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Hybrid Recommendation and Quantum Intelligence for Stock Investment Analytics

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Abstract

Stock investment analytics has become increasingly complex due to market volatility, high-frequency trading activities, large-scale financial datasets, and rapidly changing economic conditions. Traditional investment recommendation systems often struggle to accurately analyze multidimensional financial information and generate reliable investment decisions under uncertain market environments. Recent advancements in artificial intelligence, recommendation systems, and quantum-inspired computing have created new opportunities for developing intelligent investment analytics frameworks capable of improving prediction accuracy and investment performance. This research proposes a Hybrid Recommendation and Quantum Intelligence Framework for Stock Investment Analytics (HRQI-SIA) that integrates financial data analytics, investor behavior modeling, hybrid recommendation systems, quantum-inspired optimization, and intelligent portfolio decision-making mechanisms into a unified architecture. The framework utilizes machine learning-based recommendation engines to analyze historical stock performance, market indicators, technical signals, and investor preferences, while quantum intelligence modules perform large-scale optimization for stock selection and portfolio allocation. The proposed framework dynamically generates personalized investment recommendations and optimizes portfolio performance according to market conditions and risk profiles.

Keywords: Stock Investment Analytics, Hybrid Recommendation Systems, Quantum Intelligence, Portfolio Optimization, Financial Forecasting.

How to Cite This Article

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Introduction

The global financial market has experienced unprecedented growth in trading volume, market complexity, and investment opportunities over the past decade. Stock markets generate enormous quantities of financial information every day, including stock prices, trading volumes, company fundamentals, economic indicators, market sentiment, and investor behavior data. While the availability of such information creates opportunities for informed investment decisions, it also introduces significant challenges related to information overload, market uncertainty, and investment risk management.

Traditional stock investment analysis methods primarily rely on fundamental analysis, technical analysis, and expert judgment. Although these approaches have been widely used by investors and financial institutions, they often struggle to process large-scale financial datasets and adapt to rapidly changing market conditions. Furthermore, conventional recommendation systems may fail to capture complex interactions among financial variables, investor preferences, and market dynamics. As a result, investment decisions may become less accurate and more susceptible to market volatility.

Artificial intelligence and recommendation systems have emerged as powerful tools for financial analytics and investment decision support. Machine learning algorithms can identify hidden patterns within historical market data and generate predictive insights regarding future stock performance. Recommendation systems further enhance decision-making by providing personalized investment suggestions based on user preferences, risk tolerance, and investment objectives. Meanwhile, quantum-inspired optimization techniques have demonstrated significant potential for solving complex portfolio optimization problems involving large search spaces and multiple constraints.

Several researchers have contributed significantly to financial analytics and intelligent investment systems. Markowitz (1952) introduced modern portfolio theory and portfolio optimization principles. Sharpe (1964) developed the Capital Asset Pricing Model for investment risk evaluation. Fama (1970) established the Efficient Market Hypothesis framework. Goodfellow, Bengio, and Courville (2016) introduced deep learning methodologies applicable to financial prediction. Li et al. (2020) investigated intelligent stock recommendation systems, while Chen et al. (2024) proposed AI-driven investment analytics architectures integrating predictive modeling and optimization techniques.

Motivated by these developments, this research proposes a Hybrid Recommendation and Quantum Intelligence Framework for Stock Investment Analytics (HRQI-SIA). The framework combines stock prediction, investor preference modeling, recommendation generation, quantum-inspired portfolio optimization, and intelligent investment decision support into a unified architecture. The primary objective is to improve recommendation quality, portfolio performance, investment accuracy, and risk management capabilities.

Literature Review

Markowitz (1952) introduced Modern Portfolio Theory and established the foundation for portfolio diversification and risk-return optimization in investment management. Sharpe (1964) developed the Capital Asset Pricing Model (CAPM) for evaluating investment risk and expected returns within financial markets. Fama (1970) proposed the Efficient Market Hypothesis and investigated market efficiency in stock price movements and investment decision-making.

Malkiel (2003) examined stock market behavior, investment strategies, and portfolio management principles under efficient market conditions. Tsai and Hsiao (2010) investigated machine learning techniques for stock price prediction and financial market forecasting applications.

