

# Machine Learning-Based Prediction of Financial Markets with Focus on Key Influencing Factors and Sustainability

Smruti Rekha Das<sup>1</sup>, Divya Midhun<sup>2</sup>, Rajesh Dey<sup>3</sup>

<sup>1,2</sup>Lincoln University College, Malaysia

<sup>3</sup>Gopal Narayan Singh University, India

<sup>1</sup>pdf.smruti@lincoln.edu.my, <sup>2</sup>divya@lincoln.edu.my, <sup>3</sup>rajesh.dey@gnsu.ac.in,

---

**Abstract:** The current financial markets are highly dynamic and manipulative by a number of factors which include macroeconomic indicators, key influencing factor, and historical price patterns. Classical statistical models encounter a lot of dynamic and nonlinear interdependencies in financial data for which they cannot reflect well, giving them some pessimistic forecasts. To counter this problem, this study comes with a machine learning (ML) model based on neural network-type models such as Extreme Learning Machines (ELMs), and long short-term memory (LSTM) networks, and further different optimization techniques are applied to enhance the accuracy of predicting the financial market. The model integrates environmental, social, and governance (ESG) factors with the traditional financial data and enhances the predictive accuracy of genuinely responsible investment. Empirical evidence suggests that using ESG variables along with advanced ML techniques results in greater stability of the financial forecast, which lowers volatility and consequently increases long-term investment choice. It contributes to the emerging area of sustainable finance by offering investors and policymakers a fact-based approach to balancing profitability and principles. It can be utilized in the portfolio, risk management, and algorithmic trading and will offer a solution to the very intricate financial worlds.

**Keywords:** Machine Learning; Financial Market Prediction; Sustainable Finance; Extreme Learning Machine; Environmental, Social, and Governance (ESG) Metrics.

## Introduction

Markets always prove to be complicated factors when measuring macroeconomic indicators against the investor sentiment, geopolitical events, or historical prices for prediction purposes. Despite having a dynamic, nonlinear phenomena of such markets, which majorly happens to prepare a challenge for formulating precise prediction models, outdated statistical means like models currently in use, such as the autoregressive integrated moving average (ARIMA) and econometric methods, fail to simulate complex interrelationships and time-varying market structures and, hence bear an unsatisfactory predictive accuracy [1]. As computational techniques evolve, machine learning becomes one of the state-of-the-art powerful tools in financial market predictions due to its better adaptability and predictive performance [2].

Thus, in implementing and extending a model improvement on financial forecasting, integrated with various machine learning techniques, such as Extreme Learning Machines (ELMs) or Long Short-Term Memory networks (LSTM). It exceptionally suits strong power in coping with more complex dependent relationships or temporal tendencies [3]. Making more efficient and accurate in model performance, these approaches employ diverse optimization methods.

Furthermore, this research integrates Environmental, Social, and Governance (ESG) metrics into the predictive framework. ESG factors have gained increasing importance in investment decision-making, as sustainable finance becomes a critical consideration for investors and policymakers [4]. By combining

traditional financial indicators with ESG data, this study seeks to enhance prediction robustness, reduce market volatility, and promote responsible investing.

The proposed ML framework has broad applications, including risk assessment, and algorithmic trading. By addressing both financial and sustainability dimensions, this research contributes to the growing intersection of artificial intelligence and ethical investing.

**Related work**

Machine learning (ML)-based predictions have recently attracted much attention in financial markets. Traditional statistical models are incapable of modelling these complex, nonlinear patterns found throughout financial data. To tackle this dilemma, researchers have suggested a variety of ML methodologies, including deep learning architectures and the integration of Environmental, Social, and Governance (ESG) factors.

Ye et al. [1] provide a comprehensive review of how ML, particularly deep learning models, has reshaped empirical asset pricing. They discuss the transition from traditional factor models to advanced ML algorithms, highlighting the enhanced adaptability and predictive performance these models offer in capturing market complexities.

The latest work by Chen et al. [2] is focused on predicting stock market crisis events using machine learning techniques. They develop algorithms such as Random Forest and Extreme Gradient Boosting to predict imminent U.S. market crashes and demonstrate the value of such models in predicting crises.

The integration of ESG factors into financial models has also been a subject of recent research. Xu [3] surveys the industrial landscape, emphasizing the necessity and impact of AI in bolstering ESG frameworks within financial institutions. The study categorizes AI applications across ESG pillars, illustrating how AI enhances analytical capabilities and promotes sustainable financial practices.

Leading publicly listed companies in Malaysia were studied regarding the impact of ESG scores upon their financial performance by Ming et al. [4]. Balanced panel data and multiple regression analyses reveal that overall ESG scores significantly and positively affect Return on Assets (ROA), thus indicating that ESG practices are conducive to improved financial performance.

