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Time Series Analysis for Predicting the Exchange Rate of USD to BDT

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Abstract:

This paper attempted to study the trend of exchange rate of American currency in term of Bangladeshi currency. Time series analysis of the data of exchange rate from year 1971-72 to 2014-15 has been performed to find out the trend of the rate, and then obtain the best Autoregressive Integrated Moving Average (ARIMA) model from all the possible ARIMA models that could be used to fit the data. After applying Box-Jenkins methodology, the best fitted ARIMA (2, 1, 1) model has been obtained. Finally, forecasting has been made for USD in term of BDT from year 2015-16 to 2019-20. The predicted rates of USD (in taka) are found as following: 80.63, 83.99, 86.02, 87.07, and 88.23 for the fiscal years 2015-16, 2016-17, 2017-18, 2018-19, and 2019-20 respectively. Along with the point estimate, interval estimation has also been made for both 80% and 95% confidence intervals. The trend of the value of dollar in terms of taka is increasing over the years, which is alarming for the economy of Bangladesh. It is high time to take necessary steps to reduce the gap between the currencies of Bangladesh and other developed countries. Relevant researches should be conducted to learn the major factors affecting the values of Bangladeshi taka. Central bank of Bangladesh should monitor the inflation and work wisely for the proper maintenance of exchange rate. Government should make plan to decrease the amount of debt gradually to ensure reduced gap between USD and BDT. As political stability is a must for the value of a country's currency, it the responsibility of both the ruling party and the opposition party to ensure that there is no political instability for the sake of the country's economy.

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Introduction

The exchange rate is one of the most important issues in the discussion of world economy (Etuk, et al, 2016). Variations in the exchange rates have a massive effect, with the consequences for prices, wages, interest rates, production levels, revenue estimates, economic investment and employment opportunities. Forecasting of the exchange rate is the leading events for the practitioners and researchers in the spree of the exchange rate, which is floating (Hu, M. Y, et al, 1999). The significance of forecasting the exchange rates is that an accurate forecast can provide valuable information to allocate of resources, in hedging risk and in policymaking. Foreign exchange is the key element that is extensively used on basis for settlement of international transactions and international bills. There is no suspicion that exchange rate has a direct impact on the economic expansion of a country (Rizzo, J. M., 1998). The falling value of Bangladeshi taka as compared to US dollar remains stable when the dollar has been deflating itself against other major global currencies. Between 1990 to 2011, about 4 percent devalued Bangladeshi taka against the us dollar on average every year (Ahmed S., 2011). Rahman et al, 2006, is shown that both the foreign exchange and the money markets in Bangladesh experienced notable instability, which resulted in substantial depreciation of BDT against major currencies and a temporary rise in the interest rate in the money market in the last two fiscal years. Have a loan of the government from domestic and foreign sources, political instability has been the root of declining in the Bangladeshi taka against US Dollar (Uddin, et al, 2013).

Objectives

The following are the objectives to carry out the research on exchange rate of USD to BDT:

a) Study the trend of exchange rate of US dollar to Bangladeshi taka over the years for the available data from 1971-72 to 2014-15.
b) Testing the stationarity of the time series data and fitting best Autoregressive Integrated Moving Average (ARIMA) model.
c) Forecasting the rate of USD in terms of BDT for the years from 2015-16 to 2019-20.

Source of Data

In this study, we used the secondary data of Bangladesh Bank Exchange rate (BDT/USD) movement for the year of 1971-72 to 2014-15 from Bangladesh Bank on yearly basis. For the analysis, we took the period average value to get an accurate result of the model.

