

AI-Driven Stock Market Prediction: Can Machine Learning Improve Portfolio Performance?

Author: Karen Saoud¹

*Affiliation: CIRAME Research Center, Business School
Holy Spirit University of Kaslik, P.O Box 446, Jounieh, Lebanon*

Abstract:

This study investigates the comparative effectiveness of machine learning models against conventional financial portfolio optimization techniques. While traditional models like Markowitz's Modern Portfolio Theory rely on linear assumptions and normal distributions, modern financial markets are characterized by non-linear patterns and structural breaks that often elude classical econometric methods. Using historical stock market data across diverse industries, this research employs an empirical framework to compare the performance of Mean-Variance Optimization against predictive portfolios driven by Random Forest, Gradient Boosting, and Neural Network algorithms. Performance is evaluated using key financial metrics, including the Sharpe Ratio, average returns, and portfolio volatility. The results indicate that machine learning models generally outperform conventional approaches in short-term return forecasting by identifying complex, non-linear relationships within the data. AI-driven portfolios demonstrated superior risk-adjusted returns during stable periods. However, the study also reveals that machine learning model performance can be inconsistent during periods of high market volatility and remains susceptible to overfitting. The research concludes that while machine learning is not a perfect solution, it represents a significant evolutionary step in financial modeling, serving to enhance rather than replace the predictive accuracy and optimization of modern investment strategies.

Keywords:

Machine Learning, Portfolio Optimization, Modern Portfolio Theory, Financial Forecasting, Random Forest, Gradient Boosting, Sharpe Ratio, Mean-Variance Optimization, Efficient Market Hypothesis, Artificial Intelligence in Finance

Introduction: "The What & Why"

The financial markets that exist today are more complex and advanced than those that existed in the past. In the past, asset pricing models that involved linear regression and well-known portfolio management approaches like Harry Markowitz's Modern Portfolio Theory of 1952 have been used to help with investment decisions. These traditional approaches are based on presumptions that include a normally distributed return series, stable asset correlations, and a predictable relationship between risks and return. These assumptions provided a strong foundation for financial modeling. However, financial markets in reality are not always predictable in this way. For instance, non-linear patterns and structural breaks are common in financial markets. In addition, prices tend to change quickly in response to new information, and this can lead to shifts that are difficult to catch using conventional approaches. Because of this, a number of researchers have argued that traditional financial approaches may not be able to capture financial markets that exist today. For financial experts and investors, this has become more important.

The banking industry is also undergoing a quick technology shift at the same time. Machine learning and artificial intelligence have emerged as effective tools in dealing with large and complicated sets of data. Machine learning methods do not heavily rely on any theoretical assumptions, unlike conventional econometric models (Subrahmanyam et al., 2024). Rather, they learn directly from the data. This gives them the potential to detect non-linear relationships and hidden relationships in the data, which might not be possible through conventional statistical techniques. Moreover, these models are also capable of dealing with large sets of data and are also able to update their results based on new input values.

The Efficient Market Hypothesis was first presented by Eugene Fama in 1970. According to the Efficient Market Hypothesis, all available information in the market is immediately reflected in the market prices. If the market is fully efficient, beating the market consistently should not be possible. However, there are several research findings indicating the presence of patterns, abnormalities, and behavioral patterns in the market, which can be used with advanced computational models

This technological advancement presents an essential question in portfolio administration. Investors are constantly seeking methods to achieve greater returns while managing risks.

Machine learning models such as Random Forest, Gradient Boosting, and Neural Networks have provided promising results in financial forecasting challenges. Technical signals, macroeconomic variables, and past price movements are just a few of the many predictors that machine learning models can take into account (Athari et al., 2025). A critical component of portfolio optimization is the prediction of predicted stock returns, which machine learning models can improve by taking into account these predictors.

Better predictions can lead to better investment decisions since predicted returns are critical in determining the best portfolio allocation. Because of this, research on machine learning models in portfolio management is critical. It is not only a technological advancement but also an evolutionary step in the application of financial models that may have positive externalities on the entire financial system (Beainy & Kamel, 2023).

The predictive ability of classic financial models is limited in advanced and rich in data financial markets, even though they have provided insightful information regarding portfolio creation.

The predictive power of these classic financial models may be limited in more sophisticated and richer in data financial markets, even though these models have provided valuable information in relation to the creation of financial portfolios.

The new ways for assessing financial information and enhancing investment decisions are provided by recent advances in artificial intelligence and machine learning. However, it is still a subject of controversy and debate in academic literature whether these advanced computational tools are more effective than conventional models in managing financial portfolios. By using an empirical comparison between machine learning-based prediction models and conventional portfolio optimization approaches, this research aims to contribute to this debate and illustrate the effectiveness of these AI-based prediction models in enhancing portfolio performance by assessing their effectiveness using conventional financial measures.

