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PORTFOLIO OPTIMIZATION USING MARKOWITZ MODEL

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ABSTRACT

Portfolio optimization is a systematic investment approach for balancing expected return and investment risk through diversification. This research paper examines the application of the Markowitz Mean-Variance Model to selected Information Technology and Banking sector companies listed on the National Stock Exchange (NSE) of India. The study uses secondary historical stock-price data for ten companies, comprising five IT companies – TCS, Infosys, Wipro, HCL Technologies and Tech Mahindra – and five banking companies – HDFC Bank, ICICI Bank, Axis Bank, State Bank of India and Kotak Mahindra Bank. Daily returns, average returns, variance, standard deviation, covariance, correlation, portfolio weights, portfolio return and portfolio risk are used to evaluate the risk-return profile. The analysis indicates that Tech Mahindra recorded the highest positive average daily return among the selected IT companies, while SBIN recorded the highest positive average daily return among the selected banks. Wipro and Kotak Mahindra Bank recorded the highest volatility within their respective sectors. The optimized IT portfolio generated a daily return of -0.000478 with portfolio risk of 0.013807, while the optimized banking portfolio generated a daily return of -0.000247 with portfolio risk of 0.013648. The study concludes that the Markowitz framework provides a structured basis for diversification, risk measurement and portfolio construction.

KEYWORDS: *Markowitz Model, Risk, Return, Mean, Portfolio, Security.*

1. INTRODUCTION

Investment decisions require a trade-off between return and risk. A security with the possibility of higher return may also expose the investor to higher volatility, while concentrating funds in a single security can increase unsystematic risk. The Markowitz Mean-Variance Model addresses this issue by evaluating securities collectively rather than considering each security in isolation. It uses expected return, variance, standard deviation, covariance and correlation to identify combinations of assets that provide an efficient risk-return relationship.

The Indian IT and Banking sectors provide a useful setting for portfolio analysis because they contain large, actively traded companies with different business drivers. Diversification across companies and sectors can reduce security-specific risk when the selected securities do not move perfectly together. The present study therefore applies the Markowitz approach to ten NSE-listed companies and evaluates their historical return and risk characteristics. The study period stated in the report is April 2024 to March 2026.

Portfolio management focuses on achieving an appropriate balance between profitability and risk. The Markowitz framework, introduced through Harry Markowitz's portfolio selection work, established diversification as a central principle of modern portfolio theory. Instead of asking only which stock has the highest return, the model asks how each security contributes to the total portfolio return and risk, including the interaction between securities through covariance and correlation.

For investors and investment advisers, this framework is relevant because historical return and risk measures can be converted into an evidence-based asset allocation process. The conceptual framework in the underlying report follows a sequence of stock selection, historical-data collection, return calculation, risk measurement, relationship analysis, Markowitz optimization, portfolio-weight determination, portfolio evaluation, efficient-frontier construction and selection of an optimal portfolio.

2. RESEARCH PROBLEM

The rapid growth and volatility of financial markets have increased the difficulty of selecting securities that can provide satisfactory returns without exposing investors to excessive risk. Stock-price movements are influenced by market conditions, economic changes,

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inflation, policy developments and industry-specific factors. Investors who select securities primarily on intuition, recent performance or market opinion may fail to consider the interaction among securities within the overall portfolio.
The research problem is therefore to identify an appropriate combination of selected NSE-listed IT and Banking sector stocks that balances expected return and risk using the Markowitz Mean-Variance Model. The study evaluates whether systematic measurement of daily returns, volatility, covariance and correlation can support more rational portfolio construction and diversification.

Research Objectives

- To calculate the daily returns of the selected companies.
- To estimate the average return of each selected stock.
- To measure investment risk using variance and standard deviation.
- To analyze relationships among selected stocks using covariance and correlation matrices.
- To determine appropriate portfolio weights using the Markowitz approach.
- To calculate portfolio, return and portfolio risk.
- To construct and evaluate efficient portfolios based on the risk-return trade-off.

Scope of the Study

- Ten NSE-listed equity companies: five IT companies and five Banking companies.
- Study period: April 2024 to March 2026, as stated in the report.
- Analysis is based on historical stock-price data and the Markowitz Mean-Variance Model.
- The study is restricted to equity investments and selected companies; behavioral and broader macroeconomic factors are not incorporated into the model.

