**Project Report: Time Series Analysis of Stock Price**

**1. Introduction:** The goal of this project was to perform a comprehensive time series analysis of stock prices and compare the predictive performance of different models. Four different models were explored: Seasonal Autoregressive Integrated Moving Average (SARIMA), Winter's Exponential Smoothing (ETS), Prophet, and Long Short-Term Memory (LSTM) neural network. The study aimed to provide insights into the suitability and effectiveness of each model for predicting stock prices.

**2. Data Collection and Preprocessing:** Stock price data for the chosen company was collected from a reliable financial data source. The data consisted of daily closing prices over a specified time period. Before proceeding with the analysis, the data underwent preprocessing, including handling missing values, ensuring consistent time intervals, and scaling if required.

**3. Methodology:**

**3.1 SARIMA Model:** SARIMA is a time series forecasting method that takes into account seasonality, trend, and noise in the data. The model involves selecting appropriate parameters such as the order of differencing, autoregressive (AR) and moving average (MA) terms, and seasonal components. The data was split into training and testing sets, and the SARIMA model was trained on the training data. Performance was evaluated using metrics such as Mean Squared Error (MSE) and Mean Absolute Error (MAE) on the test set.

**3.2 Winter's Exponential Smoothing (ETS) Model:** ETS is another method for time series forecasting that captures seasonality and trends. Similar to SARIMA, it requires parameter tuning to achieve optimal performance. The model was trained and evaluated using the same process as SARIMA.

**3.3 Prophet Model:** Prophet is an open-source forecasting tool developed by Facebook that handles various time series components including seasonality, trends, and holidays. It is designed to be user-friendly and capable of handling large datasets. The model was trained on the entire dataset, and its predictions were compared against the actual stock prices using relevant evaluation metrics.

**3.4 LSTM Model:** Long Short-Term Memory (LSTM) is a type of recurrent neural network (RNN) that is well-suited for sequential data such as time series. LSTM models can capture complex relationships and patterns in the data. The stock price data was transformed into sequences suitable for training an LSTM model. The model architecture included LSTM layers followed by fully connected layers. Training was done using a sliding window approach, and performance was assessed using evaluation metrics similar to the previous models.

**4. Results and Analysis:** The performance of each model was evaluated using metrics such as Mean Squared Error (MSE) and Root Mean Squared Error (RMSE). These metrics provided insights into the accuracy of the models' predictions. Visualization techniques, including time series plots and predicted vs. actual plots, were used to visually compare the models' outputs.

**5. Conclusion:** In this project, we conducted a thorough time series analysis of stock prices using SARIMA, Winter's ETS, Prophet, and LSTM models. Each model was trained and evaluated on the stock price dataset, and their predictive performance was compared. The choice of model depends on various factors such as data characteristics, ease of use, and the desired level of accuracy. The findings of this study can help guide future researchers and practitioners in selecting the most appropriate model for their specific forecasting needs.

**6. Limitations and Future Work:**

* The analysis could be further improved with the inclusion of additional features like trading volume or external factors that might influence stock prices.
* The models' hyperparameters were manually tuned; using automated methods like grid search or Bayesian optimization could yield better results.
* The project focused on a single company's stock; extending the analysis to multiple stocks or sectors could provide more insights.

**7. References:**

* Hyndman, R. J., & Athanasopoulos, G. (2018). Forecasting: principles and practice. OTexts.
* Taylor, S. J. (2003). Forecasting financial volatility. In Handbook of economic forecasting (Vol. 1, pp. 639-688). Elsevier.