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Effectiveness of Random Forest Model in Predicting Stock Prices of Solar Energy Companies in India

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ABSTRACT

The solar energy industry's positive impact on India's GDP is perceptible through increased investments, innovation, and enhanced energy security. As the nation continues to prioritize clean energy solutions, the solar sector stands as a key player driving both economic prosperity and environmental sustainability, aligning India with worldwide determinations to battle climate change and encourage a greener future. As the Indian government continues to champion initiatives promoting renewable energy, Solar Energy Companies have seen unprecedented growth and have become increasingly attractive to investors seeking long-term, sustainable returns. This influx of interest, however, brings with it the challenge of navigating the volatile and dynamic nature of the stock market. In this context, forecasting the stock prices of solar energy corporations in India becomes a pivotal aspect of investment strategy for both institutional and retail investors. This paper targets to add to the prevailing body of knowledge by evaluating the efficacy of the Random Forest model, a machine learning technique known for its versatility and robustness, in forecasting the stock prices of top four Solar Energy Companies in India on the basis of market capitalization, by using the daily opening, high, low and closing stock prices ranging from 1st October, 2019 to 30th September, 2023 i.e. 4 years. The findings reveal that high Coefficient of Determination (R^2) values for all companies, ranging from 0.9928 to 0.9939 is a clear indication of the model's ability to predict a substantial portion of the variance in each company's stock prices. But in case of Adani Green Energy Ltd. a notably higher MSE and RMSE are exhibited, implying a greater degree of fluctuation in prediction accuracy compared to the other companies. On the other hand, all the selected solar energy companies display lower MAE values, indicating tightly clustered predictions around actual values.

Keywords: Energy, Machine Learning, Random Forest, Forecasting

JEL Classifications: Q2, Q4, C32, C53, G17

1. INTRODUCTION

The solar energy industry is rapidly emerging as a transformative force in India (Timilsina et al., 2012) (Devabhaktuni et al., 2013), catalyzing a profound shift towards sustainable and clean energy sources (Surie, 2017) (Pegels et al., 2018). With a burgeoning population and increasing energy demands, India is strategically harnessing its abundant sunlight to expand its energy portfolio and moderate reliance on conventional fossil fuels (Dey et al., 2022) (Mittal, 2023). Government initiatives, such as the National Solar Mission, have set ambitious targets for solar capacity installation, fostering a favorable environment for investment and innovation (Shrimali and Rohra, 2012) (Kapoor et al., 2014) (Johnson, 2016) (Sawhney, 2021). The robust expansion of the solar energy sector has not only diversified the country's energy mix but has also created employment opportunities, fostering economic development (Dey et al., 2022) (Dai and Xiong, 2023). Technological advancements and declining solar equipment costs further bolster the sector's viability (Crowe, 2013) (Burke et al., 2019) (Chawla et al., 2020) (Harichandan et al., 2023). As solar power becomes increasingly competitive with traditional energy sources, India is positioned to not only meet its energy needs sustainably but also emerge as a global frontrunner in the solar energy landscape (Elavarasan et al., 2020) (Sharma et al., 2012). The solar energy industry's trajectory underscores India's commitment to a greener future and exemplifies the nation's proactive approach to combating climate change. The increasing adoption of solar technologies in various sectors, including residential, commercial, and industrial, has not only reduced dependency on conventional fossil fuels but has also contributed to mitigating environmental concerns (Goel, 2016) (Rathore and Panwar, 2022). Moreover, the solar energy industry's positive impact on India's GDP is perceptible through increased investments, innovation, and enhanced energy security (Rej and Nag, 2022). As the nation continues to prioritize clean energy solutions, the solar sector stands as a key player driving both economic prosperity and environmental sustainability, aligning India with worldwide efforts to battle climate change and encourage a greener future.

