Foreign Exchange Rate Analysis using Economic Factors with Regression techniques

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USD to INR Exchange Rate Prediction

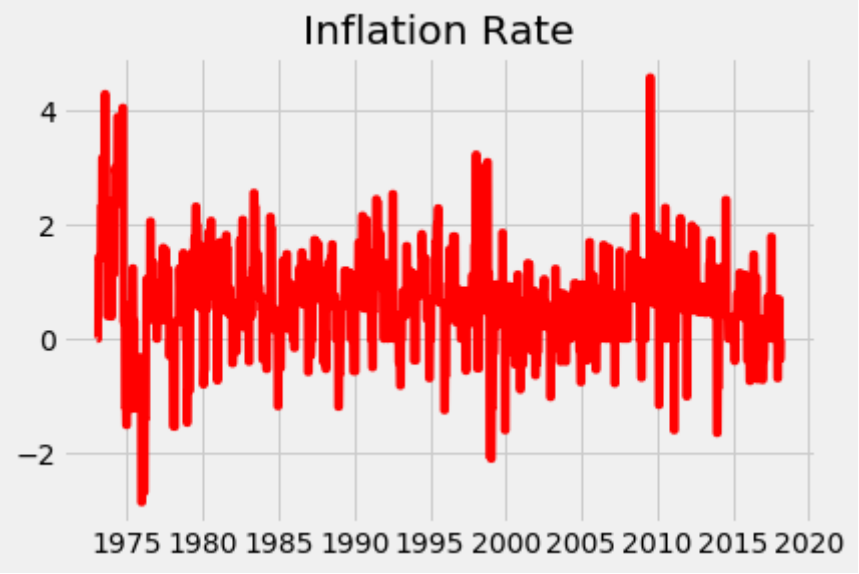
In a Floating Exchange Rate system, the value of the currency is allowed to fluctuate freely according to changes in demand and supply of foreign exchange, which are determined by several economic factors. The aim of this project is to create a model that predicts USD to INR exchange rates, taking into account the various economic factors that affect the exchange rate.

Introduction

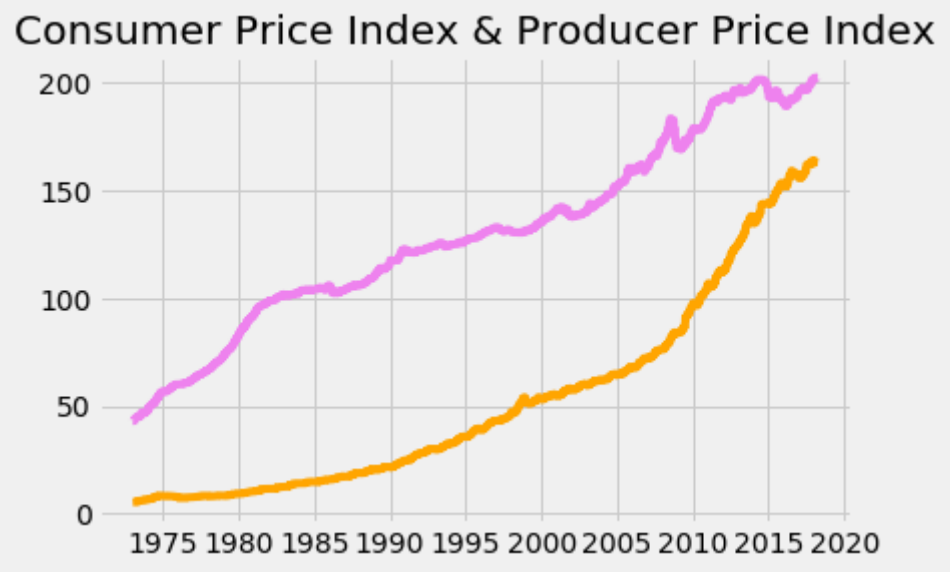
In a Floating Exchange Rate system, economic factors play a significant role in determining the exchange rate of currency. Hence, the dataset used for this project also includes the following features, which have been taken into account while creating the regression model to predict USD to INR exchange rates.

1. **Total Current Account Balance for India**
   A country's current account reflects balance of trade and earnings on foreign investment. This directly affects the exchange rate.

