

Stock Market Prediction Using Machine Learning

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Abstract

Stock market prediction has been a subject of significant interest and research for both financial analysts and machine learning practitioners. This abstract presents a concise overview of the key aspects and approaches in the realm of stock market prediction. The unpredictable and dynamic nature of financial markets poses a challenge for accurate forecasting. However, advancements in machine learning techniques, availability of large-scale financial data, and computational power have led to the development of sophisticated prediction models.

In this endeavour, we investigate the application of various machine learning algorithms, including regression, time series models and support vector machine, to forecast stock prices. The research focuses on data preprocessing, feature engineering, and model evaluation to enhance prediction accuracy. Using a diverse dataset Evaluation metrics such as Mean Squared Error (MSE), Root Mean Squared Error (RMSE), and Mean Absolute Percentage Error (MAPE) are utilized to measure model performance. While acknowledging the inherent uncertainty of financial markets, this research contributes to the broader dialogue on data-driven decision-making in investment and finance. The outcomes of this study offer insights into the strengths and limitations of machine learning techniques in stock price prediction.

Keywords: Machine Learning¹, Linear Regression², Investment Strategies³, Financial Markets⁴.

1. Introduction

The stock market, as a dynamic and intricate financial ecosystem, has captivated the attention of investors, analysts, and researchers for generations. Its inherent volatility and complexity have prompted the pursuit of accurate predictive methods to decipher its movements. The quest for effective stock market prediction is not merely an academic exercise; it holds profound implications for financial decision-making, risk management, and the broader understanding of market dynamics.

The unpredictability of stock market fluctuations has historically posed challenges to investors seeking to time their trades and maximize returns. While the Efficient Market Hypothesis (EMH) asserts that stock prices reflect all available information and are thus unpredictable, the reality often showcases deviations that give rise to potential predictive opportunities. This duality between theory and practice has spurred the development of an array of prediction models, ranging from traditional statistical approaches to contemporary machine learning algorithms.

Over the years, the evolution of technology and the digital age has revolutionized the landscape of stock market prediction. The accessibility to vast volumes of historical and real-time financial data has provided a fertile ground for data-driven strategies. Moreover, the rise of sentiment analysis and natural language processing has introduced non-traditional data sources, such as social media and news sentiment, into the prediction equation.

This introduction sets the stage for an exploration into the multifaceted realm of stock market prediction. It will delve into the various methodologies employed to forecast market movements, considering both their historical roots and their adaptation to modern computational tools. Additionally, the introduction will address the significance of accurate predictions in financial planning and investment decisions, while also acknowledging the ethical considerations and potential risks associated with overreliance on predictive models.

2. Review

• **Stock Price Prediction Using LSTM on Indian Share Market:**

Researchers were increasingly adopting machine learning techniques such as deep learning, reinforcement learning, and ensemble methods to improve prediction accuracy. The application of LSTM models has been used for emphasizing the importance of historical data and suggesting that different sectors may have distinct patterns in their stock price movements. The study aims to provide insights for market analysis and future growth predictions [1].

• **Stock Market Prediction Using Machine Learning:**

With the rise of complex machine learning models, this paper outlines a comprehensive approach for using machine learning techniques, specifically SVM with an RBF kernel, to predict stock market trends. It underscores the importance of leveraging historical stock data and the power of Python for implementing these predictive models [2].

• **Stock Market Prediction: A Time Series Analysis:**

In this research the authors compare the performance of linear regression, random forest, Support Vector Regression (SVR), Vector Autoregression (VAR), and Long Short-Term Memory (LSTM) models. It also adds to the understanding of how different regression models can be applied to stock market prediction and highlights the significance of LSTM for achieving accurate predictions. This work could be valuable for investors and researchers interested in stock market forecasting [3].

• **Stock Price Prediction Website Using Linear Regression - A Machine Learning Algorithm:**

It demonstrate the effectiveness of linear regression as a machine learning technique for forecasting stock market behaviour and to provide a useful tool in the form of a stock price prediction website. Also the authors address the evolving nature of stock market prediction and suggest areas for future research in the field [4].

• **Stock Closing Price Prediction using Machine Learning Techniques:**

The primary goal of this paper is to explore and compare the efficacy of ANN and RF in predicting the closing stock prices using historical data and to provide insights into potential avenues for future research of five different companies representing various sectors [5].

