

# Forecasting foreign exchange rate: Use of FbProphet

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**Abstract** - Foreign exchange rate prediction can be considered crucial in today's world. The exchange rate of a country plays a vital role in its economic growth. The Central Bank of a country holds the authority in managing the exchange rate and its policies. The study predicts the foreign exchange rate of American Dollar to Sri Lankan Rupee using FbProphet model; a time-series forecasting model developed and introduced by Facebook. The daily exchange rate values for USD/LKR were obtained and the values are predicted for another twenty-four months starting from November 2020. R Squared value is calculated to verify the fitting of the model and the value is 0.98, which indicates that the model for prediction very well fits for the data set used. And further, Mean Squared Error and Mean Absolute Error are calculated to measure the performance of the model. These metric measurements show that the model is appropriate for the data set which has been selected for the research study.

**Keywords** - exchange rate, FbProphet, forecasting, US Dollar

## I. INTRODUCTION

In today's world, one of the most important liquid markets is the Foreign Exchange (FOREX) markets. The relative price between two different currencies is known as the exchange rate. It is the value of a money of a country's currency for undertaking international trade for goods, finance, and services, being the key to a country's monetary condition. The Central Banks are the monetary authorities of a nation which has been granted the power to manage the exchange rate as part of its monetary, financial, and economic development policies under relevant statutes. According to the perspective of macroeconomy, exchange rate policy is the key instrument for the mobilization of foreign capital and savings in order to fill the resource gaps in the domestic and also expand the investments [1].

The fluctuations in the exchange rate of a country have both favorable and unfavorable effects on the economic activities and standard of living of the people due to the trade being largely globalized and finance involving the exchange of currencies. Generally, appreciation in the currency of a country will have benefits, whereas depreciation will have the reverse impacts:

- Downfall in the domestic prices of products which are being imported because the import cost will be less if the domestic currency value is higher. This will result in a lower inflation depending on the volume of imports in local consumption and manufacturing activities.
- Reduction in the amount of outstanding foreign debt of a country which will lessen the burden of a nation's repayment of foreign debt.

- An imbalance in the trade of a country may be caused due to the increase in the imports as a result of lower cost in importing goods, which is unfavorable for the country.
- Another disadvantage is that there will be a downfall in the income of exporters which may discourage them in exporting products resulting in an adverse effect in the export industries. But, if a lower inflation prevails in the country, the demand for export products in the foreign countries will rise balancing the initial reduction in the exporter's income.

Sri Lanka maintains a healthy relationship with several foreign countries, as a result of which it receives more foreign exchanges. The American Dollar (US Dollar) is the common currency used by both the government and monetary policy makers of Sri Lanka. The transaction price of an US Dollar in the year 1970 was Rs. 5.95 Sri Lankan Rupees (LKR), which, after two decades, increased to Rs. 40 LKR [2]. Similarly, in the year 2020, the price has been elevated to Rs.180.76 LKR. In the economic point of view, the exchange rate is generally ascertained by the demand and the supply curve of the exchange rate which is much similar to the common commodity market system. The relative commodity price, inflation rate and interest rate are the main factors which influence on the exchange rate. It is also notable that the higher the exchange rate is the higher the promotion of economic growth of a nation.

This study attempts to forecast the exchange rates of USD/LKR for the next 24 months from November 2020 which would be useful for making economic decisions, using FbProphet model. The remainder of the paper is as follows. Section 2 of the paper is a literature review on the technologies adopted by researchers to predict the exchange rate of currency. Section 3 and 4 describes the methodology adopted to predict the USD/LKR exchange rate for this study and the results obtained from the model. Finally, section 5 concludes the study on time series forecasting of foreign exchange rate of USD/LKR.

## II. LITERATURE REVIEW

According to the study conducted by [3] on designing and developing an algorithm to predict fluctuation of currency rates, the key purpose of the study was to compare the precision of three models: Autoregressive Integrated Moving Average (ARIMA), Artificial Neural Networks (ANN) and Vector Support Machines (SVM). The import, export and USD currency exchange series for LKR data were chosen for training the data. It was possible to see that the SVM forecast performed better than other models after

training the data set and comparing each algorithm. Also, from the study it has been understood that the merging of SVM and SVR models has further strengthened the algorithm that can predict the fluctuations of the currency rates.