As the world grapples with climate change and environmental sustainability, investments in clean energy have not only become a moral imperative but also an enticing financial prospect (Khalil and Nimmanunta, 2023). The potential returns from investing in Solar Energy Companies in India appeal to a wide spectrum of investors, ranging from institutional giants with substantial portfolios to individual retail investors seeking sustainable and profitable avenues (Shrimali, 2021) (Tarczynska-Luniewska et al., 2022). The appeal of solar energy investments lies not only in their alignment with environmental consciousness but also in the robust growth and innovation within the sector. As the Indian government continues to champion initiatives promoting renewable energy, Solar Energy Companies have seen unprecedented growth and have become increasingly attractive to investors seeking long-term, sustainable returns. This influx of interest, however, brings with it the challenge of navigating the volatile and dynamic nature of the stock market. In this context, predicting the stock prices of solar energy companies in India becomes a pivotal aspect of investment strategy for both institutional and retail investors. Understanding the intricacies of stock price movements in the solar energy sector is fraught with challenges due to the multifaceted influences ranging from regulatory policies and technological advancements to global economic factors. Consequently, investors are compelled to seek predictive models that can help unravel the complexities and provide insights into potential market trends. It is within this context that this research paper embarks on an exploration of the efficiency of the Random Forest (RF) model in predicting stock prices of Solar Energy Corporations in India.

The significance of accurate stock price prediction cannot be overstated, particularly in a sector where technological advancements, government policies, and global market dynamics are in a constant state of flux. Investors face the daunting task of making decisions in an environment characterized by rapid changes (Boubaker et al., 2018), and the ability to forecast stock prices becomes instrumental in mitigating risks and maximizing returns (Andersson et al., 2016). This research paper aims to add to the prevailing body of information by evaluating the efficacy of the Random Forest model, a machine learning technique known for its versatility and robustness, in forecasting the stock prices of Solar Energy Companies in India. The choice of the RF model is strategic, considering its capability to handle complicated datasets, capture non-linear relationships, and mitigate overfitting-challenges often encountered in the realm of stock price prediction (Kraus and Feuerriegel, 2017) (Tang et al., 2022). Through a comprehensive analysis, this study seeks to not only assess the accuracy and reliability of the Random Forest model but also to provide valuable insights for investors navigating the dynamic landscape of Solar Energy Company stocks in India.

2. REVIEW OF LITERATURE

The Random Forest (RF) technique is widely employed in machine learning for the purpose of predicting stock prices. Multiple studies have demonstrated the efficacy of RF in forecasting stock market patterns. Random Forest has proven to be aeffective tool for investors and traders alike (Park et al., 2019) (Abraham et al., 2022) (Maini and Govinda, 2017). As input features, the algorithm makes use of past trading data and a variety of technical indicators (Lavingia et al., 2022) (Yin et al., 2023). It adjusts learning parameters during the training process to optimize accuracy (Park et al., 2019). Research has demonstrated that Random Forest outperforms competing models, such as Support Vector Machine, in terms of prediction accuracy (Maini and Govinda, 2017) (Cai et al., 2023). Combining Random Forest with other AI technologies has also helped with stock price analysis and investment decision-making (Du et al., 2022) (Dhanalakshmi et al., 2023). The algorithm has produced good results when applied to various stock markets, such as the NASDAQ, BSE, NSE, and SSE A-share (Lavingia et al., 2022) (Qiu and Jia, 2022).

(Sadorsky, 2022) research utilizes machine learning algorithms that are structured like trees to predict the future value of solar stocks, paying close attention to technical indications, silver prices, volatility in silver prices, and volatility in oil prices. For a forecast period between eight and 20 days, the accuracy of these methods is higher than 85%. There are important indications in the volatility of both the oil price and the silver price. A trading strategy utilizing these indications surpasses a basic buy and hold strategy in terms of investment portfolio performance.

The energy market in China, which is still developing, is particularly vulnerable to changes in market conditions because of its distinctive energy sector. This research presents a novel financial forecasting model that utilizes a cluster learning technique, specifically Random Forest, as opposed to a genetic algorithm. The model is utilized for short-term stock prediction, specifically to ascertain stock price patterns. The findings demonstrate that the GSRF stochastic forest model provides superior returns and reduced risk (Song et al., 2023).

Accuracy rates for a 20-day forecast horizon range from 85% to 90% when using tree bagging and random forest approaches, and from 55% to 60% when using logit models (Sadorsky, 2021). These findings corroborate previous studies that have shown RFs to be very accurate stock price predictors (Ampomah et al., 2020) (Ballings et al., 2015) (Weng et al., 2018) (Basak et al., 2019) (Lohrmann and Luukka, 2019).