3. REVIEW OF LITERATURE

The literature reviewed in the underlying report covers research published mainly from 2021 to 2025. Across the studies, the Markowitz framework is applied to conventional equities as well as cryptocurrencies, ESG portfolios and hybrid artificial-intelligence models. The recurring themes are diversification, risk-adjusted return, dynamic allocation and the extension of mean-variance optimization with computational techniques.

1. Hanif et al. (2021) – Optimization of Stock Portfolio Using the Markowitz Model in the Era of the COVID-19 Pandemic. LQ45 data were used to estimate return and risk. The study reported that Markowitz optimization could lower investment risk while maintaining adequate profitability during volatile conditions.

2. Li et al. (2021) – Multi-Period Portfolio Optimization Using Model Predictive Control with Mean-Variance Framework. MATLAB-based simulation was used for dynamic rebalancing. Multi-period optimization produced better risk-adjusted performance and improved portfolio stability.

3. Mansouri & Moghadam (2021) – Markowitz-Based Cardinality Constrained Portfolio Selection Using Artificial Rabbits Optimization. The study combined Markowitz optimization with a metaheuristic algorithm under asset-number constraints. The proposed approach improved optimization efficiency and diversification.

4. Owhadi-Kareshk & Boulanger (2021) – Portfolio Optimization on Classical and Quantum Computers Using Port Fawn. Computational experiments examined classical and quantum approaches. The study highlighted potential gains in scalability and processing efficiency.

5. Sirait et al. (2022) – Investment Portfolio Optimization Model Using the Markowitz Model. Historical stock data were analyzed using Microsoft Excel and mean-variance optimization. Diversification improved stability and supported attractive return-risk combinations.

6. Chaweewanchan & Chaysiri (2022) – Markowitz Mean-Variance Portfolio Optimization with Predictive Stock Selection Using Machine Learning. Python-based predictive methods were integrated with Markowitz optimization. The hybrid approach produced stronger risk-adjusted performance than traditional approaches.

7. Irfani & Sudrajad (2023) – Portfolio Optimization Using Markowitz Model on Sri-Kehati Index. ESG metrics and Microsoft Excel were incorporated into portfolio construction. The study reported improved diversification and more balanced risk-adjusted returns.

8. Bu & Liu (2023) – Optimizing Returns of Diversified Investment Portfolio with Markowitz Model. Monte Carlo simulation and Python were used to evaluate numerous portfolio combinations. Diversification improved stability and investment efficiency.

9. Jeleskovic et al. (2023) – Optimization of Portfolios with Cryptocurrencies: Markowitz and GARCH-Copula Approach. The study combined Markowitz optimization with advanced volatility and dependence modelling. Diversified cryptocurrency portfolios showed improved risk-adjusted performance.

10. Boyd et al. (2024) – Markowitz Portfolio Construction at Seventy. The study reviewed the continuing relevance of Markowitz theory and modern optimization constraints. Convex optimization and quantitative methods strengthened practical portfolio construction.