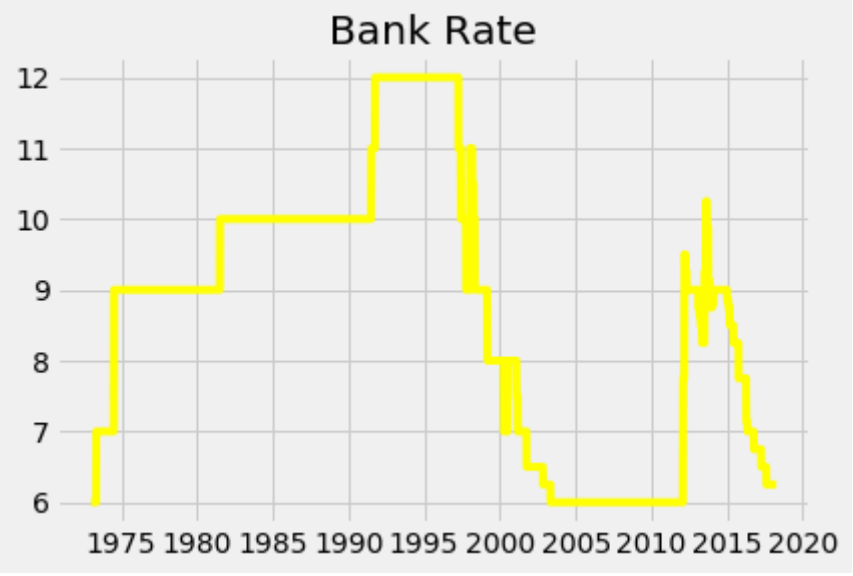
2. **Inflation Rate in India**
   A higher inflation rate in the country will result in depreciation in the value of the domestic currency. This is because a higher inflation rate implies the prices of domestic goods rise. The foreign goods become cheaper. As a result, exports fall, leading to fall in the demand for the domestic currency from the rest of the world. Similarly, a lower inflation rate will result in appreciation of the domestic currency.



3. **Consumer Price Index of India & Producer Price Index of India**
   CPI and PPI are a measure of inflation, and affect exchange rates.



4. **Central Bank Rates for India**
   Forex rates, interest rates, and inflation are all correlated.
   Also, higher interest rates tend to attract foreign investment, which increased demand of domestic currency, leading to appreciation in value. Similarly, lower interest rates result in decrease in demand of domestic currency leading to depreciation in value.



5. **Gross Domestic Product of India**
   GDP is an indicator if the economic stability of the country, which can influence exchange rates.

6. **Previous years' USD to INR exchange rates**

This project uses two different datasets. One is a complete dataset showing daily USD to INR exchange rates, including economic factors as features, and another is a time series showing