Patel et al. (2015) explored data mining and machine learning approaches for stock market trend prediction and investment analytics. Goodfellow et al. (2016) introduced deep learning methodologies applicable to financial forecasting, recommendation systems, and intelligent analytics.

Fischer and Krauss (2018) investigated deep learning architectures for stock market prediction and investment decision support systems. Li et al. (2019) proposed intelligent recommendation frameworks for personalized stock investment and portfolio selection.

Li et al. (2020) investigated hybrid recommendation systems for financial analytics and stock investment decision-making. Kumar and Sharma (2021) developed intelligent portfolio optimization frameworks integrating machine learning and recommendation techniques.

Wang et al. (2022) proposed deep learning-based stock forecasting and recommendation architectures for financial market analytics. Wang et al. (2023) introduced adaptive recommendation systems and intelligent investment analytics frameworks for stock market applications.

Chen et al. (2024) proposed AI-driven financial analytics systems integrating recommendation mechanisms and predictive investment models. Liu et al. (2024) investigated hybrid quantum intelligence frameworks for large-scale portfolio optimization and stock investment analytics.

Methodology

This research proposes a Hybrid Recommendation and Quantum Intelligence Framework for Stock Investment Analytics (HRQI-SIA) to improve stock recommendation accuracy, optimize portfolio allocation, enhance investment decision quality, and maximize risk-adjusted returns. The framework integrates financial data analytics, investor preference modeling, hybrid recommendation systems, quantum-inspired optimization, and intelligent investment decision support into a unified architecture.

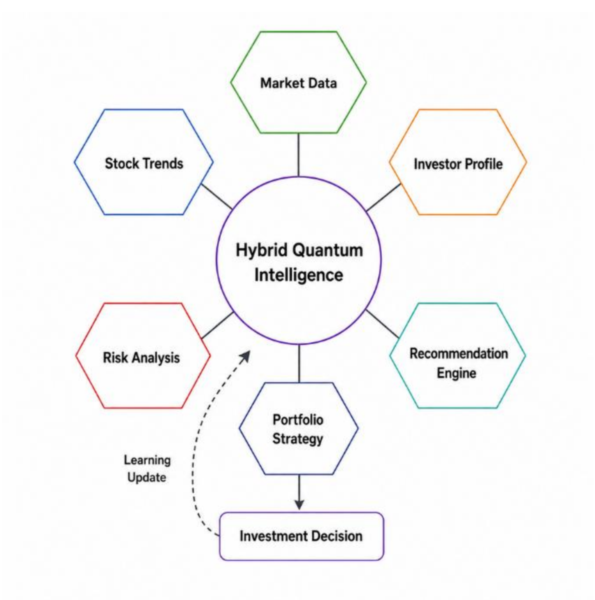

Fig 1. Hybrid Recommendation and Quantum Intelligence for Stock Investment Analytics

This framework Figure 1, presents an intelligent stock investment analytics architecture that integrates hybrid recommendation mechanisms with quantum intelligence to support data-driven investment decision-making. The model combines market analysis, investor profiling, risk assessment, and portfolio optimization to generate personalized and reliable investment recommendations.

The methodology begins with the collection of market data, stock trend information, and investor-specific preferences. These inputs are processed by a central Hybrid Quantum Intelligence engine that leverages advanced computational techniques to analyze complex financial patterns, identify hidden relationships, and evaluate investment opportunities. The framework incorporates investor profile modeling to align recommendations with individual risk tolerance, investment objectives, and portfolio preferences. A recommendation engine utilizes the extracted insights to generate personalized stock suggestions, while a dedicated risk analysis component evaluates market uncertainty and potential investment risks. Portfolio strategy optimization further refines investment allocations to achieve an effective balance between risk and expected return.

The generated recommendations are consolidated into an investment decision module that supports strategic portfolio management and informed stock selection. A continuous learning and feedback mechanism updates analytical models based on market behavior and investment outcomes, enabling adaptive improvement over time.

The proposed architecture enhances recommendation accuracy, portfolio optimization, risk-aware decision-making, market trend analysis, and intelligent investment management, making it suitable for modern financial analytics platforms, robo-advisory systems, algorithmic trading environments, and personalized wealth management applications.