• **Stock Price Prediction of “Google” based on Machine Learning:**

The study analyse the accuracy of Linear Regression and Random Forest Regression models in forecasting Google's stock prices and discusses their implications for investors. It aims to provide

practical insights for investors and financial analysts while also acknowledging the complexities and limitations of Linear Regression and Random Forest Regression models. Ultimately, the paper seeks to enhance the understanding of how machine learning can be applied to stock price forecasting [6]

- **Stock price prediction based on CNN model for Apple, Google and Amazon:**

The paper explores the application of Convolutional Neural Networks (CNN) and Recurrent Neural Networks (RNN) in the field of predicting the stock prices by applying deep learning models to real-world data. It also suggest the directions for future research and potential tasks of CNN and RNN models. However, further refinement and consideration of external factors could enhance the paper's robustness [7].

- **Stock Price Prediction System:**

The aims of this paper is to improving stock price prediction accuracy by utilizing PCA as a dimensionality reduction technique and applying Linear Regression as the predictive model. It's goal is to contribute to the field of financial forecasting and give directions for future research in this area [8].

As we have gone through several research paper, above mentioned 8 research found that we can use several algorithm techniques and framework to build and predict models. Each algorithm techniques and framework suited to different types of data and tasks. The choice of choosing the algorithm depends of the problems, characteristics of data and our goals. While some of the researcher have used machine learning algorithms and some of them have used deep learning algorithm. To enhance performance XGBOOST (Extreme Gradient Boosting) ensemble technique is used. It's known for robustness and effectiveness in classification and regression tasks. It includes gradient boosting and regularization techniques, making it less prone to overfitting.

3. Problem Statements

The field of stock market prediction poses a significant challenge in the realm of finance and data science due to the inherent complexity and dynamic nature of financial markets. The problem at hand is to develop and refine prediction models that can effectively forecast stock price movements, taking into account factors such as historical price trends, external influences, and market sentiment. The central question is whether it is feasible to create predictive models that outperform random chance and provide valuable insights for investors and financial decision-makers.

Traditional financial theories, such as the Efficient Market Hypothesis (EMH), suggest that stock prices already incorporate all available information and thus are unpredictable. However, empirical evidence showcases instances of market inefficiencies and anomalies that imply the existence of predictive opportunities. The challenge lies in identifying reliable patterns within noisy financial data and discerning between genuine signals and random fluctuations.

In light of these challenges, the problem statement encompasses the following key aspects:

- **Prediction Accuracy:** Developing predictive models that can consistently outperform random guessing and traditional benchmarks, with a focus on accuracy and reliability.
- **Incorporating Diverse Data:** Exploring the integration of various data sources, including historical price data, macroeconomic indicators, news sentiment, and social media chatter, to enhance prediction accuracy.

- **Model Robustness:** Creating models that can adapt to changing market conditions and unexpected events, mitigating the risk of overfitting to historical data.
- **Ethical Implications:** Addressing the ethical concerns associated with the use of predictive algorithms in financial decision-making, including algorithmic trading and potential market manipulation.
- **Market Efficiency:** Investigating the compatibility of prediction models with the Efficient Market Hypothesis and understanding the limitations of predictability within the context of efficient markets.

4. Concise Significant

The study of stock market prediction holds significant importance due to its implications for financial decision-making, risk management, and the broader understanding of market dynamics.

The findings of such studies can offer the following key contributions:

- **Informed Investment Decisions:** Accurate stock market prediction models empower investors with insights to make more informed investment decisions, potentially leading to improved portfolio performance and risk mitigation.
- **Risk Management:** Prediction models enable investors and financial institutions to anticipate market downturns and mitigate losses, thereby enhancing risk management strategies and minimizing financial vulnerabilities.
- **Market Efficiency Assessment:** Research in this area provides insights into the efficiency of financial markets, bridging the gap between theoretical frameworks like the Efficient Market Hypothesis and observed deviations in market behaviour.
- **Algorithmic Trading Advancements:** The development of ethical and accurate algorithmic trading systems has the potential to enhance market stability, liquidity, and fairness by incorporating predictive insights while adhering to regulatory and ethical standards.
- **Technological Innovation:** Advances in machine learning and data analysis techniques driven by stock market prediction research can have far-reaching effects beyond finance, influencing various fields that require pattern recognition and data-driven decision-making.
- **Interdisciplinary Insights:** The study of stock market prediction merges finance, statistics, machine learning, and behavioral economics, contributing to interdisciplinary knowledge and fostering collaborations between academia and industry.
- **Ethical Considerations:** Exploration of ethical implications in algorithmic trading and predictive models raises awareness about potential pitfalls and aids in the development of responsible and transparent financial technologies.
- **Real-World Application:** Successful prediction models can be integrated into investment firms, asset management, and trading platforms, translating research outcomes into practical tools for financial professionals.
- **Economic Stability:** Accurate predictions have the potential to enhance economic stability by helping policymakers anticipate market trends and respond proactively to potential crises or market disruptions.