On another study by [4], the research is conducted using the Artificial Neural Network models to make multi-step forecasts of the Sri Lankan Rupee foreign exchange rate against three international currencies, to test the accuracy of these models and where present, to identify deficiencies. Basic Recurrent Neural Network, Multi-Layer Perceptron, Long-Term Memory, Gated Recurrent Unit and Convolutional Neural Network Architectures were the algorithms that are used for this study. With the exception of a few Gated Recurrent Unit models, many simulations have been able to forecast 10-day forward exchange rates with a greater degree of accuracy. The final output of the study showed that among the other algorithms, the Basic Recurrent Neural Networks with a single input layer, a hidden layer, a flattened layer, and an output layer is the best one to make the predictions.

A research had been conducted by [5] which aimed at comparing the forecast accuracy of the most widely used algorithms and to identify the more accurate one for forecasting Sri Lankan Rupees' daily exchange rates against the Euro and Yen. The NAR model (Nonlinear Auto Regressive Neural Network) with SCG learning and SVR model with Gaussian function were employed in the study conducted to make the forecasts. And the results of the study showed that SVR model outputted better predictions than ANN models.

Besides these, there is also a related work done by [6], which studied about the ways that United States US Dollar (USD) exchange rate can be predicted against Sri Lankan Rupees (LKR) using three different deep learning models, namely Long Short-Term Memory (LSTM), the Convolutional Neural Network (CNN) and Temporary Convolution Network (TCN). The findings of the research showed that the CNN model is superior to other models when it comes to financial time series prediction.

On another research by [7], the authors recommended a hybrid forecasting model for foreign exchange rate forecasting using EMD (Empirical Mode Decomposition) and FNN (Feedforward Neural Network) and the concert of the model is related with NAR and SVR (support vector regression) models. The methodology used EMD with several Intrinsic Mode Functions (IMFs) and one residual series to break down the original non-linear and non-stationary chain. In order to estimate the IMF exchange rate and the received residual inputs, the hybrid model is then used. The analytical results from the study proved that the Sri Lanka Rupee Euro and Yen daily exchange rate forecast was more accurate with EMD-FNN model.

The SCG algorithm trained Feedforward Neural Network (FFNN) performed better than BPR algorithms trained FFNN was put forward by [8] at a study conducted to discover a model that can foresee the US dollar with a better level of precision compared to Sri Lankan Rupee (USD/LKR) using existing neural network models.

In [9]'s research, GARCH model and the ANN model (FFNN model having Backpropagation algorithms) are used to compare the accuracy for the predictions of USD to LKR exchange rates. With both models, historical stagnated findings of the data and average of the other measures were

utilized as the response variable and the forecasting output were analyzed using a variety of popular statistical parameter. The findings revealed that ANN model performed better when compared to GARCH model.

Along with these, the research by Lingaraja and his co-authors [10] focused on long term volatility of Sri Lankan LKR against USD with nine other currencies that are considered to be emerging in Asian region, that would help in supporting financial decision making based on Asia. The study conducted used the GARCH model with correlation and the test was done based on Granger Causality test.

The subsequent analyses of USD/LKR exchange rate forecasts indicate that numerous Machine Learning models and algorithms have been used to forecast exchange rates. They include models ranging from various types of the Artificial Neural Network (ANN), ARIMA, Support Vector Machine (SVM), etc. The related study further shows that hybrid techniques have also been pursued in the design of the models. And each work offers a promising accuracy rating that has prompted this research to pursue a totally new paradigm that is distinct from all the other existing models, to come up with more successful predictions.

### III. METHODOLOGY

The USD/LKR exchange rate prediction for the next twenty-four months starting from November 2020 is shown by the methodology adopted. For some important business decisions, such as whether to invest in USD to LKR currency pair or whether to purchase or sell USD/LKR pair, forecasting is known to be unavoidable.

#### A. Installation in Python

As the initial step, the library for FBProphet model need to be installed. FBProphet is available as an open-source library and based on the choice of programming language (Python or R) it can be used. To the study conducted, the Python3 is selected and therefore the python installation of the corresponding library was done.

#### B. Select and prepare data

Daily exchange rates of United States Dollar (USD) on Sri Lankan Rupee (LKR) were selected from the data repository of CurrencyConverter [11] for this study. The daily exchange rate from 2009-10-07 to 2020-11-22 were collected. The USD was selected as the currency to forecast the USD/LKR pair since, it is the widely used currency for trading and investments with LKR among the other currencies of world economy. Therefore, the input to the research is the exchange rate data from the timeline mentioned above (2009-10-07 to 2020-11-22) and provided the input in form of date and exchange rate in LKR, the study will forecast the subsequent 24 months. The dataset was prepared as a CSV file, having two columns, ds and y since the input data frame for FBProphet must be in a format that has ds and y columns indicating the date and the numeric values.

