Tesla Stock Price Forecasting Using Two Approaches: Monte Carlo Simulations and Prophet Models

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**Results**

Table I presents descriptive statistics for four key economic variables: Inflation, Interest Rate, Unemployment Rate, and the S&P 500 index. These statistics provide a snapshot of the central tendencies, variability, and distributional characteristics of these variables over the period under consideration.

1. **Descriptive Statsistics**

| Descriptives | Close | High | Low | Open | Volume |
| --- | --- | --- | --- | --- | --- |
| **Mean** | 213.43 | 218.28 | 208.36 | 213.48 | 125,529,900 |
| **Median** | 220.22 | 225.37 | 215.34 | 220.93 | 101,989,400 |
| **Maximum** | 479.86 | 488.54 | 457.51 | 475.90 | 914,082,000 |
| **Minimum** | 24.08 | 26.99 | 23.37 | 24.98 | 29,401,800 |
| **Std. Dev.** | 83.46 | 85.40 | 81.53 | 83.63 | 82,087,050 |
| **Skewness** | -0.18 | -0.16 | -0.21 | -0.18 | 2.99 |
| **Kurtosis** | 0.21 | 0.23 | 0.17 | 0.21 | 15.31 |
| **Jarque-Bera** | 9.36 | 8.22 | 10.50 | 8.89 | 14050.84 |
| **Probability** | 0.01 | 0.02 | 0.01 | 0.01 | 0.00 |

Starting with Close prices, the mean is 213.43 and median is 220.22, and there is a fairly symmetrical distribution. The data range is moderate as marked by a standard deviation of 83.46. The negative skewness of -0.18 shows that the distribution is very lightly skewed towards lower prices. The kurtosis of 0.21 shows that the distribution is very lightly lighter in the tails relative to a normal distribution. The Jarque-Bera statistic of 9.36, with a probability of 0.01, indicates that data is not normal.

For the High prices, mean is 218.28, and median is 225.37, which is slightly higher central tendency. The standard deviation of 85.40 is of moderate variability. The negative skewness of -0.16 means slight asymmetry towards lower values, and the kurtosis value of 0.23 means lighter tails. The Jarque-Bera test statistic value of 8.22, with probability value of 0.02, also indicates non-normality.

The Low prices have a mean of 208.36 and median of 215.34, showing a similar pattern. The standard deviation is 81.53, showing moderate variability. The skewness of -0.21 shows slight asymmetry towards lower values, and the kurtosis of 0.17 shows lighter tails. The Jarque-Bera test statistic of 10.50, with probability 0.01, confirms non-normality.

For the Open prices, the mean is 213.48 while the median is 220.93, displaying a bit more central tendency. The standard deviation of 83.63 depicts moderate variability. The negative skewness of -0.18 reflects a minimal positive asymmetry towards lower values, and the kurtosis of 0.21 demonstrates lighter tails. The Jarque-Bera test statistic of 8.89, with the probability of 0.01, confirms non-normality.

Lastly, the Volume has a mean of 125,529,900 and a median of 101,989,400, which indicates right-skewedness with a skewness of 2.99. The large standard deviation of 82,087,050 reflects a tremendous amount of variation. The kurtosis of 15.31 indicates much heavier tails than in a normal distribution. The Jarque-Bera test statistic of 14,050.84, with a probability of 0.00, is bound to ascertain that the volume data significantly deviates from normality.

1. **Tesla stock prices between 2020 to 2025**

A graph of a stock price

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The chart of Table II shows the historical price of Tesla stock from January 2020 to February 2025. It showcases a volatile pattern, with periods of sharp increases followed by significant declines. Notably, prices surged to over $400 per share in December 2024, then plummeted to below $120 per share in January 2023.

As it shows above, the Tesla stock price usually gets higher. There are certain periods, such as in January 2023, where the stock price decreases to $120 per share. On the other hand, at the end of 2024, in November and December, the stock price reaches its highest price.

1. **Unit Root Test**

| Unit Root Results | ADF | PP |
| --- | --- | --- |
| **Close TSLA** |  |  |
| Constant | -2.15\*\*\* | -2.00\*\*\* |
| 1st Difference | -2.15\*\*\* | -2.00\*\*\* |
| **Volume TSLA** |  |  |
| Constant | -3.36\*\*\* | -14.27\* |
| 1st Difference | -3.36\*\*\* | -14.27\* |
| **Open TSLA** |  |  |
| Constant | -1.68\*\*\* | -1.87\*\*\* |
| 1st Difference | -1.68\*\*\* | -1.87\*\*\* |
| **High TSLA** |  |  |
| Constant | -1.86\*\*\* | -1.87\*\*\* |
| 1st Difference | -1.86\*\*\* | -1.87\*\*\* |
| **Low TSLA** |  |  |
| Constant | -1.91\*\*\* | -1.92\*\*\* |
| 1st Difference | -1.91\*\*\* | -1.92\*\*\* |

*Note: p<0.1\*; p<0.05\*\*; p<0.001\*\*\**

Table III shows the results of unit root tests for five key variables: Close, High, Low, Open, and Volume. The Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) tests are employed to determine whether these time series are stationary, which is a critical step before performing further econometric analyses such as regression or cointegration tests.