- **Academic Advancement:** Advances in stock market prediction research contribute to the academic literature by introducing novel methodologies, refining existing theories, and challenging traditional assumptions about market behaviour.

5. Methodology

- **Data Collection:** This might include historical stock price data, financial indicators, economic data, news articles, social media data, etc. The dataset we have used to perform the analysis and build a predictive modelling is Tesla Stock Price data has been collected from Kaggle.com [9]. Dataset includes 5 years of data from **2016-08-16** to **2021-08-13**. The data contains information about the stock such as High, Low, Open, Close, Adjacent close and Volume. The 80% of data has been used for training and 20% of data has been used for testing. After training the model, evaluation has been performed on unseen data of our model.

Open: means the price at which the stock started trading when the market open on the particulate day.

Close: It's the price of the individual stock when the stock exchange closed market of of the day. It represents last day by sell order between two traders.

High: It's the highest price at which the stock traded during the period.

Low: It's the lowest price of the period.

Volume: It's the total amount of trading activities during the period time.

Adj Close: It's the calculation of adjustment made to the stock closing price. It is more complex and accurate than the closing price.

- **Data Preprocessing:**

Data preprocessing is a crucial step in building accurate and effective stock prediction models. Data preprocessing is a process of preparing the raw data and making it suitable for a machine learning model. It is the first and crucial step while creating a machine learning model.

When creating a machine learning model, it is not always necessary that we come across the clean and formatted data. So before applying any operation with data, It is mandatory to clean the noises, missing values & outliers from the data and then keep it in a formatted way. It is often said that "*garbage in, garbage out*". The choice of preprocessing steps depends on the specific dataset and the goals of the analysis or modelling task. Properly cleaned and prepared data sets the foundation for meaningful insights and accurate predictive models.

Steps involves in preprocessing of stock price prediction:

- Data Collection
- Date Formatting and Sorting (Time Series Formatting)
- Handling Missing Data
- Feature Engineering
- Lag Features
- Returns Calculation
- Volume and Price Normalization
- Removing Outliers
- Train-Test Split
- Handling Multiple Stocks (if applicable)
- Calendar Effects

- **Data Visualization**

Data preprocessing is a crucial step in building accurate and effective stock prediction models. As stock price prediction is challenging, and the choice of preprocessing steps may vary based on the specific characteristics of the data and the modeling approach you intend to use.

- **Feature Selection / Engineering:**

Feature engineering is the pre-processing step of machine learning, which is used to transform raw data into features that can be used for creating a predictive model using Machine learning or statistical Modelling. Feature engineering in machine learning aims to improve the performance of models. The goal of feature engineering is to provide the algorithm with the most relevant and informative data to make accurate predictions. Feature engineering requires a deep understanding of both the data and the problem domain. Outline the process of selecting relevant features or creating new ones that could enhance the predictive power of models.

Here are some common feature selection and engineering techniques specifically tailored for stock price prediction:

Feature Selection:

- **Correlation Analysis:** Identify and keep features that have a strong correlation with the target variable (stock price). Remove redundant features with high inter-correlation.
- **Statistical Tests:** Use statistical tests (e.g., t-tests or F-tests) to assess the significance of each feature.
- **Recursive Feature Elimination (RFE):** Employ RFE with machine learning algorithms to recursively remove the least important features, based on model performance.
- **Information Gain/Mutual Information:** Evaluate the information gain or mutual information between each feature and the target variable to select features with high predictive power.
- **Regularization Techniques:** Use regularization methods like Lasso or Ridge regression to penalize the coefficients of less important features, encouraging sparsity.
- **Principal Component Analysis (PCA):** Apply PCA to reduce dimensionality while retaining the most important features that capture the variance in the data.

