 0% to HDFC Bank — gives the best risk-adjusted return, at 27.15% return for 19.53% risk.

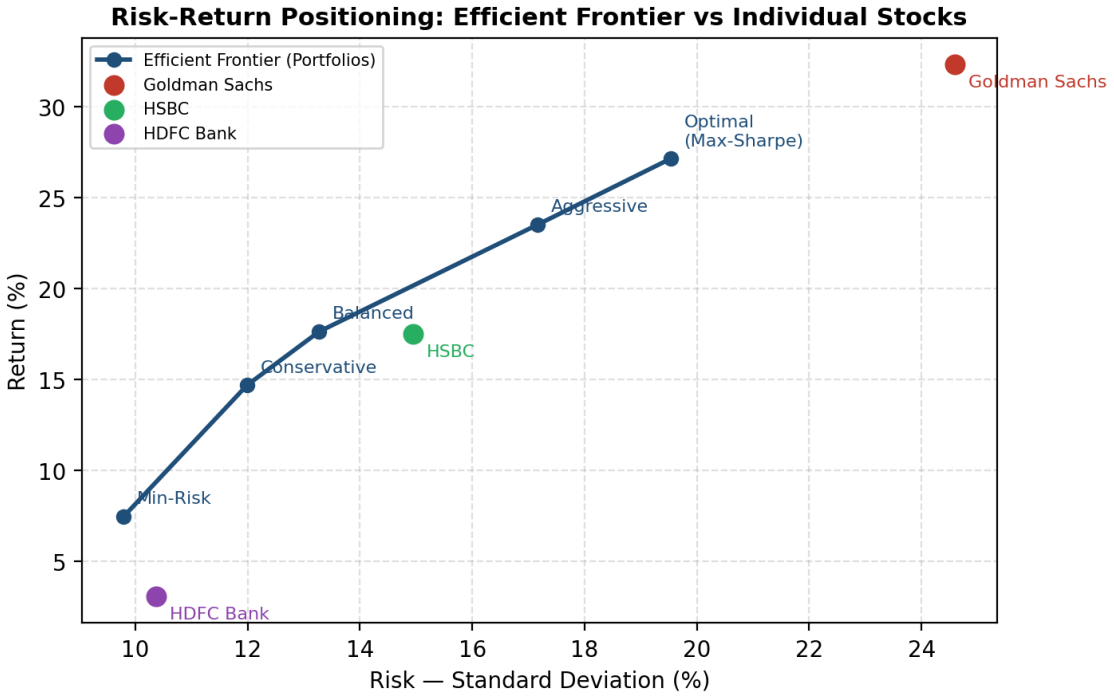

Figure 1: Risk-Return Positioning — Efficient Frontier vs Individual Stocks

Table 5: Sharpe Ratio Comparison (Rf = 4%)

Investment	Return (%)	Risk (%)	Sharpe Ratio
Goldman Sachs	32.34	24.60	1.15
HSBC	17.50	14.95	0.90
HDFC Bank	3.08	10.37	-0.09
Optimal (Max-Sharpe) Portfolio	27.15	19.53	1.19

Source: Compiled and computed from the historical share-price data of the companies (NYSE, LSE, and NSE).

Interpretation: The optimal portfolio achieves the highest Sharpe ratio (1.19) among all the options, ahead of

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Goldman Sachs (1.15) and HSBC (0.90), while HDFC Bank alone yields a negative Sharpe ratio (-0.09) given its low return relative to its risk. This confirms that diversified optimization delivers a superior risk-adjusted outcome to holding any single stock.

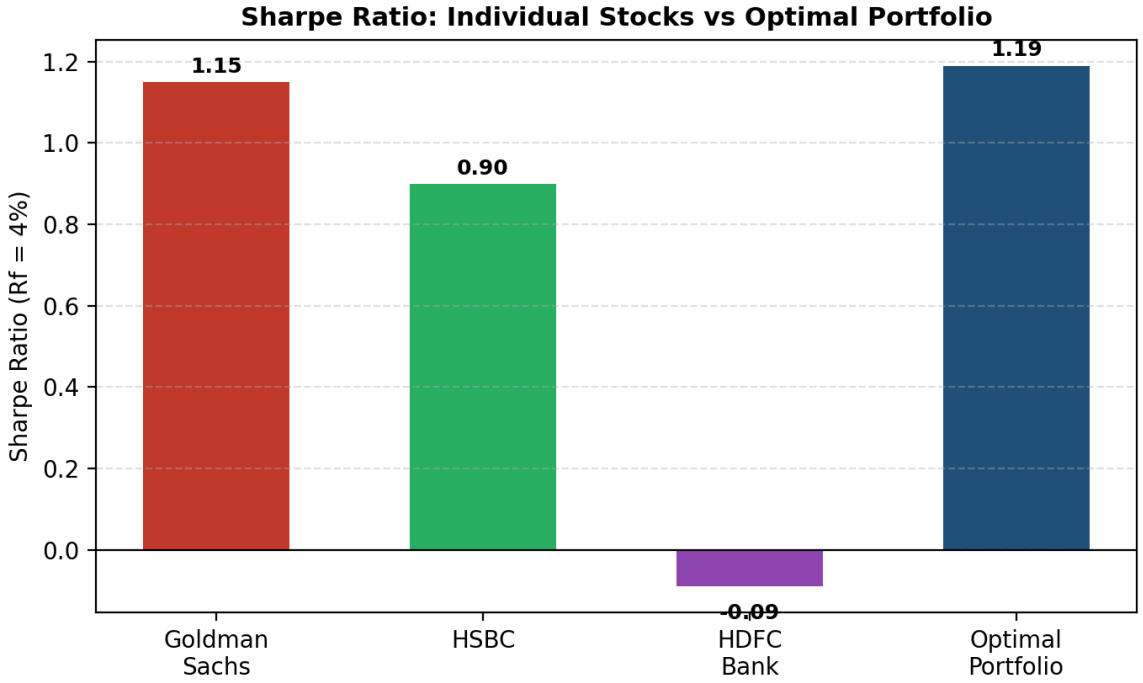

Figure 2: Sharpe Ratio — Individual Stocks vs Optimal Portfolio

Hypothesis Testing

H_0 (Null Hypothesis): Portfolio optimization using MPT does not significantly reduce risk.