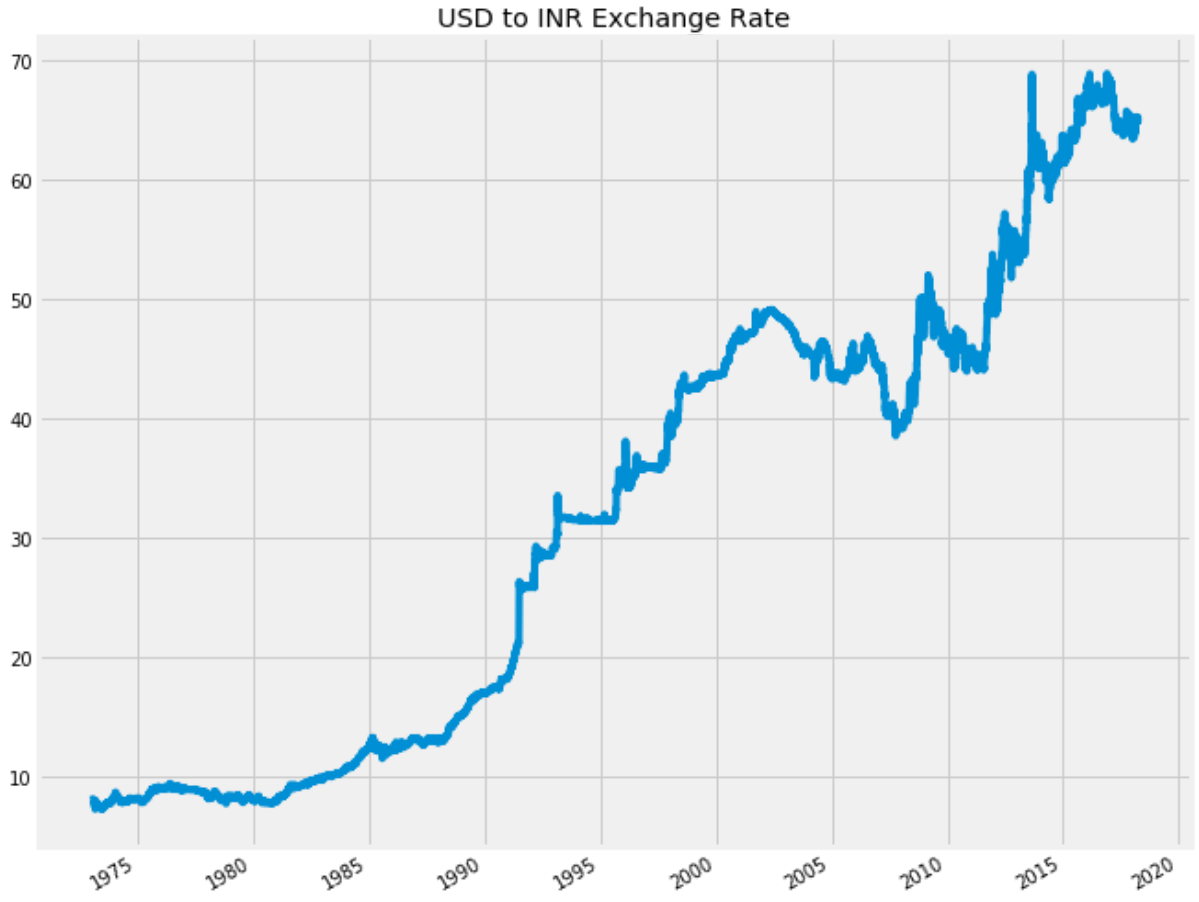
only the daily exchange rates.

Methodology

To make predictions, two regression models have been used on the initial dataset and ARIMA has been used on the time series.

The first dataset that has been created includes economic features, that show high levels of correlation. Each of the economic factor can be affected by the others. Both LASSO and Ridge Regression models are well suited for when the features show high level of multicollinearity. Further, the value of a country's currency is strongly dependent on the above mentioned factors. Hence, LASSO and Ridge Regression models models were chosen.

ARIMA was chosen to analyse the data as a time series.



Regression Models

The two regression analyses are performed over a dataset showing daily USD to INR exchange rates from January 4, 1973 to January 8, 2018.

LASSO Regression

LASSO or the **least absolute shrinkage and selection operator** is a type of linear regression model that uses **Shrinkage** i.e. it shrinks data values towards a central point.

It uses L1 Regularisation, i.e. it adds the penalty equal to the **absolute value of the magnitude of the coefficient** to the cost function:

$$\sum_{i=1}^{n} (Y_i - \sum_{j=1}^{p} X_{ij}\beta_j)^2 + \lambda \sum_{j=1}^{p} |\beta_j|$$

where Y_i is the outcome and $X_{ij} = (X_1, X_2, X_3 ... X_j)$ is the covariate vector for the i^{th} case in a sample consisting of *n* cases, each consisting of *p* covariates.

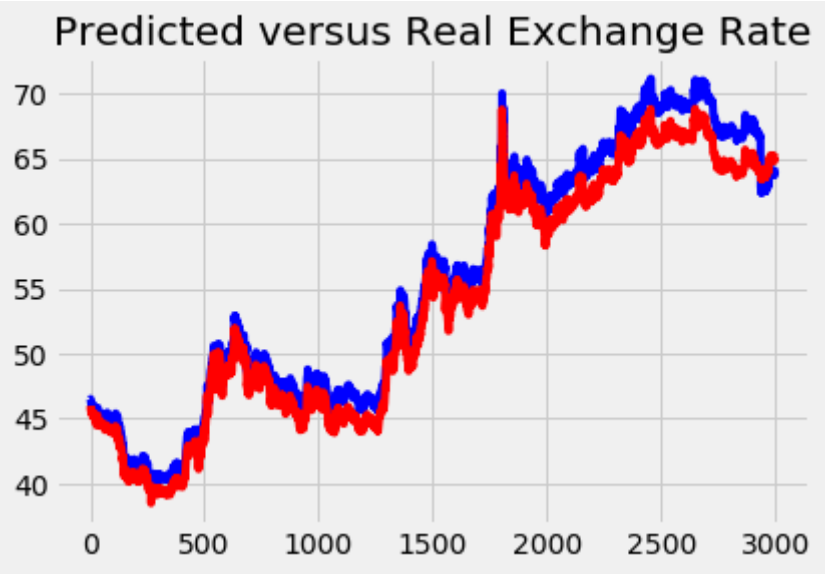
The goal is to minimize this cost function. Here, **λ** is the parameter that determines the amount of shrinkage. Some of the coefficients may be shrunk to zero, which completely eliminates them from the model, making it a lot simpler.