(Meher et al., 2024) attempt to use the RF model with high-frequency data (HFD) to forecast stock values in the rapidly growing Indian FinTech community. When it comes to predicting the stock values of FinTech businesses in India using HFD, the results provide solid evidence that the Random Forest model is beneficial. All of the chosen firms have a coefficient of determination more than 95%, indicating that the random forest forecasting model produces very accurate predictions (Du et al., 2022) when it comes to predicting stock prices, Random Forest is a great tool that can help both large institutions and individual investors.

2.1. Research Gap and Need of the Study

Despite the growing interest in predicting stock prices using machine learning techniques, there exists a notable research gap in the context of forecasting stock prices specifically for solar energy companies in the Indian market. While various studies have explored stock prediction models, limited attention has been given to the unique challenges and dynamics of the solar energy sector in India. This investigation aims to tackle this space by employing the Random Forest algorithm, a powerful machine learning tool, to predict stock prices of solar energy companies. The gap lies in the absence of comprehensive studies that consider the specific factors swaying the stock prices of solar energy firms in the Indian context, such as government policies, regulatory frameworks, and the impact of environmental factors. Bridging this research gap is crucial for shareholders, legislators, and market analysts looking for accurate and context-specific predictions to make informed judgements in the promptly evolving landscape of renewable energy investments in India.

3. RESEARCH METHODOLOGY

This research employs a quantitative and empirical approach, aiming to predict stock prices of Solar Energy corporations in India through the application of the RF machine learning technique using Python. Particularly appropriate for predicting financial time series data due to its efficient handling of non-linear relationships, the approach involves collecting daily open, high, low, and close stock prices from the top four Solar Energy companies on the NIFTY Energy Index-Adani Green Energy Ltd., Jaiprakash Power Ventures Ltd., NHPC Ltd., and SJVN Ltd. Data, sourced from Yahoo Finance for the period from October 1, 2019, to September 30, 2023, ensures a robust historical dataset with 993 data points for each company, totaling 3,972 data points across the four companies. The subsequent data preprocessing encompasses steps such as cleaning, feature selection, handling missing values using linear equation series, and structuring the data for model development. The model formulation centers on Random Forest, known for its prowess in handling complex relationships and mitigating overfitting. Implemented using Python-scikit-learn library, the model is trained on historical data with hyperparameters tuned through cross-validation for optimization. Validation techniques involve assessing forecasting accuracy through metrics like Mean Absolute Error (MAE), Mean Squared Error (MSE), Root Mean Squared Error (RMSE), and R-squared (R^2). Out-of-sample forecasting accuracy is evaluated by splitting the data into training (70%, 695 data points) and testing sets (30%, 298 data points) using a rolling window methodology to estimate performance over time. This comprehensive approach seeks to develop a precise and robust forecasting model, offering valuable insights for investors, analysts, and policymakers in the Solar Energy sector in India.

3.1. Limitations of the Study

- Data Limitations: One potential limitation of the research study could be related to the quality and quantity of the data used. If the dataset lacks comprehensive information or if there are many missing values, it could impact the accuracy and reliability of the Random Forest prototype's forecasts. The model framed from the selected data, might not be capable to capture diverse market scenarios.
- Model Generalization in dynamic market environments: The efficiency of the RF model in predicting stock values might be limited in its generalization to other market conditions or time periods. The study may not explore how well the model performs during periods of economic volatility, policy changes, or other external factors that can significantly impact stock prices. This lack of generalizability could limit the practical application of the model in dynamic market environments.
- Lack of Interpretability: Understanding the decision-making process of the Random Forest algorithm may be challenging for stakeholders, such as investors or policymakers, who may be interested in the rationale behind stock price predictions. This lack of interpretability could limit the practical utility of the model in real-world decision-making scenarios.
- Weak Forecasting due to Limited Predictors: The study is limited to different prices of stocks i.e., the open, high, low, close prices as predictors. It did not consider any macro-economic variables as predictors due to which the forecasting may be consider as a weak one.

Additionally, it is important to remember that these limitations should be understood in the framework of the particular study and the information given in the research.