11. Xu (2025) – Integrating Machine Learning with Markowitz Optimization. Machine-learning techniques were combined with portfolio optimization using U.S. stock-market data. The study reported improved allocation efficiency and higher risk-adjusted performance.
12. Hao (2024) – Novel Portfolio Designs Based on Markowitz Portfolio Theory and Various Assets. CAPM, Yahoo Finance and statistical techniques were used to evaluate portfolio designs. Global minimum-variance portfolios offered stability while downside-risk methods improved risk control.
13. Zouaoui (2025) – Portfolio Optimization Based on MPT-LSTM Neural Networks. Python and LSTM-based neural networks were used to improve portfolio-weight decisions. The study reported better prediction accuracy and more efficient risk-adjusted allocation.
14. Jin (2025) – Research on Portfolio Optimization Based on Markowitz Model and Single Index Model. Historical S&P 500 data and statistical analysis were used to compare approaches. Markowitz produced stronger diversification and portfolio efficiency, with efficient-frontier analysis supporting selection.
15. Zhang et al. (2025) – An Empirical Investigation of Portfolio Optimization Using the Markowitz Model. Shanghai Stock Exchange data were evaluated using mean-variance analysis. Diversification reduced volatility and optimized portfolios outperformed randomly selected combinations.
16. Budiandriani et al. (2025) – Optimal Portfolio Analysis Using the Markowitz Model. Microsoft Excel and mean-variance techniques were applied to mining-sector stocks. The optimized portfolio provided more balanced risk-return combinations.
17. Markowitz Model Overview – The overview explains the relationship between expected return, risk and diversification. It emphasizes that combining assets with different return characteristics can reduce unsystematic risk and identifies the Efficient Frontier as a central concept.
18. Efficient Frontier Study – The study focuses on the relationship between portfolio return and risk. Efficient-frontier analysis was used to identify efficient investment combinations, with diversification supporting improved risk-return outcomes.
19. Portfolio Optimization Theory Study – The study explains modern portfolio optimization and mathematical asset allocation. It emphasizes diversification as a mechanism for reducing unsystematic risk and improving stability.
20. Hierarchical Risk Parity (2024) – Hierarchical Risk Parity was examined as an alternative/complement to mean-variance optimization. Clustering and machine-learning techniques were used to improve diversification and reduce estimation-error effects.
21. Comparative Study Researchers (2025) – A comparative study examined Markowitz, CAPM and Fama-French approaches for portfolio return forecasting. Markowitz remained effective for diversification, while multifactor models added information on systematic risk drivers.
22. Sustainable Portfolio Optimization Researchers (2023) – ESG principles were integrated with the Markowitz model for the Sri-Kehati Index. ESG scorecards, mean-variance optimization and Sharpe analysis were used to evaluate sustainable portfolios.
23. AI and CVaR Optimization Study – The study combined AI algorithms, Conditional Value-at-Risk and econometric models for investment forecasting and allocation. AI-enhanced optimization improved prediction accuracy and adaptive risk management.
24. Chaweewanchan & Chaysiri (2022) – A hybrid framework integrating CNN, BiLSTM and Markowitz optimization was applied to SET50 companies. The combined model reported lower prediction error and improved return-risk characteristics compared with standard approaches.
25. IDX30 Portfolio Study (2022) – Daily data for IDX30 companies were screened and analyzed using expected value, variance, covariance and correlation before applying the Markowitz model. A smaller set of stocks was selected as the preferred portfolio based on return-to-risk analysis.

Literature Synthesis
The reviewed studies consistently support diversification and systematic risk-return analysis as core principles of portfolio construction. Recent research also shows a movement toward integrating Markowitz optimization with machine learning, deep learning, Monte Carlo simulation, GARCH-Copula models, ESG metrics and alternative allocation techniques. Although these extensions address specific limitations of traditional mean-variance optimization, the Markowitz model continues to function as a benchmark framework for portfolio diversification and risk-return optimization.

4. RESEARCH METHODOLOGY

Research Design
The study follows a descriptive and analytical research design. The descriptive component is used to present the characteristics and historical performance of the selected companies, while the analytical component evaluates risk, return and portfolio optimization through statistical measures and the Markowitz Mean-Variance framework.

Nature and Sources of Data
The study is based entirely on secondary data. The underlying report identifies NSE, BSE, financial reports and online financial databases as sources. Historical stock-price data are used to calculate daily returns and the subsequent risk-return measures.

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Sample Design

Sector	Companies
Information Technology	TCS, Infosys (INFY), Wipro, HCL Technologies (HCLTECH), Tech Mahindra (TECH M)
Banking	HDFC Bank, ICICI Bank, Axis Bank, State Bank of India (SBIN), Kotak Mahindra Bank
Total	10 companies

Analytical Framework

Stage	Analysis / Measure	Purpose
1	Daily Return	Measure periodic stock-price performance.
2	Average Return	Estimate the mean return of each security.
3	Variance & Standard Deviation	Measure returns volatility and investment risk.
4	Covariance	Measure how two securities move together.
5	Correlation	Measure strength and direction of co-movement.
6	Portfolio Weights	Determine allocation among selected securities.
7	Portfolio Return	Estimate expected return of the optimized portfolio.
8	Portfolio Risk	Estimate overall portfolio volatility.
9	Efficient Frontier	Compare efficient return-risk combinations.

Key Model Concepts

The Markowitz model evaluates portfolio return as a weighted combination of individual expected returns. Portfolio risk depends not only on individual security volatility but also on covariance between securities. Consequently, a diversified portfolio can have lower risk than some individual securities when the assets are not perfectly positively correlated.

Limitations

- The analysis is restricted to ten companies.
- Historical stock prices may not accurately predict future market performance.
- Only the Markowitz Mean-Variance Model is considered for the main optimization.
- Behavioral factors are not included.
- Macroeconomic variables are not incorporated into the analysis.

5. HYPOTHESIS

The underlying report proposes three hypotheses concerning the statistical behavior of equity returns. The report does not provide separate statistical test results for these hypotheses; therefore, they are presented here as proposed hypotheses rather than as empirically accepted or rejected hypotheses.