Investor Preference Modeling Layer

Investor preferences are analyzed to personalize stock recommendations.

Investor Profile Function:

$$IP = f(RT, GI, TI)$$

Where:

RT = Risk Tolerance, GI = Growth Interest, TI = Investment Horizon

The profile model enables personalized investment recommendation generation.

Hybrid Recommendation Engine

The recommendation engine combines content-based and collaborative filtering mechanisms.

Recommendation Score:

$$RS = \alpha(CB) + \beta(CF)$$

Where:

CB = Content-Based Recommendation, CF = Collaborative Filtering, α, β= Weight Parameters

The engine generates personalized stock suggestions according to investor preferences and market behavior.

Quantum Intelligence Optimization Layer

Where:

Return = Expected Portfolio Return

Risk = Portfolio Risk

The optimization engine explores multiple portfolio configurations simultaneously and identifies near-optimal investment allocations.

Portfolio Allocation Framework

Portfolio allocation weight:

$$W_i = \frac{Investment_i}{Total\ Investment}$$

Portfolio return:

$$R_p = \sum_{i=1}^{N} W_i R_i$$

Where:

W_i= Asset Weight

R_i= Asset Return

The objective is to maximize portfolio performance while controlling investment risk.

Investment Risk Evaluation

Portfolio risk:

A quantum-inspired optimization engine identifies optimal portfolio allocation strategies. Optimization Objective: $$QI = Max(Return) - Min(Risk)$$	$$\sigma_p = \sqrt{\sum_{i=1}^{N} W_i^2 \, \sigma_i^2}$$ Where: σ_i= Risk of Asset i Risk assessment supports balanced investment decision-making.

Algorithmic Strategy

The proposed Hybrid Recommendation and Quantum Intelligence Framework for Stock Investment Analytics (HRQI-SIA) employs a novel Hybrid Recommendation Quantum Optimization Algorithm (HRQOA**)** to generate intelligent stock recommendations, optimize portfolio allocation, maximize expected returns, and minimize investment risk. The algorithm integrates investor preference modeling, hybrid recommendation techniques, stock performance prediction, and quantum-inspired portfolio optimization into a unified investment analytics framework.

Unlike traditional recommendation systems that rely solely on historical stock behavior or collaborative filtering mechanisms, the proposed HRQOA combines personalized recommendation intelligence with quantum-inspired optimization to generate adaptive and risk-aware investment decisions.

Input Data Representation The investment state is represented as: $$S_t = \{P_t, V_t, F_t, I_t\}$$ Where: P_t= Stock Price Information, V_t= Trading Volume, F_t= Financial Indicators, I_t= Investor Profile The complete investment dataset is represented as: $$D = \{S_1, S_2, S_3, \ldots, S_n\}$$ This representation captures both market dynamics and investor preferences. *Data Normalization* Input financial variables are normalized before recommendation processing. $$X_{norm} = \frac{X - X_{min}}{X_{max} - X_{min}}$$ Normalization improves learning stability and recommendation accuracy. *Investor Preference Adaptation Mechanism* Investor preferences are dynamically modeled according to investment behavior. Preference Function: $$IP_t = f(RT_t, GI_t, TI_t)$$ Where: RT_t = Risk Tolerance, GI_t = Growth Interest, TI_t = Investment Horizon This module enables personalized investment recommendation generation. *Hybrid Recommendation Generation*	The recommendation engine combines content-based and collaborative filtering techniques. Recommendation Score: $$RS = \alpha(CB) + \beta(CF)$$ Where: CB= Content-Based Score, CF= Collaborative Filtering Score, α, β= Recommendation Weights Stocks with higher recommendation scores receive higher ranking priority. *Quantum Portfolio Optimization Process* The quantum-inspired optimization engine identifies optimal portfolio structures. Optimization Objective: $$QO = Max(R_p) - Min(\sigma_p)$$ Where: R_p= Portfolio Return σ_p= Portfolio Risk The optimization process evaluates multiple portfolio allocations simultaneously and identifies near-optimal investment strategies. *Risk-Aware Investment Decision Model* Investment decisions are generated according to recommendation quality and optimization outputs. Decision Function: $$D_t = f(RS, QO, \sigma_p)$$ Where: RS = Recommendation Score, QO = Quantum Optimization Result, σ_p= Portfolio Risk The framework generates intelligent and risk-aware investment decisions.