4. ANALYSIS, RESULTS AND DISCUSSION

Random Forest, a powerful ensemble learning technique, is renowned for its efficacy in handling diverse datasets, yet its application to time series data poses unique challenges and opportunities. Time series data, characterized by temporal dependencies, trends, and seasonality, deviates from the assumptions of independence that underlie the conventional use of Random Forest. However, innovative adaptations and methodologies have been developed to harness the potential of Random Forest in this context. In the realm of time series analysis, Random Forest demonstrates its prowess by capturing intricate patterns and non-linear relationships, making it suitable for forecasting tasks. The algorithm's inherent capacity to handle high-dimensional datasets, accommodate missing values, and provide variable importance metrics adds to its allure. Yet, its application demands careful consideration of hyperparameters, window sizes, and lag values to navigate the temporal intricacies effectively. Moreover, the incorporation of techniques like rolling-window cross-validation and out-of-bag error estimation ensures robust model evaluation in a time-dependent context. Despite the challenges posed by the sequential nature of time series data, Random Forest proves to be a versatile tool, offering predictive accuracy and interpretability. Researchers and practitioners continue to explore novel adaptations and hybrid models to enhance the algorithm's performance, solidifying its role in forecasting and uncovering temporal patterns in a myriad of domains, from finance to healthcare. In this study it is applied to forecast the stock values of solar energy corporations.

4.1. Brief About the Selected Solar Energy Companies

Adani Green Energy Limited operates within the renewable energy industry, providing renewable energy to several government bodies and government-supported enterprises in India. The corporation encompasses in the development, ownership, and supervision of power plants that utilize solar, wind, and hybrid energy sources. Adani Green Energy Limited currently operates solar power facilities with a total capacity of 4,763 megawatts (MW) and wind power plants with a total capacity of 647 MW as of March 31, 2022. Established in 2015, the company is headquartered in Ahmedabad, India.

In India, Jaiprakash Power Ventures Limited generates electricity and grinds cement. Power stations owned and operated by the firm include the 400 MW Jaypee Vishnuprayag hydropower plant, the 1,320 MW Jaypee Nigrie thermal power plant, and the 500 MW Jaypee Bina thermal power plant. The company also generates electricity from thermal, solar, and hydroelectric sources. In addition to its sand mining operations, Jaiprakash Power Ventures Limited runs a cement grinding mill. The business changed its name in December 2009 to Jaiprakash Hydro-Power Limited. It was incorporated in 1994 and has its headquarters in New Delhi, India.

NHPC Limited and its subsidiaries are involved in electricity generation and sales in India, utilizing wind, hydro, and solar power plants. The company also provides consultancy services in various areas, including operation and maintenance, design and engineering, survey and investigations, geotechnical engineering, construction management, and contract management. NHPC Limited, incorporated in 1975, is based in Faridabad, India. It sells electricity to bulk customers, including state government-owned electricity utilities and private distribution companies.

SJVN Limited and its affiliates produce and sell energy in the Indian subcontinent, Bangladesh, and Nepal. Power transmission, thermal power, hydropower, wind power, and solar power are all areas of operation for the establishment. The NathpaJhakri Hydro Power Station (1500 MW) in Shimla District and the Rampur Hydro Power Station (412 MW) in Kullu District are two of its most prominent projects in Himachal Pradesh. One solar power project in Gujarat and one wind power project in Maharashtra are both run by SJVN Limited. The business rebranded in September 2009 from its previous name, Satluj Jal Vidyut Nigam Limited. Established in 1988, SJVN Limited is based in Shimla, India.

4.2. Application of RF in Forecasting Stock Prices of Solar Energy Corporations in India

In this analysis, the focus revolves around transforming non-stationary data sets from various solar energy companies into stationary formats to facilitate the application of the random forest model. After importing all the data into Python, the non-stationary data are converted into stationary data and further inspected using Dickey Fuller Augmented Unit Root test. The construction of the RF model in this study was accomplished using the "scikit-learn" Python package. We utilized the pre-set hyperparameters included in the package, achieving a compromise between the intricacy of the model and the computational efficiency. The parameter denoting the number of trees (n_estimators) was set to the default value of 100 to strike the optimal balance between performance and processing resources. The lack of a specified maximum depth for the trees (max_depth) allowed them to continue growing until the leaves achieved a high level of purity or contained just a small number of samples, thus efficiently capturing the complex characteristics of the data. The parameter min_samples_split was assigned a value of 2, enabling accurate segmentation of the dataset and enhancing the learning process from the training set.