Hypothesis Area	Null Hypothesis (H0)	Alternative Hypothesis (H1)
Normality	Daily equity returns follow a normal distribution.	Daily equity returns exhibit heavy tails (excess kurtosis) and negative skewness.
Independence	Daily equity returns are independent over time with no serial correlation.	Daily equity returns exhibit conditional heteroskedasticity / volatility clustering.
Correlation Breakdown	Asset correlations remain constant across market regimes.	Asset correlations significantly increase during periods of high market volatility.

6. DATA INTERPRETATION (MAJOR SUMMARY)

Banking Sector – Key Results

Bank	Avg. Daily Return	Variance	Std. Deviation
Axis Bank	0.000310	0.000226	0.015027
HDFC Bank	-0.000937	0.000662	0.025726
ICICI Bank	0.000260	0.000147	0.012113
Kotak Mahindra Bank	-0.001510	0.001525	0.039045
SBIN	0.000644	0.000251	0.015828

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SBIN recorded the highest positive average daily return among the selected banks at 0.000644. Kotak Mahindra Bank recorded the lowest average daily return at -0.001510 and the highest variance and standard deviation, indicating the greatest volatility in the banking sample. ICICI Bank recorded the lowest standard deviation at 0.012113, indicating the lowest observed volatility among the five banks.

Banking Sector – Relationship Analysis

The banking covariance matrix contains positive values across the selected securities, indicating generally similar movement in returns. The correlation matrix also shows positive relationships, with the strongest reported relationships including Axis–ICICI (0.548), Axis–SBIN (0.527) and ICICI–SBIN (0.480). Kotak shows comparatively lower correlations with the other selected banks, which can be relevant from a diversification perspective.

The optimized banking portfolio generated a portfolio return of -0.000247 per day and portfolio risk of 0.013648, as reported in the study.

DATA INTERPRETATION

IT Sector – Key Results

IT Company	Avg. Daily Return	Variance	Std. Deviation
Infosys (INFY)	-0.000240	0.000243	0.015576
TCS	-0.000934	0.000179	0.013386
HCL Technologies	-0.000183	0.000235	0.015315
Tech Mahindra	0.000349	0.000269	0.016414
Wipro	-0.001382	0.000793	0.028160

Tech Mahindra recorded the highest positive average daily return among the five IT companies at 0.000349. Wipro recorded the lowest average daily return at -0.001382. Wipro also recorded the highest variance (0.000793) and standard deviation (0.028160), indicating the highest observed volatility in the IT sample. TCS recorded the lowest standard deviation at 0.013386.

IT Sector – Relationship Analysis

All reported covariance values among the IT companies are positive, indicating that the selected stocks generally moved in the same direction during the study period. The correlation matrix shows relatively strong positive relationships among Infosys, TCS, HCL Technologies and Tech Mahindra. The reported correlations include INFY–TCS (0.733), INFY–HCLTECH (0.713), INFY–TECH M (0.692), TCS–HCLTECH (0.667) and TCS–TECH M (0.641).

Cross-Sector Interpretation

The results show that individual stock performance differs materially across companies. Higher return does not automatically imply lower risk. The Markowitz framework is therefore relevant because portfolio construction depends on both individual security statistics and the covariance/correlation structure of the securities.

DATA INTERPRETATION (MAJOR SUMMARY – CROSS-SECTOR)

Comparative Risk-Return Snapshot

Metric	IT Sector	Banking Sector	Key Interpretation
Highest Avg. Daily Return	Tech Mahindra: 0.000349	SBIN: 0.000644	Both sectors have a clear positive-return leader.
Lowest Avg. Daily Return	Wipro: -0.001382	Kotak: -0.001510	Negative average returns were observed for some securities.
Highest Variance	Wipro: 0.000793	Kotak: 0.001525	These securities carried the highest observed volatility.
Lowest Variance	TCS: 0.000179	ICICI: 0.000147	These securities had the lowest observed variance.
Highest Std. Deviation	Wipro: 0.028160	Kotak: 0.039045	Highest individual-stock risk in each sample.
Lowest Std. Deviation	TCS: 0.013386	ICICI: 0.012113	Lowest individual-stock volatility in each sample.
Optimized Portfolio Return	-0.000478	-0.000247	Both optimized portfolios had negative average daily returns.
Optimized Portfolio Risk	0.013807	0.013648	Portfolio risk was lower than the highest-risk individual stocks.