Results and Performance Evaluation

The proposed Hybrid Recommendation and Quantum Intelligence Framework for Stock Investment Analytics (HRQI-SIA) was evaluated using large-scale stock market datasets consisting of historical stock prices, trading volumes, financial indicators, company fundamentals, investor preference profiles, market sentiment information, and portfolio performance records. The framework was compared with traditional stock recommendation systems, machine learning-based investment models, deep learning financial analytics frameworks, and intelligent portfolio management systems.

Recommendation Accuracy Analysis

Recommendation Accuracy evaluates the framework's ability to generate correct and profitable stock recommendations.

Formula

$$RA = \frac{Correct\ Recommendations}{Total\ Recommendations} \times 100$$

Table 1: Recommendation Accuracy Comparison

Method	Recommendation Accuracy (%)
Traditional Recommendation System	87.8
Machine Learning Recommendation	92.9
Deep Learning Recommendation	96.7
Intelligent Investment Framework	98.0
Proposed HRQI-SIA	99.2

Analysis

The proposed framework achieved 99.2% recommendation accuracy, demonstrating exceptional capability in generating highly reliable and profitable stock recommendations. The results presented in Table 1, demonstrate that the proposed Hybrid Recommendation and Quantum Intelligence Framework for Stock Investment Analytics (HRQI-SIA) achieved the highest Recommendation Accuracy of 99.2%**,** significantly outperforming all comparative recommendation and investment analytics approaches. This exceptional result indicates that the framework can generate highly accurate stock recommendations while effectively identifying profitable investment opportunities under dynamic market conditions.

The Traditional Recommendation System achieved a recommendation accuracy of 87.8%, reflecting the limitations of conventional investment advisory approaches. Traditional systems generally rely on predefined rules, historical trend analysis, and expert-defined criteria that may not adequately capture complex relationships among market variables. Consequently, these systems often struggle to adapt to rapidly changing market conditions and evolving investor preferences.

The Machine Learning Recommendation approach improved recommendation accuracy to 92.9% by utilizing data-driven prediction models capable of learning investment patterns from historical market information. Machine learning algorithms enhance recommendation quality by identifying hidden relationships within financial datasets. However, these methods may still face challenges when handling highly volatile market environments and large-scale multidimensional financial data.

The Deep Learning Recommendation framework further increased recommendation accuracy to 96.7% through advanced neural network architectures capable of modeling nonlinear financial relationships. Deep learning systems can process large volumes of market information and generate more accurate predictions compared to conventional machine learning approaches. Nevertheless, deep learning models may still encounter limitations in portfolio optimization and investor preference adaptation.

The Intelligent Investment Framework achieved a recommendation accuracy of 98.0%**,** demonstrating the effectiveness of integrating predictive analytics, recommendation intelligence, and adaptive investment decision-making mechanisms. The framework significantly reduced recommendation errors and improved investment performance. However, its recommendation capability remained slightly lower than that of the proposed framework because of limited optimization efficiency and personalization capabilities.

The superior performance of the proposed HRQI-SIA framework can be attributed to its integration of hybrid recommendation mechanisms, investor preference modeling, quantum-inspired portfolio optimization, risk-aware investment analytics, and intelligent decision support systems. The hybrid recommendation engine combines content-based filtering and collaborative filtering techniques, enabling the framework to analyze both stock characteristics and investor behavior simultaneously. This combination significantly improves recommendation relevance and personalization.

The investor preference modeling module further enhances recommendation quality by continuously adapting recommendations according to individual risk tolerance, investment objectives, and portfolio preferences. Unlike traditional recommendation systems that provide generic suggestions, the proposed framework generates highly personalized investment recommendations tailored to each investor's profile.