The min_samples_leaf parameter was set to 1, which enhances the accuracy of class distinctions, particularly beneficial for datasets with complex decision boundaries. The "auto" setting in scikit-learn sets the maximum number of features (max_features) used in splits to the square root of the total number of features. This fosters biodiversity among the trees and contributes to the generalization of the model. In addition, the implementation of bootstrap samples was automatically enabled, so introducing unpredictability to the training process of each individual tree. The introduction of randomization served to condense overfitting and expand the prototype's ability to draw generalizations.

The dataset for each company comprises 993 data points, subsequently divided into two segments: the initial 80%, encompassing 794 data points, and the remaining 20%, constituting 199 data points. The former serves as the training set, while the latter functions as the testing set. The training set is instrumental in constructing the RF model, while the testing set is employed to apply the formulated model for prediction purposes. The efficacy and appropriateness of the random forest model are assessed through metrics such as MSE, RMSE, MAE, and R^2, calculated using specified formulae.

Mean Squared Error	Root Mean Squared Error
$MSE = \frac{1}{N}\sum_{i=1}^{N}\left(y_i - \hat{y}\right)^2$	$RMSE = \sqrt{MSE} = \sqrt{\frac{1}{N}\sum_{i=1}^{N}\left(y_i - \hat{y}\right)^2}$
Mean Absolute Error	**Coefficient of Determination**
$MAE = \frac{1}{N}\sum_{i=1}^{N}\left\|y_i - \hat{y}\right\|$	$R^2 = 1 - \frac{\sum\left(y_i - \hat{y}\right)^2}{\sum\left(y_i - \bar{y}\right)^2}$

In the evaluation of the formulated model using $\hat{y}$ a testing dataset, where represents the predicted value of y, and denotes the mean value of y, the results manifest as forecasted stock prices alongside the observed (actual) stock prices. These outcomes are visually illustrated in a graph to highlight disparities between the predicted and actual values. Given the substantial size of the testing set, comprising 199 data points, presenting differences through conventional graphs may lack clarity. Therefore, a deviation graph is employed to effectively portray the variances between the actual and predicted stock prices.

Table 1 presents the computed MSE, RMSE, MAE, and R^2 of for the chosen green energy companies. Regression analysis uses the Coefficient of Determination, or R^2, as a critical performance indicator to show how much of the variance in the dependent variable can be predicted from the independent variables. The R^2 values derived from the Random Forest model forecasts for the concerned green energy companies are remarkably high. Each of the four companies-ADANIGREEN at 0.9939, JPPOWER at 0.9928, NHPC at 0.9931, and SJVN at 0.9929-has an incredibly high Coefficient of Determination (R^2). These numbers show how well the model can account for a significant amount of the variation in each company's real stock price.

The average squared difference (MSE) between the actual and forecasted values of next day close price differs dramatically for the companies. The MSE for ADANIGREEN is 2737.26 which is notably higher, indicating a greater degree of fluctuation in the stock price prediction accuracy. Where JPPOWER has the lowest MAE (0.1440), closely followed by SJVN (0.5034) and NHPC (0.5140). this is implying that the predictions are tightly clustered around the actual values.

The RMSE values, providing a measure of the average magnitude of errors, are in line with the MSE findings. The average magnitude of the model's prediction errors is indicated by the Root Mean Squared Error (RMSE) measure. Different green energy companies have different RMSE values from our Random Forest model, which reflects variations in forecast accuracy.

The RMSE for ADANIGREEN is 52.32, a substantial increase above the other companies' figures. This figure indicates that there is an average deviation of approximately 52.32 units between the model's predictions and the actual stock prices for ADANIGREEN. A high root mean square error (RMSE) suggests higher average prediction errors, which may be caused by data inconsistencies, stock price volatility, or other market factors that the model did not account for.

In contrast, JPPOWER shows an RMSE of only 0.2026, which suggests that the model's predictions are considerably more tightly clustered around the actual stock values. The RMSE values for NHPC and SJVN are 0.7474 and 0.7320, respectively. The fact that these values are still quite low, even though they surpass JPPOWER's, indicates that the model's predictions for NHPC and SJVN are likewise rather accurate, with an average deviation of less than a unit. The Random Forest model's accuracy and dependability for JPPOWER, NHPC, and SJVN are demonstrated by the reduced RMSE values, which indicate that the model can consistently generate predictions that are near to the actual observed stock prices for these companies.

Again, the anticipated stock prices are computed using the developed models and displayed in line graphs alongside the actual stock prices for comparison.