#### C. Exploratory visual analysis

Data visualization is important in order to understand the dataset used for the study. A visual representation of the data may, as always, be effective and informative [12]. A time series plot for the whole-time frame was generated by which the seasonal and abnormal deviations can be shown

if data were to be presented for such a prolonged period of time (2009 – 2020).

By plotting the data, the overview and the shape of the dataset used was visualized. Under this context, the ability to quickly dig into multiple timeline periods to better analyze the details and to find visual hints about possible patterns, intermittent and unexpected outcomes is understood and that is possible with one of the most valuable features provided by Plotly.

The Fig 1 shows how the data set is visualized in terms of years and values (exchange rates). In addition, the visualization shows that that the data is not fixed with a prominent increasing trend.

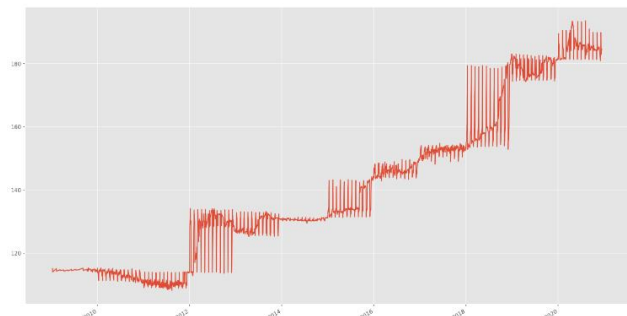


Fig. 1. Daily Exchange Rates (USD/LKR) from 2009 to 2020

#### D. Build the predictive model

The future predictions for the USD/LKR exchange rates are created by the predictive model built. The predictive model is developed by using FBProphet which is a time series forecasting model implemented by the data scientists of Facebook. Prophet is a technique based on an additive model for forecasting time series data where non-linear trends are consistent with yearly, weekly, and daily seasonality, plus holiday outcomes. For time series which have strong seasonal effects and a few seasons with chronological data, this works well [13]. The Prophet is responsive to missing values and generally it is capable of handling the outliers.

Sklearn Machine Learning Model is accompanied by FBProphet where the Prophet Class instance is generated to its fit and predict methods, as its syntax follows the Scikit learn’s train and predicting model. A data frame is used as the input to Prophet (consisting of ds and y columns). The Prophet object would then be constructed to match the model. The algorithm would be able to learn the data as a function of the model fit, which can be expanded later to a similar type of data.

Hence, the predictive model has been built by selecting the features such as dates and exchange rates. As stated already, the ds and y are considered to be the standard input format preferred by FBProphet. Here the ds have been assigned as the date whereas the y is the exchange rate corresponding to each date. Table I shows the input data frame that has been used in building the predictive model. The input data frame starts from 2009-10-07 and it goes up to 2020-11-22.

For the study conducted, the dataset has not been divided into training dataset and test dataset to build the prediction model instead the whole data has been used to fit the model, which has later given the predictions for the

exchange rates for future 24 months, i.e. the exchange rate up to November 2022.

TABLE I. USD / LKR EXCHANGE RATES (ds and y)

	ds	y
0	2009-07-10	114.8271
1	2009-08-10	114.7283
2	2009-09-10	115.2225
3	2009-10-10	114.8294
4	2009-11-10	114.8158

where,  
 ds – datestamp, data type is date or datetime  
 y – numeric value to predict

#### E. General model predictions

Once the model has been fit and instantiated, the predictions will be based on the data frame consisting of the future dates. In Prophet those future dates are known by the term, period. The USD/LKR exchange rate predictions are generated for the upcoming 24 months starting from December 2020. The methodology uses the frequency in terms of month (Freq = ‘M’) which implies the monthly data. Since the forecasted data covers 24 months, (Period = 24) the comparison can be made in between the actual and predicted values and it will be helpful in coming to a conclusion as to how well the model forecasts the exchange rates.

TABLE II. THE FUTURE DATES FOR FORECASTS (DS)

	ds
4084	2022-07-31
4085	2022-08-31
4086	2022-09-30
4087	2022-10-31
4088	2022-11-30

Table II, illustrates the future dates that are been selected by tail command to output the last part of the whole data frame. Based on those future dates, the predictions are generated.