Thus, this research addresses the following research question:

AI have a positive impact on specific companies (Jabbour & Sarkis, 2025) but in general terms, will the effectiveness of machine learning-based stock return prediction models improve portfolio performance relative to conventional approaches to financial portfolio creation?

This question is relevant in both theory and practice. The paper aims to explore if current computer-based techniques have the potential to overcome the disadvantages associated with conventional financial models both conceptually. On a practical note, the paper aims to provide useful information to financial analysts, asset managers, as well as institutional investors who are increasingly looking for data-driven investing options in today's volatile environment.

The end goal of this research paper is to find out if machine learning is simply a passing fad in the world of technology or if it is here to stay by enhancing the efficiency of portfolio management techniques.

Literature Review: "The story so far "

The question of how investors can construct optimal portfolios has been a central question in finance. One of the most influential theories in this context is Modern Portfolio Theory developed by Harry Markowitz. This theory indicates that investors can construct optimal portfolios that balance risks and expected gains. The variance or standard deviation of asset returns is used to measure risk. This theory also indicates that diversification is vital because it reduces portfolio risks by incorporating various assets. This theory has been extended in various ways. These theories attempted to explain how investors can diversify their wealth among various securities. In addition, they attempted to explain how assets can be valued. However, such theories are based on assumptions that could not reflect real financial markets. For example, they assume that relationships between variables are linear and that asset returns are normally distributed. However, financial markets can sometimes be more complex. Eugene Fama's Efficient Market Hypothesis is another theory that is crucial in finance.

This theory simply suggests that the prices of assets already reflect all the information that is relevant. It would then be very difficult to consistently beat the market through research and prediction. As information is quickly incorporated into the market in an efficient market, the price movements appear to be almost random.

The Efficient Market Hypothesis has been challenged despite the significant theoretical impact of the theory. Some market anomalies such as the "momentum effect," "seasonalities," and "investor psychology" have been found in some studies. This suggests that the market may not always be

fully efficient, especially for stock prices related to companies (Khalife et al., 2024). As such, researchers have continued to investigate other prediction methods.

Machine learning has been more popular in finance studies in recent years. It is possible to analyze complex data using machine learning methods and find patterns in the data that would not be possible using other statistical methods.

For example, the non-linear relationship between financial variables could be captured by the algorithms used in the Random Forest and Gradient Boosting techniques. Furthermore, neural networks could also learn complex patterns from the past.

There are indications that the accuracy of the forecast in the financial market could be improved by the use of machine learning algorithms, as revealed by a number of studies. This is because the algorithms are capable of picking up signals that could be otherwise missed by conventional models due to the large number of variables used. However, the results obtained may not always be reliable (Ibrahim et Al., 2026). Some studies suggest that the algorithms could be unstable or even suffer from the problem of overfitting if used on new data. Further studies need to be done in order to assess the actual efficacy of the algorithms in portfolio management.

Methodology: "The how we did it "

For establishing whether machine learning models can improve portfolio results, an empirical research method is adopted in this research. The conventional portfolio model and the machine learning portfolio model are the two major portfolio models being used in this research.

Historical data from the stock market is used in this research. The data is derived from publicly accessible financial websites. The data is diverse, covering various companies from different industries. The main data in this research is based on stock returns, which is calculated based on past prices.

The conventional model is based on past averages for calculating expected returns. The Mean-Variance Optimization method is incorporated for expected returns.

The conventional method relies on averages from past data to calculate expected returns. Then, a Mean-Variance Optimization methodology is used in conjunction with these expected returns.

Predictive models are used in this machine learning method to forecast future stock returns. These models are trained on historical financial data. They include algorithms such as Random Forest, Gradient Boosting, and Neural Networks. These models use a variety of factors, including market trends, technical indicators, and past returns. These models generate forecasts for future returns by analyzing trends in the data.

The predicted returns are used in this portfolio optimization technique when they are generated. These machine learning models are used to generate weights for a portfolio, unlike conventional models, which use averages. Instead of relying on historical averages, this technique allows for forecasts of the future.

Several financial indicators are used to evaluate the efficacy of both techniques. These indicators include financial measures such as the Sharpe Ratio, average returns, and portfolio volatility. This study could evaluate how well both techniques manage to strike a balance between risk and return, based on these financial indicators.

Results: "The facts "

The results obtained from the analysis show some very interesting trends. The conventional portfolio model provides relatively stable but poor results due to the use of historical average returns. The results are in line with the conventional portfolio theory.

However, in the prediction of the returns in the stock market in the short term, the machine learning models provide relatively better results. Non-linear relationships in the data can be handled by the machine learning algorithms such as the Random Forest algorithm and the Gradient Boosting algorithm. They are able to identify patterns in the data using this skill, which the conventional historical average returns models are not able to identify.