Feature Engineering:

- **Moving Averages:** Create features representing different moving averages (short-term, long-term) to capture trends and smooth out noise in the data.
- **Technical Indicators:** Introduce technical indicators such as Relative Strength Index (RSI), Moving Average Convergence Divergence (MACD), Bollinger Bands, and Stochastic Oscillator.
- **Price Rate of Change:** Calculate the percentage change in prices over a specified period to capture momentum.
- **Volatility Measures:** Incorporate measures of volatility, such as standard deviation or average true range, to capture market volatility.
- **Seasonality and Calendar Effects:** Create features that capture seasonality or calendar effects, considering factors like day of the week, month, or holidays.

- **Lagged Features:** Introduce lag features to represent past values of the target variable. This helps the model capture temporal dependencies.
- **Volume-Related Features:** Include features related to trading volume, such as moving averages of volume or volume rate of change.
- **Sentiment Analysis:** If available, incorporate sentiment analysis scores from financial news or social media to capture market sentiment.
- **Economic Indicators:** Include macroeconomic indicators (e.g., GDP growth, interest rates) that may influence overall market conditions.
- **Rolling Statistics:** Compute rolling statistics (e.g., rolling mean, rolling standard deviation) to capture trends and fluctuations in the data.
- **Categorical Encoding:** If dealing with categorical data (e.g., stock symbols), encode them using techniques like one-hot encoding.

Model Development:

A machine learning model is defined as a mathematical representation of the output of the training process. As we know there are lots of models and algorithms available. But to choose the best model is one most confusing question that arises to any beginner that "which model should I choose?". So, it depends mainly on the business requirement or project requirement. It also depends on the relationship between attributes of the dataset, the number of features, complexity, etc. However, we always start with the simplest model that can be applied to the particular problem and then gradually enhance the complexity & test the accuracy with the help of parameter tuning and cross-validation.

Each machine learning algorithm settles into one of the three models:

- Supervised Learning
- Unsupervised Learning
- Reinforcement Learning

Algorithms/Library:

Predicting stock prices often involves various algorithms and techniques have been applied to address it. The choice of algorithm and libraries depends on the characteristics of the data and the specific goals of the prediction.

So following are some algorithms and libraries listed below which we have used to forecast the stock market:

Algorithms:

- **Linear Regression**

Linear regression models the relationship between the independent variables (features) and the dependent variable (stock price) as a linear equation. It is simple and interpretable but may not capture complex nonlinear patterns.

- **Support Vector Machines (SVM)**

SVM can be used for both regression and classification tasks. It aims to find a hyperplane that best separates or fits the data in a high-dimensional space.

- **Decision Trees and Random Forests**

Decision trees recursively split the data based on the features, and random forests aggregate predictions from multiple decision trees. They can capture complex relationships in the data but may be prone to overfitting.

- **Neural Networks (Deep Learning)**

Recurrent Neural Networks (RNNs) and Long Short-Term Memory (LSTM) networks are popular for time series prediction, as they can capture sequential dependencies in data. Feedforward Neural Networks (FNNs) and deep learning architectures like Convolutional Neural Networks (CNNs) have also been applied.

- **ARIMA (AutoRegressive Integrated Moving Average)**

ARIMA models are designed for time series forecasting and can capture trends, seasonality, and autocorrelation in the data.

- **Ensemble Methods**

Methods like Gradient Boosting Machines (GBM) or XGBoost combine the predictions of multiple weak learners to improve overall model performance.

- **K-Nearest Neighbors (KNN)**

KNN makes predictions based on the similarity of data points. It can be effective when local patterns are important.

- **Prophet**

Developed by Facebook, Prophet is designed for time series forecasting with daily observations that display patterns on different time scales. It handles missing data and outliers well.

- **Reinforcement Learning:**

Reinforcement learning algorithms, such as Deep Q-Learning, have been applied to stock trading strategies, learning to make buy/sell decisions based on historical price data.

- **Hybrid Models:**

Combine multiple models to leverage their strengths. For example, combining a time series model with a machine learning model or using a hybrid of statistical and machine learning approaches.