Similarly, the Table III given below shows the future data frame (forecasts) for the USD/LKR exchange rate and the results from the full data frame show a quit a lot of data in various columns which includes the predictions based on trend, seasonality components as well the other additive terms. But for each future row, the focus has to be given to only few important columns including yhat, yhat\_upper and yhat\_lower.

yhat – stores the forecast values in this column

Therefore, such output data frame was generated using the appropriate Prophet function and it is shown below in Table IV. It consists of the forecasts that are tailed to last few months with each future row consisting of ds (date) and its resultant yhat, yhat\_lower and yhat\_upper values.

TABLE III. THE FORECASTS FOR USD/LKR EXCHANGE RATE

	ds	trend	yhat_lower	yhat_upper	trend_lower	trend_upper	additive_te	re_terms_lower	multiplicative_terms_upper	yhat
4084	2022-07-31	204.873181	181.133118	227.063420	183.767902	227.509829	-1.054975	•••	0.0	203.818206
4085	2022-08-31	205.639267	180.648363	228.610257	182.570091	230.564283	-1.637560	•••	0.0	204.001707
4086	2022-09-30	206.380640	178.974067	231.386060	181.536730	233.054414	-1.416293	•••	0.0	204.964347
4087	2022-10-31	207.146725	178.370946	233.421029	180.312570	235.170386	-1.603842	•••	0.0	205.542883
4088	2022-11-30	207.888098	178.961628	236.731663	179.630810	237.228222	-0.887813	•••	0.0	207.000285

TABLE IV. THE FORECASTS FOR USD/LKR EXCHANGE RATE WITH VARIABLE YHAT, YHAT\_LOWER AND YHAT\_UPPER

	ds	yhat	yhat_lower	yhat_upper
4084	2022-07-31	203.818206	181.133118	227.063420
4085	2022-08-31	204.001707	180.648363	228.610257
4086	2022-09-30	204.964347	178.974067	231.386060
4087	2022-10-31	205.542883	178.370946	233.421029
4088	2022-11-30	207.000285	178.961628	236.731663

The variable yhat characterizes the exact model predictions whereas the two variables yhat\_lower and yhat\_upper represents the lower limit and upper limit for the forecast. These two variables are used as measure to calculate the yhat values for future dates. Based on this, a conclusion can be realized that the forecasts will be stored into the yhat column.

F. Plot model predictions

The model predictions are plotted to clearly understand the actual values (original data), the predicted values (forecasted data) and forecast errors. The Fig 2 shows the plotting results where the actual values are drawn in black dots, the predicted values in blue lines and the blue shaded area showing the error of predictions. The plotting leads the way to quickly evaluate the results. The model predictions plot also generates a component plot in terms of individual components as shown in Fig 3.

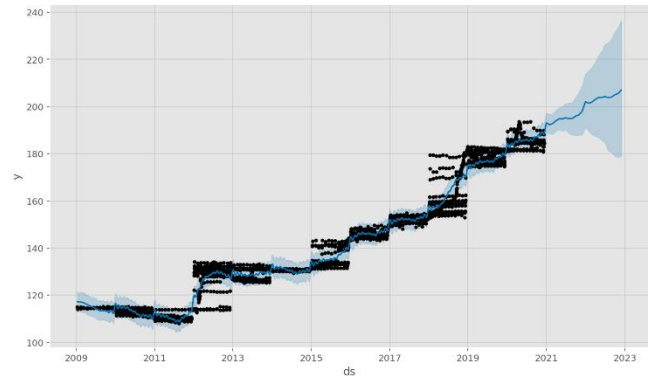


Fig. 2. The original and predicted values for USD/LKR exchange rate

The trend, weekly and yearly forecast components are plotted separately. The component plot is considered to be a vital one, as it better illustrates the factors of the forecast model.

From the individual component graph as shown in fig. 3 below, the conclusion can be made that for trend, Prophet has done a good job by showing the increasing pattern for USD/LKR exchange rates at the end of 2020. The weekly seasonality chart reveals that, the exchange rates are highest during the weekdays than that of the weekends. And during the annual holiday (December) seasonality the table shows a significant fall.