First with Close. The ADF test statistic at the level, with a constant, is -2.15, which is significant at the 1% level (p < 0.001). This suggests that the series is non-stationary at the level. The Phillips-Perron (PP) test gives a similar result, with a statistic of -2.00, significant at the 1% level (p < 0.001), reinforcing the conclusion of non-stationarity at levels.

For Volume, the ADF test statistic at the level is -3.36, which is significant at the 1% level (p < 0.001). This indicates that Volume is stationary at the level. Similarly, the PP test with a statistic of -14.27, also significant at the 1% level (p < 0.001), confirms the stationarity at levels.

Moving on to Open, the ADF test statistic at the level is -1.68, significant at the 1% level (p < 0.001), which shows that Open is non-stationary at the level. The PP test, with a statistic of -1.87, also significant at the 1% level (p < 0.001), suggests the same conclusion of non-stationarity.

For High, the ADF statistic at the level is -1.86, significant at the 1% level (p < 0.001), indicating that High is also non-stationary at the level. The PP test, showing a statistic of -1.87, also significant at the 1% level (p < 0.001), confirms that the High series is non-stationary at the level.

Lastly, for Low, the ADF test statistic is -1.91, significant at the 1% level (p < 0.001), which points to non-stationarity at the level. The PP test, with a statistic of -1.92, also significant at the 1% level (p < 0.001), supports the finding of non-stationarity at levels.

1. **Regression Analysis**

| Variable | Coefficient | Std. Error | t-Stat | P-Value |
| --- | --- | --- | --- | --- |
| **High** | 0.82 | 0.2 | -34.66 | 0.0000\*\*\* |
| **Low** | 0.85 | 0.2 | 39.64 | 0.0220\*\* |
| **Open** | -0.67 | 0.2 | 30.03 | 0.0000\*\*\* |
| **Volume** | 0.00 | 0.00 | 1.38 | 0.1669 |
| **Constant** | -0.30 | 0.43 | -0.69 | 0.4927 |

*Note: p<0.1\*; p<0.05\*\*; p<0.001\*\*\**

The regression analysis in Table III presents the relationship between the independent variables (High, Low, Open, and Volume) and the dependent variable. The coefficients, standard errors, t-statistics, and p-values are shown for each of the variables.

*(Tesla stock price)=*

*−0.30+0.82 x High+0.85 x Low−0.67 x Open+0.00 x Volume*

The coefficient for High is 0.82 and is significant (p-value = 0.0000). This is a positive coefficient, and it means that if the High variable goes up by 1 unit, the dependent variable would be expected to go up by 0.82 units, holding all else equal. This is an extremely strong positive relationship between the High variable and the dependent variable.

The coefficient for Low is 0.85 and is significant statistically (p-value = 0.0220). The positive coefficient indicates that with every 1 unit increase in the Low variable, the dependent variable will increase by 0.85 units, all these being equal. This reflects a positive relationship between the Low variable and the dependent variable.

The coefficient for Open is -0.67 and is significant (p-value = 0.0000). It is negative and suggests that the dependent variable would fall by 0.67 units for every 1 unit rise in the Open variable when all other variables are held constant. It suggests that higher positive values of the Open variable are typically associated with higher negative values of the dependent variable.

The coefficient for Volume is 0.00, which is not statistically significant (p-value = 0.1669). This indicates that changes in the Volume variable do not have a significant impact on the dependent variable, holding other factors constant.

The Constant term is -0.30, which is not statistically significant (p-value = 0.4927). This suggests that the constant term does not have a significant impact on the dependent variable. This is expected because we are using the variables High, Low, Open, and Volume to predict Tesla's stock price. These variables already provide the key information to predict Tesla's stock price, so the constant term doesn’t add much value in this case.

The regression analysis also provides some useful statistics for measuring the model's performance. The Multiple R value is 0.9993, indicating extremely high correlation between the observed and predicted values of the dependent variable. The R Square value is 0.9987, meaning that approximately 99.87% of the variability in the dependent variable is explained by the independent variables (High, Low, Open, and Volume). This high R Square value means that the model fits the data very well.

The value of Adjusted R Square is 0.9987, which is the R Square value adjustment for the number of predictors in the model. This value is very close to the R Square value, indicating that the explanatory power of the model is not overly inflated by the number of predictors.

The regression Standard Error is 3.0627, which measures the average distance of the observed values from the regression line. The smaller the standard error, the more accurate the model fits the data.

The number of observations available for the analysis is 1258, which is a good sample size for the regression analysis. The large sample size of observations helps to provide assurance of the validity and reliability of regression results.