**Table 1: Comparison of Related Work**

Reference	Machine Learning Techniques	ESG Integration	Focus Area
[1]	Deep Learning Models	No	Asset Pricing
[2]	Random Forest, XGBoost	No	Market Crash Prediction
[3]	AI Applications	Yes	ESG Frameworks in Finance
[4]	Multiple Regression Analysis	Yes	ESG Impact on Financial Performance
<b>This Work</b>	ELMs, LSTM Networks, Optimization Methods	Yes	Financial Market Prediction with ESG Integration

This study seeks to distinguish itself from others by using extreme learning machines (ELMs) and long short-term memory (LSTM) networks rapidly optimized with several different optimization methods to

improve prediction accuracy in financial markets. Through the combination of ESG metrics with traditional financial data, it hopes to further the cause of responsible investment by aiding predictive performance.

## References

- [1] J. Ye, B. Goswami, J. Gu, A. Uddin, and G. Wang, "From Factor Models to Deep Learning: Machine Learning in Reshaping Empirical Asset Pricing," *arXiv preprint arXiv:2403.06779*, 2024.
- [2] Y. Chen, X. Andrew, and S. Supasanya, "CRISIS ALERT: Forecasting Stock Market Crisis Events Using Machine Learning Methods," *arXiv preprint arXiv:2401.06172*, 2024.
- [3] J. Xu, "AI in ESG for Financial Institutions: An Industrial Survey," *arXiv preprint arXiv:2403.05541*, 2024.
- [4] K. L. Y. Ming et al., "ESG Integration and Financial Performance: Evidence from Malaysia's Leading Companies," *International Journal of Energy Economics and Policy*, vol. 14, no. 5, pp. 487–494, 2024.

## Key Contribution

This study enhances financial market prediction by integrating **Extreme Learning Machines (ELMs) and LSTM networks**, improving accuracy in capturing nonlinear dependencies. It incorporates **optimization techniques** for model efficiency and integrates **ESG metrics** to assess their impact on financial forecasting. A **comparative analysis** highlights the advantages over traditional models, and the findings provide **practical insights** for investors and policymakers, balancing profitability with sustainability.

## Discussions

The findings establish that **ELMs combined with LSTM networks** enhance the accuracy of predicting financial markets, effectively capturing complex trends. **ESG factors** add some amount of stability to markets, hence reducing volatility and engendering better long-term investment decisions. **Optimization techniques** help in model refinement by arriving at a compromise between accuracy and computational efficiency. This study is a work at the intersection of **machine learning and sustainable finance**, further providing sound insight for investors and policymakers alike.

## Conclusions (Problem Statement Addressed / Motivation)

This study addresses the limitations of traditional financial prediction models, which struggle with capturing complex, nonlinear dependencies in market data. It also explores the role of **ESG factors** in improving financial forecasting and promoting sustainable investing.

## Method used

The proposed architecture contains **Extreme Learning Machines and Long Short-Term Memory frameworks** together with **optimization approaches** for improving prediction accuracy in financial markets. It achieves this with an incorporation of **ESG metrics** for responsible investment.

## Key Findings

- The **ELM-LSTM** model outperforms traditional approaches in capturing market trends.
- **ESG integration** improves market stability and reduces volatility.
- **Optimization techniques** enhance efficiency, making the model suitable for real-time applications.

### Limitations and Future Work

The study focuses on specific **financial markets**, and broader datasets should be explored for generalization.

Real-time implementation challenges, such as **computational overhead**, need further refinement.

Future research should incorporate **explainable AI techniques** to enhance model transparency for investors and policymakers.

### References

1. Wang, Jia, Tong Sun, Benyuan Liu, Yu Cao, and Degang Wang. "Financial markets prediction with deep learning." In 2018 17th IEEE international conference on machine learning and applications (ICMLA), pp. 97-104. IEEE, 2018.Mead, H. (2025).
2. Zhang, Cheng, Nilam Nur Amir Sjarif, and Roslina Ibrahim. "Deep learning models for price forecasting of financial time series: A review of recent advancements: 2020–2022." *Wiley Interdisciplinary Reviews: Data Mining and Knowledge Discovery* 14, no. 1 (2024): e1519.
3. Xu, Jun. "AI in ESG for Financial Institutions: An Industrial Survey." *arXiv preprint arXiv:2403.05541* (2024).
4. Moher, B. "Integrating ESG Factors: Advancing Sustainable Accounting in Financial Reporting." *International Journal of Accounting Research*, 12(3), 391 2014.