Result

The model was trained on the data for 35 years, taking the value of **λ** as 1. Then, it was used to predict exchange rates for the remaining 10 years. The following are the results.

This model has an R-squared score of 0.967 and mean-square error of 2.907.

The blue plot shows the predicted values while the red plot shows the actual values of the exchange rates for the remaining 10 years.



The model was then trained on the entire dataset and made to predict exchange rate for the following days.

Day	**Predicted Value**	**Actual Value**
April 4, 2018	64.92022612	65.1393
May 1, 2018	66.2998113	66.6031
June 1, 2018	67.17699456	67.1451
June 30, 2018	68.56137864	68.4403

Ridge Regression

Ridge regression is a type of linear regression that also uses shrinkage. However, unlike LASSO, it uses L2 Regularisation, i.e. it adds the penalty equal to the **square of the magnitude of the coefficient** to the cost function:

$$\sum_{i=1}^{n}(Y_i - \sum_{j=1}^{p} X_{ij}\beta_j)^2 + \lambda \sum_{j=1}^{p} \beta_j^2$$

where Y_i is the outcome and $X_{ij} = (X_1, X_2, X_3 \ldots X_p)$ is the covariate vector for the i^{th} case in a sample consisting of n cases, each consisting of p covariates.

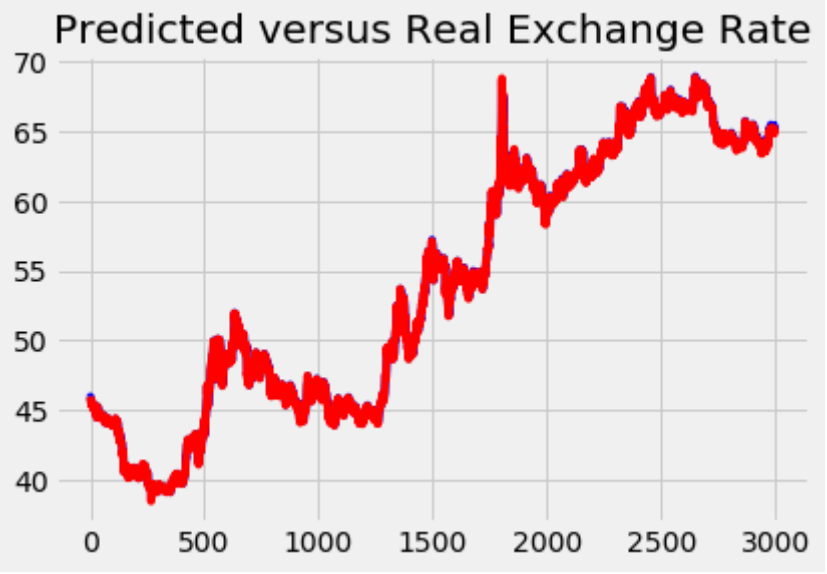
The goal is to minimize this cost function. Here, **λ** is the parameter that determines the amount of shrinkage.

Result

The model was trained on the data for 35 years, taking the value of **λ** as 1. Then, it was used to predict exchange rates for the remaining 10 years. The following are the results.

This model has an R-squared score of 0.999 and mean-square error of 0.0821.

The blue plot shows the predicted values while the red plot shows the actual values of the exchange rates for the remaining 10 years.