H_1 (Alternative Hypothesis): Portfolio optimization using MPT significantly reduces risk.

Table 6: Hypothesis Test — Risk Reduction through Optimization

Particulars	Risk — SD (%)
Weighted-average risk of the individual stocks	16.64
Risk of the optimised (minimum-risk) portfolio	9.79
Reduction in risk through optimization	6.85

Source: Compiled and computed from the historical share-price data of the companies (NYSE, LSE, and NSE).

Result: The risk of the optimised portfolio (9.79%) is clearly lower than the weighted-average risk of the individual stocks (16.64%), a reduction of 6.85 percentage points. The null hypothesis (H_0) is therefore rejected, and the alternative hypothesis (H_1) is accepted — portfolio optimization using Modern Portfolio Theory significantly reduces risk through diversification.

6. Findings

1. Goldman Sachs gave the highest average annual return (32.34%), followed by HSBC (17.50%), while HDFC Bank gave the lowest (3.08%) over 2021–2025.
2. Goldman Sachs also carried the highest risk (standard deviation 24.60%) and HDFC Bank the lowest (10.37%), confirming the fundamental risk-return trade-off — higher return came with higher risk.
3. On a return-per-unit-of-risk basis, HSBC offered the best ratio, showing that the highest-return stock (Goldman Sachs) is not necessarily the most efficient.
4. HDFC Bank showed a low correlation with both Goldman Sachs and HSBC, making it an excellent diversifier within

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the portfolio.

5. The equal-weighted portfolio gave a return of 17.64% with a risk of only 13.27%, lower than the weighted-average risk of the individual stocks (16.64%) — a diversification benefit of about 3.36 percentage points.
6. The minimum-risk optimised portfolio achieved the lowest risk of 9.79%, and the maximum-Sharpe (optimal) portfolio achieved the best risk-adjusted return with a Sharpe ratio of 1.19.
7. The optimal portfolio allocated approximately 65% to Goldman Sachs, 35% to HSBC, and 0% to HDFC Bank.
8. The hypothesis test confirmed that the optimised portfolio's risk (9.79%) was significantly lower than the weighted-average risk of the stocks (16.64%), leading to rejection of the null hypothesis.
9. The efficient frontier showed a range of portfolios from minimum-risk to aggressive, allowing investors to select a portfolio according to their risk appetite, with the optimal portfolio offering the best risk-adjusted return.

7. Suggestions

1. Investors should diversify across stocks with low or negative correlations, as demonstrated by the inclusion of HDFC Bank, to reduce portfolio risk without sacrificing much return.
2. Investors should not select stocks on the basis of return alone, but should consider risk and the risk-adjusted return (Sharpe ratio), as the highest-return stock is not always the most efficient.
3. Investors seeking the best risk-adjusted return should adopt the optimal (maximum-Sharpe) portfolio weights identified by mean-variance optimization.
4. Risk-averse investors should prefer the minimum-risk portfolio, while investors with a higher risk appetite may move along the efficient frontier towards higher-return portfolios.
5. Investors should use the efficient frontier to select a portfolio that matches their own risk tolerance and return objectives.
6. Investors should periodically review and rebalance their portfolio, as returns, risks, and correlations change over time.
7. Investors should combine stocks from different markets and sectors, as with these global and Indian financial stocks, to gain broader diversification.
8. Investors should be aware of the assumptions and limitations of Modern Portfolio Theory, particularly that correlations can rise during market crises.
9. Institutional investors and fund managers should apply mean-variance optimization systematically rather than relying on intuition in constructing portfolios.
10. Investors should view portfolio optimization as a continuous, disciplined process supported by data and analysis, not a one-time exercise.

8. Conclusion

The present study applied Modern Portfolio Theory to the optimization of a portfolio constructed from the securities of three leading financial-sector companies — Goldman Sachs, HSBC, and HDFC Bank — over the five-year period 2021 to 2025. The analysis computed the average returns, risks, covariances, and correlations of the three stocks and applied the mean-variance framework to construct an optimised portfolio. The three stocks differed considerably in their return and risk and were imperfectly correlated, with HDFC Bank in particular showing a low correlation that made it an effective diversifier. As a result, the diversified portfolio achieved a risk significantly lower than the weighted-average risk of the individual stocks, and the optimised portfolios — the minimum-risk and the maximum-Sharpe portfolios — offered superior risk-return and risk-adjusted performance.

The findings confirm the central proposition of Modern Portfolio Theory: that the scientific combination of imperfectly correlated assets reduces risk and improves the risk-return trade-off compared with investing in individual securities. The hypothesis test established that portfolio optimization significantly reduced risk, leading to rejection of the null hypothesis. The study concludes that portfolio optimization using Modern Portfolio Theory is an effective and practical tool for constructing efficient portfolios, and that investors — whether individuals or institutions — can meaningfully improve the risk-adjusted performance of their investments by applying the mean-variance framework, diversifying across imperfectly correlated assets, and selecting a portfolio on the efficient

frontier that matches their risk appetite. The limitations of the theory notwithstanding, it remains an indispensable foundation of sound investment management.

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Declarations

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Conflict of Interest: The author declares no conflict of interest.

Data Availability: The secondary data used in this study is publicly available from the sources cited in the references.