Libraries:

- **Pandas:** A powerful data manipulation library for handling structured data.
- **Matplotlib:** A popular plotting library for creating static, animated, and interactive visualizations in Python.
- **Seaborn:** Built on top of Matplotlib, Seaborn provides a high-level interface for statistical data visualization.
- **Scikit-learn:** A comprehensive machine learning library that provides tools for data preprocessing, model selection, training, and evaluation.
- **Statsmodels:** A library for estimating and testing statistical models, including time series analysis models like ARIMA.
- **TensorFlow:** An open-source deep learning library developed by Google for building and training neural network models.
- **PyTorch:** A deep learning library that provides dynamic computational graphs, making it popular for research and application development.
- **Yahoo Finance API:** For retrieving historical stock price data.

- **SciPy:** A library for scientific computing that includes optimization tools, useful for parameter tuning in models.
- **Keras:** A high-level neural networks API that can run on top of TensorFlow or other deep learning frameworks.

Before using these algorithms and libraries, make sure to install them in your Python environment using tools like pip. The effectiveness of these libraries depends on various factors, including the nature of the data, the complexity of the problem, and the chosen modeling approach

Evaluation Metrics:

To evaluate the performance or quality of the stock price prediction model, different metrics are used, to assess their accuracy and reliability and these metrics are known as performance metrics or evaluation metrics. Evaluation metrics are quantitative measures used to assess the performance of a model, algorithm or system.

The metrics used to assess the accuracy of prediction models. Metrics include Mean Absolute Error (MAE), Mean Squared Error (MSE), Root Mean Squared Error (RMSE), , R-squared , MAPE.

To calculate manually,

$$MSE = \frac{\sum (y(\text{actual}) - y(\text{pred}))^2}{N} \quad (1)$$

$y(\text{actual})$ is the Actual outcome, $y(\text{pred})$ is the predicted outcome, and N is the total number of data points.

$$MAE = \frac{\sum |y(\text{actual}) - y(\text{pred})|}{N} \quad (2)$$

$y(\text{actual})$ is the Actual outcome, $y(\text{pred})$ is the predicted outcome, and N is the total number of data points

$$RMSE = \sqrt{\frac{\sum (y(\text{pred}) - y(\text{actual}))^2}{N}} \quad (3)$$

$y(\text{actual})$ is the Actual outcome, $y(\text{pred})$ is the predicted outcome, and N is the total number of data points

$$R^2(\text{R-Squared}) = 1 - \frac{MSE(\text{model})}{MSE(\text{baseline})} \quad (4)$$

6. Result and Discussion

Stocks, also known as shares or equities, represent ownership in a company. When you own a stock, you essentially own a portion of the company's assets and earnings. Companies issue stocks to raise capital for various purposes, such as expansion, research and development, or debt repayment.

Working of stocks

- **Initial Public Offering (IPO):** When a company decides to go public, it issues shares in the form of an IPO. Investors can then buy these shares, and the company receives capital in return.
- **Stock Exchange:** Stocks are traded on stock exchanges, which are platforms where buyers and sellers come together to trade shares. Some well-known stock exchanges include the New York

Stock Exchange (NYSE) and the Nasdaq in the United States, the London Stock Exchange (LSE) in the UK, and the Tokyo Stock Exchange (TSE) in Japan.

- **Stock Price:** The price of a stock is determined by supply and demand in the market.
- **Ownership and Dividends:** When you buy a stock, you become a shareholder in the company. Shareholders may receive a portion of the company's profits in the form of dividends.
- **Capital Gains and Losses:** The value of a stock can change over time. If the stock's price increases from the time you bought it, you can sell it at a profit. Conversely, if the price decreases, you may incur a loss if you sell the stock.

Investing in stocks carries risks, as the value of stocks can be volatile and influenced by various factors such as economic conditions, company performance, and market sentiment. Many investors engage in stock trading and investing with the goal of growing their wealth over time.

Some of the diagrams and table given below of Tesla Stock Price dataset that discusses the trades of the company. As we know in real-world stock price prediction is more complex. So we need to perform more extensive hyperparameter tuning, more advanced time series analysis techniques for accurate stock market predictions.