The model was then trained on the entire dataset and made to predict exchange rate for the following days:

Day	Predicted Value	Actual Value

April 4, 2018	65.0420531	65.1393
May 1, 2018	66.4536467	66.6031
June 1, 2018	67.34964201	67.1451
June 30, 2018	68.71738389	68.4403

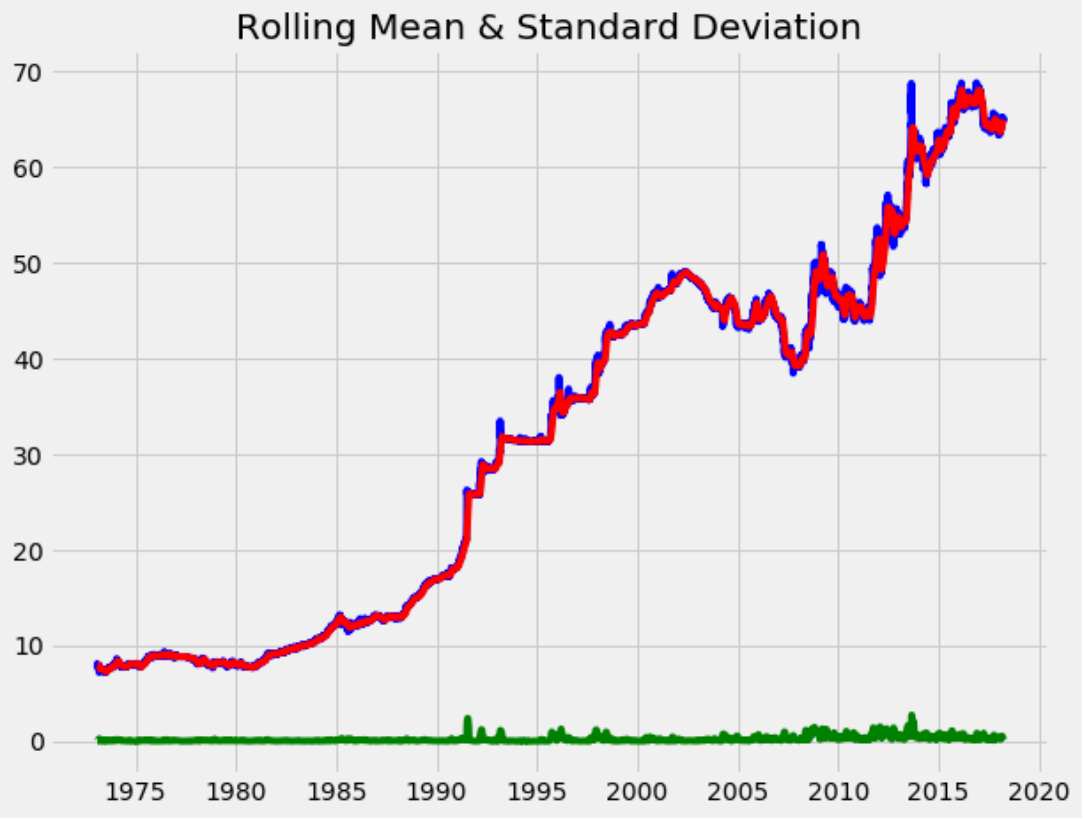
Taking λ as 2 and 3 produces similar results.

Autoregressive Integrated Moving Averages

In this approach, the ARIMA model is used to predict USD to INR exchange rates. This analysis is performed over a time series showing daily exchange rates from January 4, 1973 to January 8, 2018.

In order to create a Time Series Forecast using ARIMA, it must be ensured that the given time series is **stationary** i.e. the statistical properties remain constant over time. If not, the time series must be modified.

Plotting rolling statistics to check stationarity of the data



To test stationarity, the Rolling Mean (Red plot) and Standard Deviation (Green plot) are plotted along with the time series (Blue plot).

The variation in standard deviation is small, however, the mean is clearly increasing with time. Hence, it can be concluded that this time series is not stationary.