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Covariance and Correlation Insights

The covariance results are positive within both sector samples, indicating that the selected stocks generally moved together over the study period. However, the magnitude of correlations differs. Lower correlations can provide greater diversification benefits because the securities do not move perfectly together. In the banking sample, Kotak's correlations with several peers are comparatively low; in the IT sample, Wipro shows weaker relationships with the other IT stocks than the relationships among Infosys, TCS, HCL Technologies and Tech Mahindra.

Portfolio-Level Interpretation

The portfolio results demonstrate the central logic of the Markowitz approach: portfolio risk is a function of both individual volatility and co-movement among securities. The optimized banking portfolio has risk of 0.013648, while the optimized IT portfolio has risk of 0.013807. These figures are substantially below the standard deviation of the highest-volatility individual security in each sector, although the portfolio returns reported for the study period are negative.

Management Implication

For an investor, the appropriate decision should not be based solely on the highest-return stock. A more robust decision considers expected return, volatility, correlation and the desired risk tolerance. The Markowitz framework can therefore support evidence-based asset allocation and periodic portfolio review.

7. FINDINGS AND SUGGESTIONS (MAJOR)

Major Findings

- Average stock returns vary substantially across the selected IT and Banking companies, indicating different return-generating characteristics.
- Tech Mahindra recorded the highest positive average daily return among the selected IT companies, while SBIN recorded the highest positive average daily return among the selected banking companies.
- Wipro recorded the highest variance and standard deviation among the IT companies, indicating comparatively high volatility and risk.
- Kotak Mahindra Bank recorded the highest variance and standard deviation among the banking companies, indicating comparatively high volatility and risk.
- TCS and ICICI Bank recorded the lowest standard deviations within the IT and Banking samples respectively, indicating comparatively lower historical volatility.
- Covariance values were positive across the reported sector matrices, indicating that the selected stocks generally moved in the same direction.
- Correlation analysis showed that several IT and Banking stocks have positive relationships, while some pairs have comparatively lower correlations that may contribute to diversification.
- The optimized IT portfolio produced a daily return of -0.000478 with portfolio risk of 0.013807.
- The optimized Banking portfolio produced a daily return of -0.000247 with portfolio risk of 0.013648.
- Overall, the Markowitz Mean-Variance Model provided a structured framework for evaluating return, risk, diversification and portfolio allocation.

SUGGESTIONS

Major Suggestions

- Investors should diversify across securities and, where appropriate, across sectors rather than concentrating funds in one company.
- Investment decisions should be supported by quantitative analysis instead of relying only on rumors, recent price movements or personal judgement.
- Investors should evaluate both expected return and risk before selecting securities.
- Portfolio performance should be reviewed periodically so that allocations can respond to changing market conditions.
- The Markowitz Mean-Variance Model can be used as a structured tool for portfolio construction and asset allocation.
- Future studies can compare Markowitz optimization with the Sharpe Single Index Model, CAPM, Black-Litterman, Risk Parity and AI-based optimization approaches.
- Future research can incorporate inflation, interest rates, exchange rates, GDP growth and monetary policy to obtain a broader explanation of portfolio performance.
- Machine learning, AI and Python-based optimization can be explored to improve forecasting and portfolio-selection capability.
- Investors should rebalance portfolios periodically to maintain the intended risk-return balance.

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9. CONCLUSION

The present study examined the application of the Markowitz Mean-Variance Portfolio Optimization Model to selected IT and Banking sector companies listed on the NSE of India. Using historical stock-price data, the study evaluated daily returns, average returns, variance, standard deviation, covariance and correlation, followed by portfolio-level return and risk assessment.

The findings demonstrate that stock-level performance and risk differ substantially across the selected companies. Tech Mahindra recorded the highest positive average daily return in the IT sample, while SBIN recorded the highest positive average daily return in the Banking sample. Wipro and Kotak Mahindra Bank recorded the highest volatility within their respective samples. These results reinforce the importance of evaluating both return and risk rather than selecting securities solely on return.

The optimized portfolio results further demonstrate the importance of diversification and security interaction. The reported IT portfolio return was -0.000478 with risk of 0.013807, while the banking portfolio return was -0.000247 with risk of 0.013648. Although the reported average daily returns were negative, the portfolio approach provides a systematic basis for controlling risk relative to individual securities and for identifying combinations consistent with an investor's risk-return objective.

Overall, the Markowitz framework remains a practical and analytically grounded approach to portfolio construction. Its principal value is the integration of expected return, volatility and asset co-movement into a single decision framework. For future research and practical investment management, the model can be strengthened by incorporating macroeconomic variables, alternative risk measures and modern computational methods such as machine learning and AI.

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