1. **monte carlo prediction**

A graph of different colored lines

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Based on the Monte Carlo simulation, the expected price of Tesla's stock after 1 year is predicted to be $380.22, representing the most likely outcome given the model’s assumptions about historical trends and volatility. However, the 95% confidence interval indicates a significant level of uncertainty, with the price potentially dropping to $229.42 or increase to $531.01. This wide range suggests that Tesla's stock price has **a high level of volatility (or standard deviation).** While the most probable price is $380.22, it is important to be aware that market conditions, news events, political factors (especially those involving Elon Musk), and other factors play a significant role in influencing these predictions.

1. **hybrid pbprophebt & random forest model prediction**

A graph showing a graph of a stock market

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Table VI represents the predicted and actual Tesla stock prices from 2020 to 2025 using the Tesla Stock Prices Forecast using the Hybrid Prophet & Random Forest Model. The actual stock prices of Tesla over the period being observed are represented as black dots, which provide a point of comparison for how accurately the model predicts past trends. The blue line represents the forecasted stock prices using the hybrid model with the use of the Prophet and Random Forest algorithms. This line demonstrates the overall expected trend, showing a significant upward in the prices, particularly towards the end of 2024 and into 2025, indicating potential growth in Tesla's stock price. The dark blue dashed line represents, capturing more complex, non-linear patterns and fluctuations. The light blue shaded region around the blue line shows the confidence interval, the band in which the model expects the actual stock price to fall, with a 95% confidence level. This gap indicates that the forecast is indefinite, and bigger gaps indicate greater volatility. The chart talks about a general expansion trend of Tesla's share price but at the same time indicates huge fluctuations based on inherent market volatility and external factors beyond its control.

1. **Tesla Stock Price: Trend, Weekly, and Yearly Patterns**

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Table VII illustrates the annual trends in Tesla's stock price. Initially, there is a slight upward trend in the stock price until the first quarter of 2022. Following this period, the stock price experiences a decline, continuing until the end of January 2023. Subsequently, the stock price begins to rise again at the beginning of 2024 and maintains an upward trajectory. The forecast predicts this increasing trend to persist until 2026.

In the middle graph, which aggregates data on a daily basis over five years, it is evident that Tesla's stock prices peak on Saturdays and Sundays. This clearly highlights the highest activity and price levels occurring during these two days.

On a monthly trend basis, Tesla's stock prices over these five years collectively showed the following patterns: In January, there was a slight increase, while February saw relatively stable prices with a slight upward trend. March experienced a slight decline. April showed a noticeable decline, followed by a slight recovery in May, and a sharp increase in June. July saw the highest prices, which remained high but steady in August, and then decreased slightly in September. From October to December, prices stabilized with a slight upward slope in October, reached another peak in November, and remained high and steady in December. This analysis reflects the collective trends for each month over the five-year period.

1. **Comparison of Monte Carlo and Prophet across mse, rmse, and mae**
2. **Mean Squared Error**

- Monte Carlo: MSE = 20.90

The Monte Carlo model has an very low MSE, indicating the squared differences between actual data and simulated mean path are minimal. This indicates that the model predictions are extremely near the actual data.

- Prophet: MSE = 1140.46

which implies that the squared differences between predicted values and actual values are much larger. This means that Prophet is worse at picking up the pattern of the actual data here.

- Comparison:

The smaller the MSE, the more accurate the model. Monte Carlo is much better at minimizing huge errors compared to Prophet, possibly because of its probabilistic nature, which is more effective at modeling the inherent randomness in the data.

1. **Root Mean Squared Error (RMSE):**

- Monte Carlo: RMSE = 4.57

The RMSE for Monte Carlo is quite low, meaning the average magnitude of error is small, similar to the trend observed with MAE. Since RMSE penalizes larger errors more than MAE does, the result further highlights the Monte Carlo model's strong accuracy.

- Prophet: RMSE = 33.77

Prophet’s RMSE is very high, which underscores its difficulty in providing accurate forecasts for this specific dataset. Large deviations are being penalized, leading to such a high RMSE value.

- Comparison:

RMSE amplifies the impact of large errors. The stark difference between Monte Carlo and Prophet again shows Monte Carlo’s strength in accurately representing the data and Prophet’s limitations in this case.

1. **Mean Absolute Error (MAE):**

- Monte Carlo: MAE = 3.91

The Monte Carlo model has a very low MAE, indicating that the average absolute differences between predicted values and actual data are minimal. This suggests that the model predictions are consistently close to the actual values.

- Prophet: MAE = 25.66

This much larger MAE implies that the average errors in predictions are significantly higher. Prophet demonstrates a reduced ability to predict values close to the actual data compared to Monte Carlo.

- Comparison:

The smaller the MAE, the more accurate the model. Monte Carlo outperforms Prophet significantly, likely due to its ability to account for and model the inherent randomness of the data more effectively.