Log Transformation

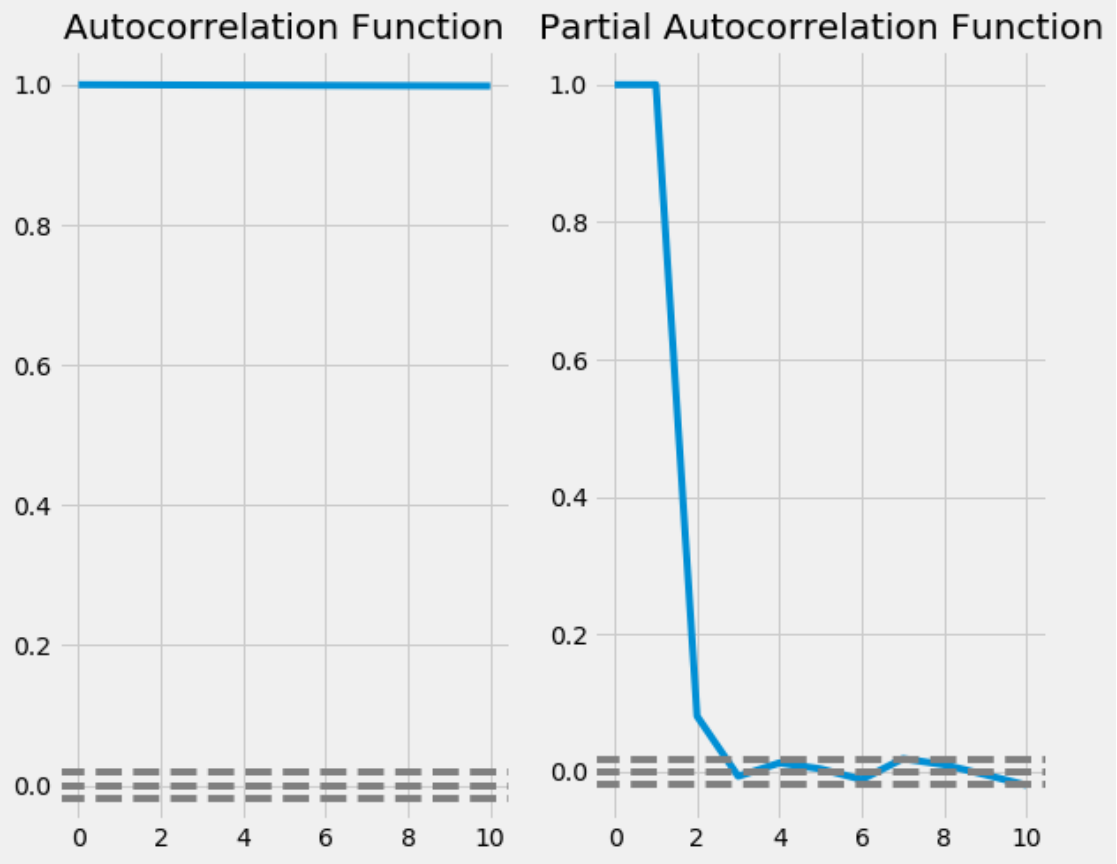
To make the time series stationary, transformation is applied. The log and square root of the times series are taken. For this analysis, **log transformation** is used.

The ARIMA model

The ARIMA forecasting equation for a stationary time series is a linear equation, that consists of three parametres:

1. **Number of Autoregressive terms (p)**
2. **Number of Differences (d)**
3. **Number of Moving Average terms (q)**

The values of q and p are determined by plotting the **Autocorrelation Function (**ACF) and **Partial Autocorrelation Function (**PACF) of the transformed time series. The lag value where the ACF and PACF value crosses the upper confidence level, gives the value of q and p respectively. Here, both p and q can take values 0, 1 and 2. In order to further stationarize the series using **differencing**, a value of 1 is taken for d.



(In this graph, the two dotted lines on either sides of 0 are the confidence intervals.)

The **ARIMA(1,1,1)** model, which is used in this project, consists of the following equation:

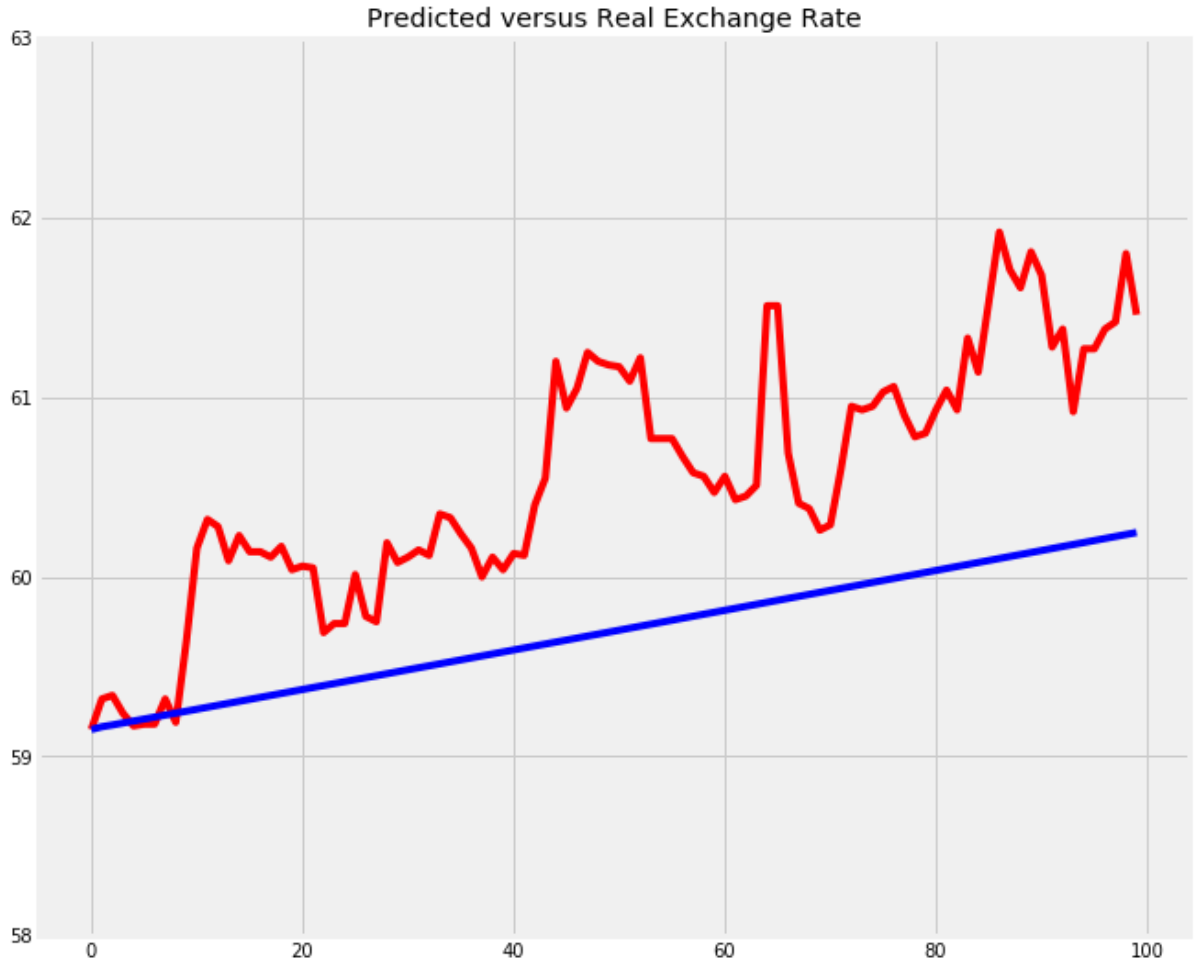
$$(1 - \varphi_1 B)(1 - B)Y_t = (1 - \theta_1 B)e_t$$

where e_t is the random shock (or noise) occurring at time t, Y_t is the time series data and B is the backward shift operator (i.e. for any time series Y and any period t, $BY_t = BY_{t-1}$).

Result

The given graph is obtained when this model is run on the given time series, to give the USD to INR exchange rate. The blue plot shows the predicted values while the red plot shows the actual values of the exchange rates for the next 100 days.

It can be noted that the model can predict the increasing trend of the time series. The model can also predict the USD to INR exchange rate for the next 8-10 days with higher accuracy.



Conclusion

Overall, all three algorithms perform well to predict the USD to INR exchange rates.

The LASSO and Ridge Regression models are able to capture the fluctuations in exchange rate (or the trend) much better than the ARIMA model. The ARIMA model can only capture the overall increasing trend.

However, the ARIMA model can predict the USD to INR exchange rate for the next 10 days with higher accuracy. Further, it does not involve consideration of the previous days' exchange rates, which are a requirement for the LASSO and Ridge Regression models. To predict future values for which previous days' exchange rates are unknown, the ARIMA model is a better choice.

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