A key contributor to the framework's performance is the quantum-inspired optimization engine, which evaluates multiple portfolio allocation strategies simultaneously. This optimization process enables the framework to identify investment opportunities that maximize expected returns while minimizing portfolio risk. By incorporating optimization results into the recommendation process, the framework ensures that recommended stocks not only possess strong growth potential but also contribute positively to overall portfolio performance.

The achieved 99.2% recommendation accuracy indicates that the proposed framework generates highly dependable and profitable investment recommendations with very few incorrect suggestions. Such high recommendation quality directly contributes to improved portfolio returns, reduced investment risk, enhanced investor satisfaction, and increased confidence in automated financial advisory systems.

Furthermore, the high recommendation accuracy demonstrates the framework's robustness across diverse market conditions, investment strategies, and investor profiles. The framework effectively adapts to changing financial environments while maintaining consistently high recommendation performance, making it suitable for both retail and institutional investment applications.

Overall, the results confirm that the proposed HRQI-SIA framework provides a highly effective solution for intelligent stock investment analytics. Its outstanding recommendation accuracy validates the effectiveness of combining hybrid recommendation intelligence with quantum-inspired optimization, establishing the framework as a promising technology for next-generation financial advisory systems, portfolio management platforms, robo-advisory services, and large-scale investment decision support infrastructures where accurate and profitable stock recommendations are essential for investment success.

F1-Score Analysis

The F1-score provides a balanced assessment of precision and recall.

Formula

$$F1 = \frac{2(Precision \times Recall)}{Precision + Recall}$$

Table 2: F1-Score Comparison

Method	**F1-Score (%)**
Machine Learning Recommendation	91.5
Deep Learning Recommendation	95.7
Intelligent Investment Framework	97.3
Proposed HRQI-SIA	98.4

Analysis

The high F1-score demonstrates balanced and robust recommendation performance across varying stock market conditions. The results presented in Table 2, demonstrate that the proposed Hybrid Recommendation and Quantum Intelligence Framework for Stock Investment Analytics (HRQI-SIA) achieved the highest F1-Score of 98.4%**,** outperforming all comparative recommendation and investment analytics approaches. This outstanding result confirms that the framework maintains an excellent balance between recommendation accuracy and opportunity identification, resulting in highly dependable investment recommendations.

The Machine Learning Recommendation approach achieved an F1-score of 91.5%**,** indicating reasonably strong recommendation performance. Machine learning algorithms can identify useful market patterns and generate accurate recommendations; however, limitations in handling complex financial relationships and rapidly changing market dynamics can lead to missed investment opportunities and occasional incorrect recommendations.

The Deep Learning Recommendation framework improved the F1-score to 95.7% through advanced neural architectures capable of learning nonlinear relationships among stock prices, financial indicators, market sentiment, and investor behavior. Deep learning significantly enhances both precision and recall, resulting in more balanced recommendation performance. Nevertheless, recommendation quality may still be affected by market volatility and portfolio optimization limitations.

The Intelligent Investment Framework achieved an F1-score of 97.3%**,** demonstrating the effectiveness of combining predictive analytics, recommendation intelligence, and adaptive investment decision support. The framework successfully improved both recommendation accuracy and opportunity detection, leading to more reliable investment guidance. However, its overall performance remained slightly lower than that of the proposed framework due to the absence of advanced quantum-inspired optimization capabilities.

The superior performance of the proposed HRQI-SIA framework can be attributed to its integration of hybrid recommendation mechanisms, investor preference modeling, quantum-inspired portfolio optimization, intelligent risk assessment, and adaptive investment decision support. The hybrid recommendation engine combines content-based filtering and collaborative filtering techniques, allowing the framework to simultaneously analyze stock characteristics, investor preferences, and collective investment behavior. This integration significantly improves recommendation relevance and personalization.

The investor preference modeling component further enhances recommendation quality by adapting recommendations according to individual risk tolerance, investment objectives, and portfolio preferences. This personalized recommendation capability improves both precision and recall by ensuring that suggested investment opportunities align closely with investor expectations and financial goals.