Figure 1 Deviations plots, which show the difference between actual and forecast stock values, are created so that a single trend line may be easily understood. The difference will be zero and there won't be a spike at that specific date and time if the model's predictions are accurate. In any other case, the line will oscillate about zero, displaying an upward spike in the case of high predictions and a downward spike in the case of low predictions. The deviations plot for each of the three chosen companies is displayed in the section that follows.

Figure 2, here the term "big spike" defined as the deviation greater than twice the average absolute deviation for any company. Total 24 significant deviations, referred to as "big spikes," were found in the ADANIGREEN dataset. The average close price of ADANIGREEN is 1120.92. The range of significant differences between the observed and predicted values was around −219.02–+293.37. This result is particularly striking, given that the average absolute deviation was recorded at 32.52.

The graph for JPPOWER displays 23 notable "big spike" with variations ranging from −0.72 to +0.78. These are noteworthy considering JPPOWER's average close price of 4.76, even though they are little in relation to the average absolute deviation of 0.14. The graph of NHPC shows thirty significant spikes with variations ranging from -1.95 to +2.67. Considering NHPC's average close price of 30.66 and these "Big spicks" are greater than the average absolute deviation of 0.51, these fluctuations are still considered to be modest. There are 27 notable "big spike" in the case of SJVN, with variances ranging from −3.40 to +2.38. When compared to the average absolute deviation of 0.50, these deviations are significant and indicate that although the model generally performs well, there are some cases of significant prediction errors.

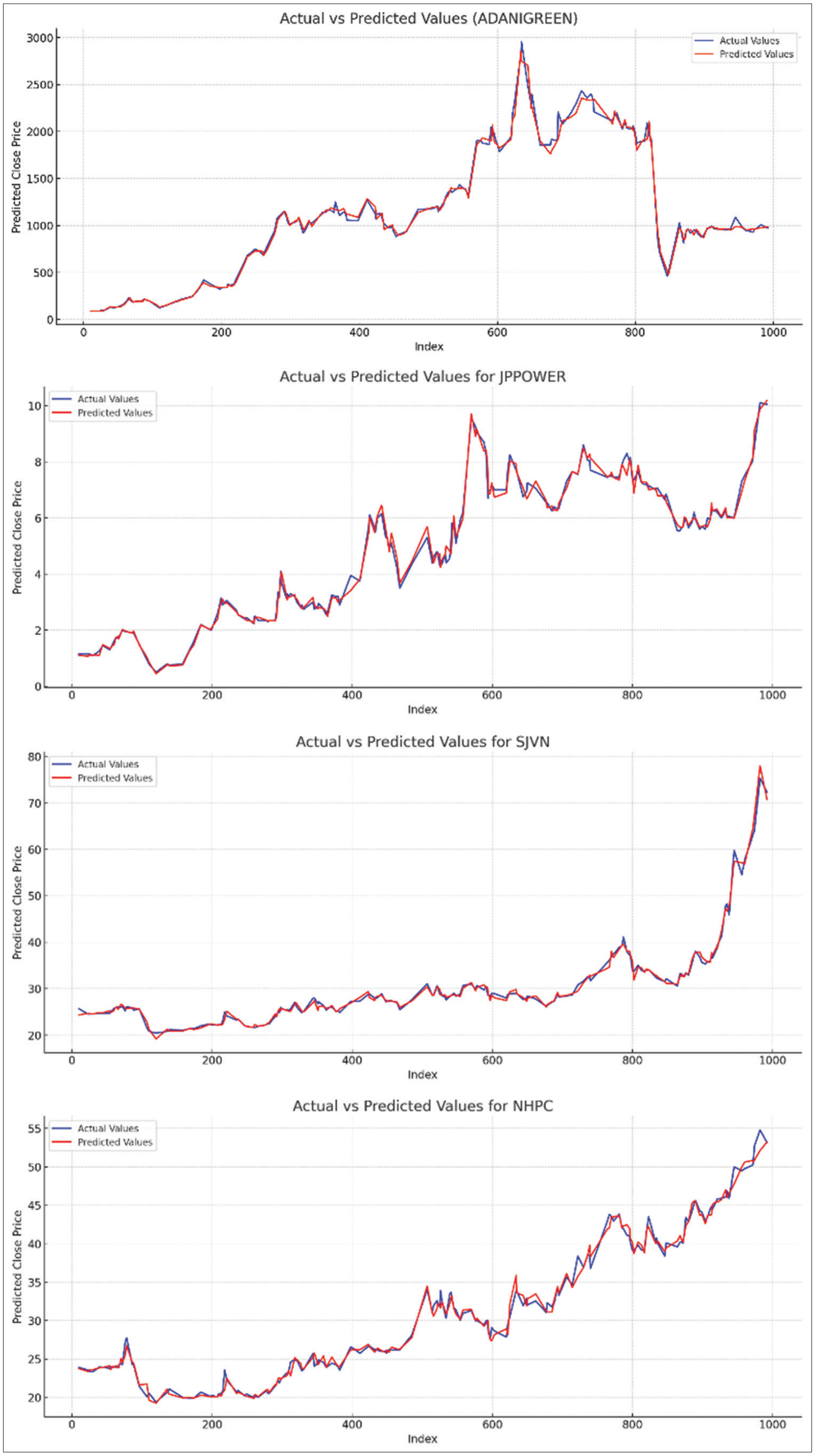
The models for every company exhibit good accuracy overall, with tiny average deviations; but the presence of these "big spikes" indicates instances in which the model's predictions deviate greatly