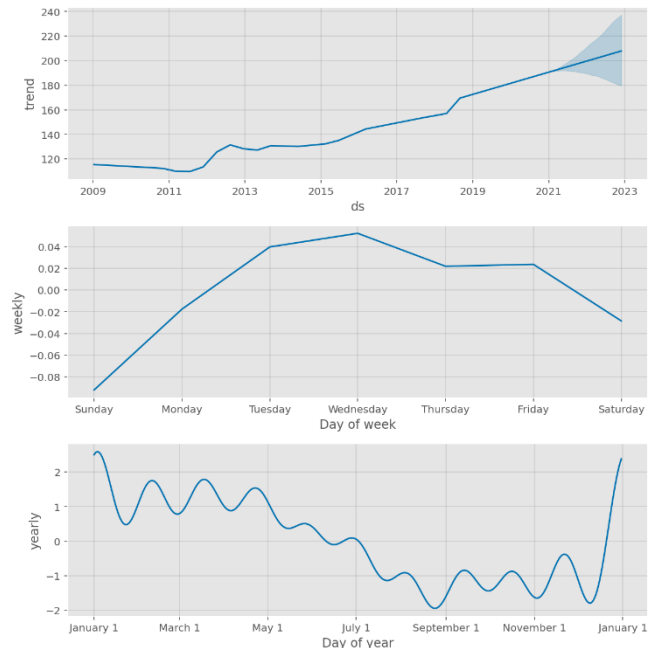


Fig. 3. Individual forecast model components for USD/LKR exchange rate

IV. RESULTS AND DISCUSSION

Forecasting foreign exchange rate is a complex task due to changings in the dynamics of its driving factors. It can be predicted by using various methods and this study uses FbProphet time series forecasting model. Daily values of USD/LKR exchange rates were used from 7<sup>th</sup> of October 2009 to 22<sup>nd</sup> of November 2020.

The performance of the FbProphet model is evaluated using the following metric measurements:

### A. R squared Score

R squared is also known as the coefficient of determination which indicates how good a model fits for the given dataset. It also illustrates the closure of the regression line to the actual data value line. The R squared value ranges between 0 and 1 where 0 means that model is not appropriate for the given dataset whereas 1 denotes that the model perfectly fits with the given data set.

For the data set provided for the study in this research, the R squared value is 0.982 which means that the model fits for the exchange rate dataset.

### B. Mean Squared Error (MSE)

MSE is the average of the square of the difference between the original and predicted values of the data. It is calculated using the formula given below.

$$\frac{1}{N} \sum_{i=0}^n (\text{actual values} - \text{predicted values})^2 \quad (1)$$

Where,

N - total number of observations per rows in the dataset.

$\sum$  - difference between actual values and predicted values for each i value from 1 to n.

MSE is used to determine the performance of the regression model. The MSE value obtained for this study is 10.31 which means that the model is working efficiently with a 90% performance.

### C. Mean Absolute Error (MAE)

MAE is the difference between the actual values and the predicted values. The result is obtained by getting the average of the error in each sample data set. The MAE value obtained for the dataset to predict foreign exchange rate is 2.1.

From the overall metric measurements taken, it can be determined that the model very well fits for the data set selected for the study and gives an efficient prediction on the foreign exchange rate values.

## V. CONCLUSION

The research analyzed the USD/LKR exchange rate time series prediction for the next 24 months, starting in December 2020. Instead of making daily projections, the monthly estimates are made so that some other decisive variables such as volume swings, adjustment in prices, business cycles and market segments may also be subjected to adjustments. Therefore, it is hoped that such forecasts will help the decision-making of the financial quarters where reports are archived in a monthly manner. The forecasts are crucial factors in evaluating the currency pair's long-term future profits.

The methodology in section 3 reveals that the unique design of the real-life research will improve the predictability of USD/LKR currency pair that goes through heavy fluctuations during certain periods of the year in a way by using the enhanced time series forecasting algorithm – FBProphet. And in this study, the goal was to evaluate a highly accurate architectural model in USD/LKR currencies for the Machine Learning to predict the exchange rate.

The findings of section 4 of the analysis are promising since the model suits well with a strong r-squared value.

This shows that the model has a good impact scale. Related to the data collection comprising of the exchange rate of USD/LKR for a longer period, the utility of the model is improved.

The numerous methods of data mining for exchange rate forecasts are considered from the inspection of past studies. It has been shown that the predictive model that is been built from FBProphet is very useful in predicting USD/LKR exchange rate.

Further, the model could be compared with the other models such as ANN, ARIMA and SARIMA models. The comparison study would help in making decisions depending on the forecast values obtained from these models. Also, this would be useful in the economic growth of a nation.

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