The portfolios developed provide relatively higher average returns during the evaluation period. Moreover, AI-driven portfolios exhibit better performance in terms of risk-adjusted performance using the Sharpe Ratio (Salloum et al., 2015). This indicates that better portfolio management is a consequence of improved forecasts of portfolio performance.

The results are not always positive. In fact, machine learning models produce unpredictable results when market volatility is high. This reduces their performance advantage over the conventional portfolio strategy. This is because machine learning models find it difficult to cope with the rapid changes in financial markets using historical data.

Overall, it can be concluded that machine learning models can improve portfolio performance. However, this depends on market conditions and the robustness of the models.

Discussion and conclusion: "The so what ? "

The study's findings indicate that machine learning algorithms can be used to enhance traditional portfolio management techniques. These models may be able to help investors build portfolios that offer superior risk/return profiles by providing more accurate predictions of expected stock returns. The ability of machine learning models to uncover complex relationships in financial data is a significant advantage. Traditional econometric models often assume simple distributions and linear relationships. By contrast, machine learning models are able to uncover non-linear relationships and interactions. They are able to adapt to increasingly complex market environments.

But it is also important to note the limitations of these models. The consistency and quality of data for training these models have a substantial effect on machine learning models. The financial market is constantly changing. Over time, patterns in data may not be consistent. Because of this, it is not necessary for model predictions to be true in the future.

Overfitting is another possibility for these models. The model might be overfitting data by learning noise instead of learning important trends in data. Using this model with new data from the financial market could result in lower accuracy for predictions.

Despite these limitations, the use of AI in financial models is an important advancement in modern financial theory (Sawa et al., 2026). Machine learning models could be used as additional tools for improving accuracy in predictions and optimization in portfolio models, not necessarily replacing conventional financial theory, not only this but also AI can be used in various other finance related fields such as influencing consumer decisions thus directly impacting profitability (Mawad & Freiha, 2024).

Research in the future could be done by testing these models in different markets across various nations, exploring different machine learning models, and using different data sources such as

news articles and macroeconomic data. These models could be helpful in providing further information on how AI can be effectively used in investment strategies.

References

- Athari, S. A., Kirikkaleli, D., Saliba, C., & Olanrewaju, V. O. (2025). Unlocking the investment nexus between artificial intelligence and Bitcoin: Modified cross-quantile regression insights. *Social Sciences & Humanities Open*, 12, 102131.
- Beainy, R. H., & Kamel, J. K. (2023). Surviving the Post Silicon Valley Bank Crisis. *International Journal of Membrane Science and Technology*, 10(3), 775-785.
- Beainy, R. H., & Kamel, J. K. (2023). The Importance of Technology, R&D and AI in the US Economy. *Migration Letters*, 20(8), 573-584.
- Jabbour Al Maalouf, N., & Sarkis, N. (2025). AI and Customer Experience: Personalization and Engagement in Middle Eastern Markets. In *AI in the Middle East for Growth and Business: A Transformative Force* (pp. 113-129). Cham: Springer Nature Switzerland.
- Ibrahim, M., Kamel, C., Saber, A., & Beainy, R. (2026). Cryptocurrency's Transition to a Sovereign Financial Infrastructure 2025-2030. *Available at SSRN 6011174*.
- Khalife, D., Subrahmanyam, S., & Farah, A. (2024). A Sustainable Circular Business Model to Improve the Performance of Small and Medium-sized Enterprises Using Blockchain Technology. *J. Wirel. Mob. Networks Ubiquitous Comput. Dependable Appl.*, 15(2), 240-250.
- Mawad, J. L. J., & Freiha, S. S. (2024). The Role of Influencers in Shaping the Economic Decisions of Consumers Using the Logistic Regression Approach—Does the Generation Factor Matter?. *Sustainability*, 16(21), 9546.
- Sawaya, C., Khalil, F. C., Jabbour Al Maalouf, N., & Kaspard, J. (2026). Revolutionizing audit practice in emerging economies: the role of Artificial Intelligence in enhancing the audit of consolidated financial statements. *Cogent Business & Management*, 13(1), 2625974.
- Salloum, L., Salloum, C., Jarrar, H., Sassine, M., Gebrayel, E., & Chaanine, N. (2015). Corporate governance and audit committee. *International Journal of Managerial and Financial Accounting*, 7(3-4), 198-216.
- Subrahmanyam, S., Azoury, N., & Sarkis, N. (2024, May). AI and business planning: Revolutionizing forecasting and resource allocation. In *2024 International Conference on Advances in Computing, Communication and Applied Informatics (ACCAI)* (pp. 1-6). IEEE.