Table 1: Values of MSE, RMSE, MAE, and R^2 using python

Statistics	Adani Green Energy Ltd. (ADNA)	Jaiprakash Power Ventures Ltd. (JAPR)	NHPC Ltd.(NHPC)	SJVN Ltd.(SJVN)
MSE	2737.26	0.0410	0.5586	0.5358
RMSE	52.32	0.2026	0.7474	0.7320
MAE	32.52	0.1444	0.5140	0.5034
R^2	0.9939	0.9928	0.9931	0.9929

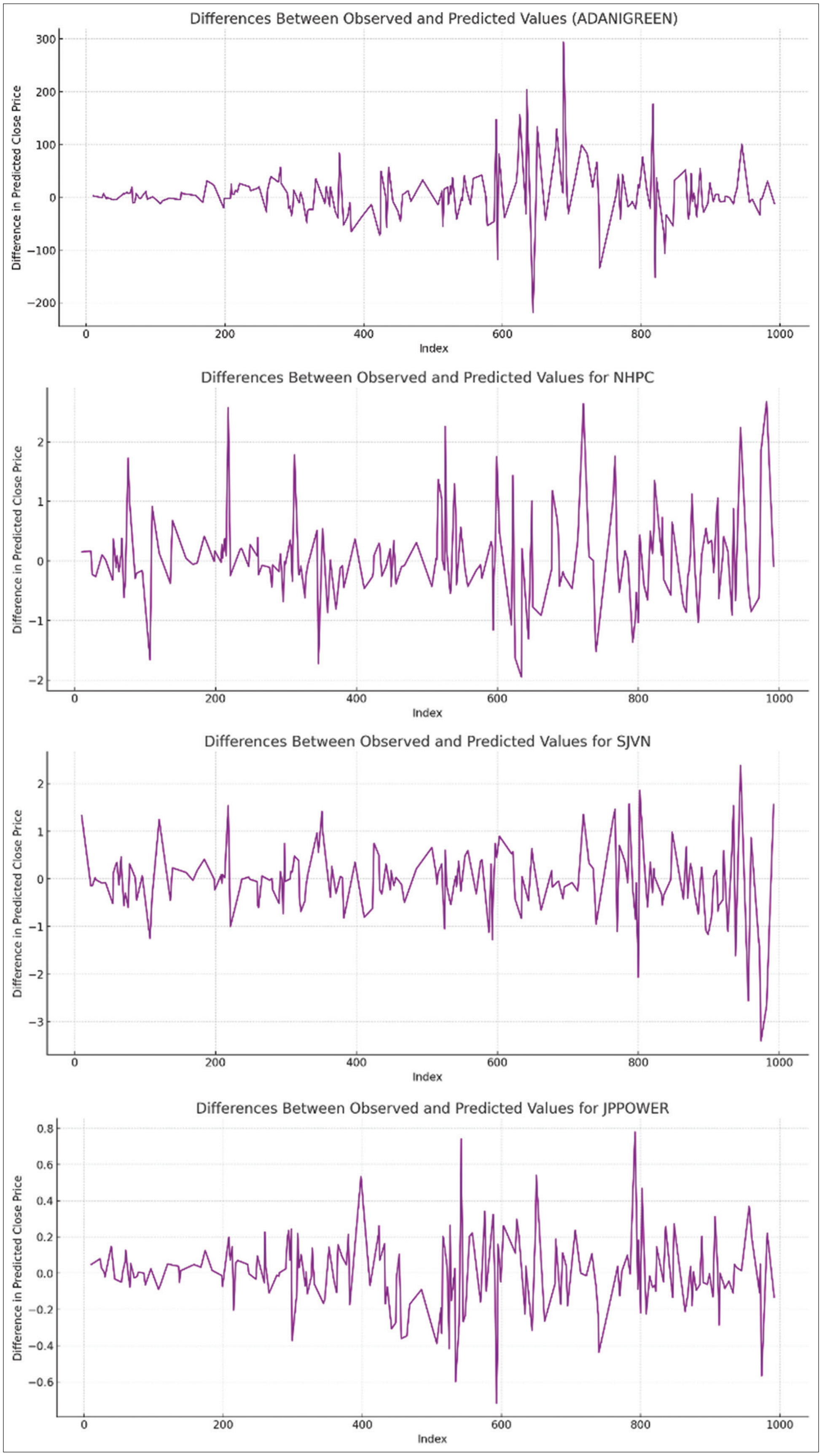
Source: Authors' calculation using Python