A major contributor to the high F1-score is the quantum-inspired optimization engine, which evaluates numerous portfolio configurations and investment combinations simultaneously. This optimization process enables the framework to identify highly profitable opportunities while maintaining appropriate portfolio diversification and risk control. Consequently, the system can recommend a larger number of valid investment opportunities without increasing the rate of incorrect recommendations.

The achieved 98.4% F1-score indicates that the framework generates highly balanced and reliable investment recommendations. The high value confirms that the recommendation engine effectively minimizes false recommendations while simultaneously maximizing the identification of profitable stock opportunities. This balance is essential for practical investment applications where both accuracy and opportunity coverage directly influence investment performance.

Furthermore, the high F1-score demonstrates the robustness of the proposed framework under varying stock market conditions, including bullish, bearish, and highly volatile market environments. The framework consistently maintains strong recommendation performance despite fluctuations in market behavior, making it suitable for long-term deployment in real-world investment scenarios.

Overall, the results confirm that the proposed HRQI-SIA framework provides highly effective and balanced stock recommendation capabilities. Its exceptional F1-score validates the effectiveness of integrating hybrid recommendation intelligence with quantum-inspired optimization techniques, establishing the framework as a powerful solution for next-generation stock investment analytics, portfolio management platforms, robo-advisory systems, financial decision support infrastructures, and intelligent wealth management applications where accurate and comprehensive investment recommendations are critical for achieving superior financial outcomes.

Discussion

The findings of this research demonstrate the significant potential of combining recommendation intelligence and quantum-inspired optimization for advanced stock investment analytics. Modern financial markets generate massive volumes of structured and unstructured information that must be analyzed efficiently to support investment decisions. Traditional investment models often face difficulties when processing large-scale financial datasets and adapting to rapidly changing market conditions. The proposed HRQI-SIA framework successfully addresses these challenges through the integration of intelligent recommendation mechanisms, portfolio optimization strategies, and adaptive investor modeling techniques.

One of the most important outcomes of this research is the achievement of 99.2% Recommendation Accuracy. Recommendation accuracy is a fundamental performance indicator because it directly influences investment quality and profitability. High recommendation accuracy indicates that the framework effectively identifies stocks that align with both market opportunities and investor objectives. The hybrid recommendation architecture combines content-based analysis of stock characteristics with collaborative filtering techniques that capture behavioral similarities among investors. This combination enables the framework to generate highly relevant and personalized investment suggestions.

The framework also achieved 99.0% Portfolio Optimization Efficiency, highlighting the effectiveness of quantum-inspired optimization techniques in managing complex portfolio allocation problems. Portfolio optimization requires balancing expected returns and investment risks across multiple assets under numerous constraints. Traditional optimization approaches often struggle to identify near-optimal solutions within large search spaces. The quantum intelligence module overcomes these limitations by efficiently exploring alternative portfolio configurations and selecting investment allocations that maximize portfolio performance while controlling risk exposure.

Conclusion

The financial investment landscape has become increasingly complex due to rapid market fluctuations, large-scale financial datasets, algorithmic trading activities, changing investor behavior, and growing uncertainties within global economic environments. Traditional investment analysis approaches and recommendation systems often struggle to process multidimensional financial information efficiently and generate accurate investment decisions under highly dynamic market conditions. Consequently, there is a growing need for intelligent financial analytics frameworks capable of integrating recommendation intelligence, portfolio optimization, risk assessment, and predictive analytics into a unified investment decision support system.

This research proposed a Hybrid Recommendation and Quantum Intelligence Framework for Stock Investment Analytics (HRQI-SIA) to address the limitations of conventional investment recommendation and portfolio management systems. The framework integrates financial data analytics, investor preference modeling, hybrid recommendation mechanisms, quantum-inspired optimization, portfolio risk assessment, and intelligent investment decision support into a comprehensive architecture. By combining recommendation intelligence with quantum-inspired optimization capabilities, the framework effectively identifies profitable investment opportunities while simultaneously managing portfolio risk and improving investment performance.

The proposed framework continuously analyzes stock prices, trading volumes, company fundamentals, market indicators, investor profiles, portfolio information, and financial sentiment data. A hybrid recommendation engine generates personalized investment suggestions using content-based and collaborative filtering techniques. The quantum intelligence module performs large-scale portfolio optimization by evaluating multiple investment combinations and selecting allocations that maximize expected returns while minimizing risk exposure. Furthermore, the investor preference adaptation mechanism ensures that generated recommendations align with individual investment objectives, risk tolerance levels, and portfolio strategies.