7. Figures and Tables

Figure 1: Trends of overall price of trades of tesla Stocks over the years

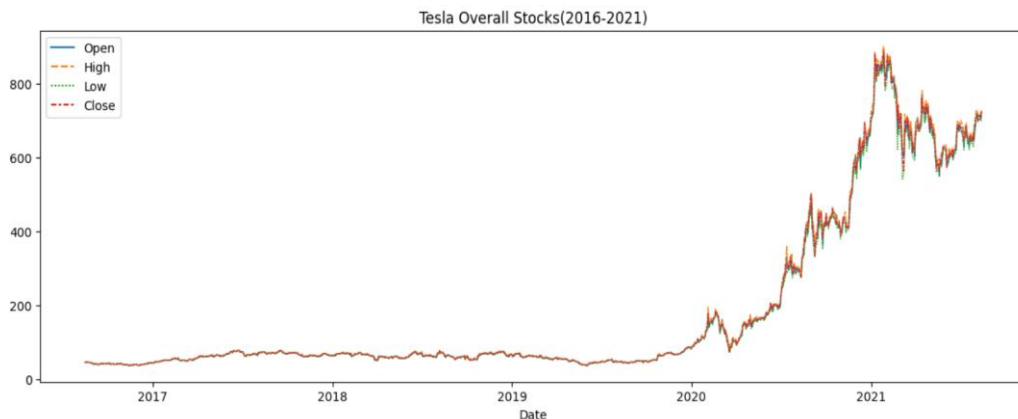


Figure 2: Actual price versus predicted trends of the closing price using three(lr vs svr vs xgb) regression techniques

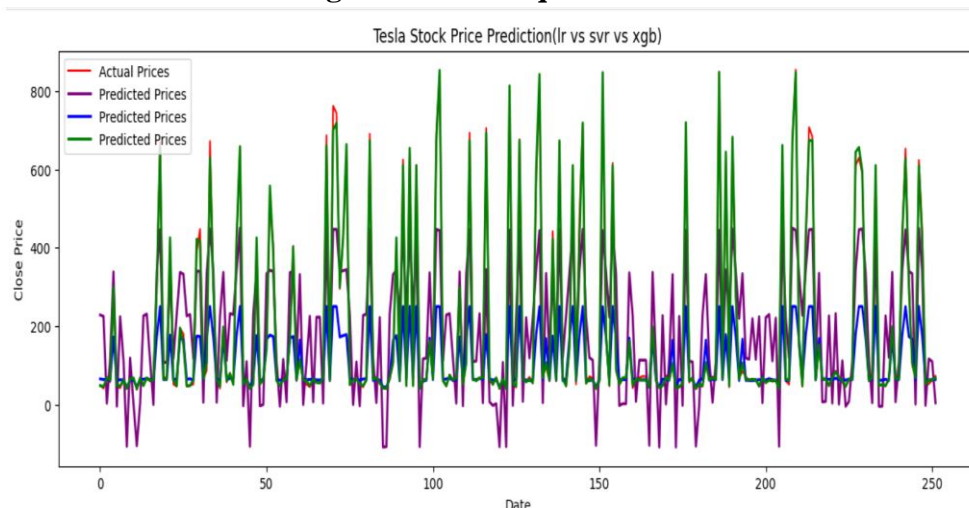


Table 1: Result of Evaluation metrics

Model name	MSE	MAE	RMSE	MAPE	R2-score
Linear Regression	22979.0454	127.31953	151.5884	143.3844	0.57779
Support vector regressor	46084.0990	122.8232	214.6720	59.6667	0.15327
XGBOOST regressor	150.72170	6.82957	12.27687	4.37883	0.9972

7. Conclusion

The stock market prediction is a complex and multifaceted area that has garnered significant attention from researchers, investors, and financial professionals alike. Through this exploration, we have delved into various methods and approaches that attempt to forecast stock market movements, ranging from fundamental and technical analysis to machine learning and artificial intelligence-driven models. It is important to recognize that while these methods have shown varying degrees of success in predicting market trends, the inherent volatility and unpredictability of financial markets pose formidable challenges to achieving consistently accurate predictions.

Throughout the paper, we have explored the application of machine learning algorithms, including Linear Regression, Support Vector Regression (SVR), and XGBoost, to forecast stock prices. These models have been evaluated using essential metrics like Mean Squared Error (MSE), Mean Absolute Error (MAE), Root Mean Squared Error (RMSE), Mean Absolute Percentage Error (MAPE), and R-squared (R2) score. These evaluation metrics provide insights into the performance of each model.

Investors and decision-makers should approach stock market prediction with a balanced perspective, recognizing that accurate forecasting is inherently challenging. Rather than solely relying on predictions, prudent investment strategies should focus on long-term goals, diversification, risk management, and staying informed about market trends. Moreover, maintaining an awareness of the limitations of prediction models can help mitigate the potential risks associated with making decisions solely based on forecasts.

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