Figure 1: Graphical illustration of actual and predicted stock values of elected green energy corporationson testing data using the formulated RF models



Source: Authors' formation of graphs using Python

Figure 2: Graphical illustration of deviations plot of elected solar energy corporations



Source: Authors' formation of graphs using Python from the observed values. This may be the result of a number of things, including unanticipated news, market volatility, or intrinsic limits in the modelling methodology.

5. CONCLUSION

In concluding remarks, the efficiency of the RF models in predicting stock prices of solar energy corporations in India is evident through a comprehensive analysis of key statistical metrics and graphical representations. Table 1 that provides a summary of the model's performance, showcasing MSE, RMSE, MAE, and R^2 for top four selected green energy companies based on market capitalization: Adani Green Energy Ltd., Jaiprakash Power Ventures Ltd., NHPC Ltd., and SJVN Ltd. The high Coefficient of Determination (R^2) values for all companies, ranging from 0.9928 to 0.9939, indicate the model's ability to predict a substantial portion of the variance in each company's stock prices. This suggests that the Random Forest model is proficient in capturing and explaining the underlying patterns in the data, leading to accurate predictions. However, a closer examination of MSE, RMSE and MAE reveals variations in the prediction accuracy among the companies. In case of Adani Green Energy Ltd a notably higher MSE and RMSE are exhibited, implying a greater degree of fluctuation in prediction accuracy compared to the other companies. On the other hand, all the selected solar energy companies display lower MAE values, indicating tightly clustered predictions around actual values.

The graphical illustration of actual and forecasted stock prices further corroborates the model's accuracy, showcasing a close alignment between the predicted and observed values for Jaiprakash Power Ventures Ltd., NHPC Ltd., and SJVN Ltd. However, the presence of significant deviations, referred to as "big spikes," suggests instances where the model's predictions deviate greatly from actual values. The deviations plots provide a clear visualization of these significant spikes, and their analysis reveals interesting insights. Adani Green Energy Ltd., in particular, exhibits 24 significant deviations, with variations ranging from −219.02 to +293.37, indicating substantial prediction errors. Similar patterns are observed for Jaiprakash Power Ventures Ltd., NHPC Ltd., and SJVN Ltd., although to varying degrees. These big spikes highlight instances where the model faces challenges, possibly due to unforeseen news, market volatility, or limitations in the modeling methodology. Although the Random Forest model demonstrates overall good accuracy in predicting stock prices for selected solar energy companies, but the presence of big spikes indicates areas where improvements can be made. These deviations emphasize the need for continuous refinement and adaptation of the model to better account for unforeseen factors that may impact stock prices. As the stock market is inherently dynamic and influenced by various external factors, ongoing monitoring and adjustment of the model are essential for maintaining its effectiveness in predicting stock prices for solar energy companies in India. The analysis could act as a base for forthcoming researchers who can inculcate many macro-economic factors to strengthen the future forecasting random forest models for energy stocks.

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