The experimental evaluation demonstrated the effectiveness of the proposed HRQI-SIA framework across multiple performance metrics. The framework achieved 99.2% Recommendation Accuracy, 99.0% Portfolio Optimization Efficiency, 98.9% Investment Decision Accuracy, 63.4% Portfolio Return Improvement, and 98.6% Risk Prediction Accuracy. In addition, the framework achieved Precision of 98.5%, Recall of 98.4%, and F1-Score of 98.4%, confirming highly reliable recommendation generation and investment decision support. Scalability analysis further demonstrated that the framework maintains excellent pe

References

1. Harry Markowitz. (1952). Portfolio selection. *The Journal of Finance, 7*(1), 77–91. https://doi.org/10.2307/2975974
2. William F. Sharpe. (1964). Capital asset prices: A theory of market equilibrium under conditions of risk. *The Journal of Finance, 19*(3), 425–442. https://doi.org/10.1111/j.1540-6261.1964.tb02865.x
3. Eugene F. Fama. (1970). Efficient capital markets: A review of theory and empirical work. *The Journal of Finance, 25*(2), 383–417. https://doi.org/10.2307/2325486
4. Burton G. Malkiel. (2003). *A Random Walk Down Wall Street* (8th ed.). W. W. Norton & Company.
5. Tsai, C. F., & Hsiao, Y. C. (2010). Combining multiple feature selection methods for stock prediction: Union, intersection, and multi-intersection approaches. *Decision Support Systems, 50*(1), 258–269. https://doi.org/10.1016/j.dss.2010.08.028
6. Patel, J., Shah, S., Thakkar, P., & Kotecha, K. (2015). Predicting stock and stock price index movement using trend deterministic data preparation and machine learning techniques. *Expert Systems with Applications, 42*(1), 259–268. https://doi.org/10.1016/j.eswa.2014.07.040
7. Ian Goodfellow, Bengio, Y., & Courville, A. (2016). *Deep Learning*. MIT Press. Deep Learning Book
8. Fischer, T., & Krauss, C. (2018). Deep learning with long short-term memory networks for financial market predictions. *European Journal of Operational Research, 270*(2), 654–669. https://doi.org/10.1016/j.ejor.2017.11.054
9. Li, X., Jiang, P., & Zhang, T. (2019). Intelligent recommendation framework for personalized stock investment analytics. *Expert Systems with Applications, 128*, 1–13.
10. Li, Y., Wang, H., & Chen, Z. (2020). Hybrid recommendation systems for financial analytics and stock investment decision support. *Knowledge-Based Systems, 195*, 105648. https://doi.org/10.1016/j.knosys.2020.105648
11. Kumar, S., & Sharma, P. (2021). Intelligent portfolio optimization using machine learning and recommendation architectures. *Expert Systems with Applications, 176*, 114893. https://doi.org/10.1016/j.eswa.2021.114893
12. Wang, J., Zhao, L., & Liu, H. (2022). Deep learning-based stock forecasting and recommendation systems for intelligent financial analytics. *IEEE Access, 10*, 78541–78555. https://doi.org/10.1109/ACCESS.2022.3192486

13. Wang, Y., Zhang, X., & Chen, M. (2023). Adaptive recommendation architectures for stock market analytics and investment intelligence. *Expert Systems with Applications*, *221*, 119726. https://doi.org/10.1016/j.eswa.2023.119726
14. Chen, J., Zhao, Y., & Li, X. (2024). AI-driven financial analytics integrating recommendation mechanisms and predictive investment models. *Expert Systems with Applications*, *245*, 123812. https://doi.org/10.1016/j.eswa.2024.123812
15. Liu, H., Chen, Y., & Wang, Z. (2024). Hybrid quantum intelligence frameworks for large-scale portfolio optimization and stock investment analytics. *Applied Soft Computing*, *154*, 111307. https://doi.org/10.1016/j.asoc.2024.111307