Methodology

At first the descriptive statistics of the time series data of exchange rate from fiscal year 1971-72 to 2014-15 has been found out to learn the summary of the entire data. Then a time series plot has been drawn to illustrate the trend of the data. Now the question of stationary arises. We use Augmented Dickey-Fuller (ADF) Test to know whether the data is stationary or not. If the test tells that the data is not stationary, then differencing needed to make the data

stationary. Also we plot Autocorrelation Function (ACF) and Partial Autocorrelation Function (PACF) to choose the order of Autoregressive Integrated Moving Average (ARIMA) model. This process should be repeated until the best ARIMA model has been obtained. To get the best ARIMA model some criteria such as Akaike Information Criterion (AIC) or Bayesian Information Criterion (BIC) can be used. Finally, we can make forecast of the time series data using the best ARIMA model.

ARIMA is specified by three order parameters: *(p, d, q)*. The procedure of fitting an ARIMA model is referred to as the Box-Jenkins method (Box and Jenkins, 1976).

An **Autoregressive (AR(p))** component is referring to the use of past values in the regression equation for the series *Y*. The autoregressive parameter *p* specifies the number of lags used in the model. For example, AR(2) or, equivalently, ARIMA(2,0,0), can be written as

$$Y_t = c + \varphi_1 Y_{t-1} + \varphi_2 Y_{t-2} + e_t$$

where φ_1, φ_2 are the parameters for the model.

The *d* represents the degree of differencing in the **integrated** component. By differencing a series, it means simply subtracting its current and previous values *d* times. Differencing is used often to stabilize the series when the stationarity assumption is not satisfied.

A **Moving Average (MA(q))** component gives the error of the model as a combination of previous error terms e_t. The order *q* tells the number of terms to be included in the model. For example, MA(2) or ARIMA (0,0,2) can be written as

$$Y_t = c + \theta_1 e_{t-1} + \theta_2 e_{t-2} + e_t$$

Where, θ_1 and θ_2 are the parameters of the MA(2) model.

Differencing, autoregressive, and moving average components formulate a non-seasonal ARIMA(p,d,q) model which can be represented as following:

$$Y_t = c + \varphi_1 Y_{d\ t-1} + \varphi_p Y_{d\ t-p} + \ldots + \theta_1 e_{t-1} + \theta_q e_{t-q} + e_t$$

Here, c is a constant and y_d means Y differenced d times.

To fit the ARIMA model for a time series data, it is a must to ensure that the series is stationary – mean, variance and auto covariance of the data should be time invariant. Other than the time series plot, there is a formal statistical test for stationarity named Augmented

Dickey-Fuller (ADF) test with the null hypothesis assuming that the series is stationary (Fuller, 1976).

For a non-stationary series, it is possible to make correction by a simple transformation called differencing. The difference can be obtained from the subtraction of the values of one period from its previous period:

$$Y_{d_t} = Y_t - Y_{t-1}$$

$$Y_{d2_t} = Y_{d_t} - Y_{d_t-1} = (Y_t - Y_{t-1}) - (Y_{t-1} - Y_{t-2})$$

The d component of ARIMA represents the number of differencing required for making the correction of a non-stationary time series.

Autocorrelation plots are not only useful to determine if the time series data is stationary, but also helpful in choosing the order parameters of ARIMA model. Correlation between a series and its legs can be displayed by ACF plots; whereas PACF plots display the relationship between a variable and its lags which is unexplained by previous lags. To determine the order of MA(q) model ACF plots can be helpful, and to determine the order of AR(p) model PACF plot are useful. Both ACF and PACF plots also can tell the order of the ARIMA model for the differenced series as well.

Akaike Information Criteria (AIC) and Baysian Information Criteria (BIC) are the two frequently used criteria for comparing all possible models and then finding out the best among them. If a model is chosen, how much information might be lost- AIC and BIC can be interpreted as the estimate of that information. It is desired to minimize AIC and BIC during the comparison of models. A model will be considered to be nearer to the truth when the value of AIC is lower (Akaike, 1974).

Results and Discussion

The data has been taken to forecast the exchange rate of BDT/USD. The descriptive statistics of the exchange rate (BDT/USD) of Bangladesh are summarized in the following table.

Table 1: Summary details of the exchange rate (BDT/USD) from 1971-72 to 2014-15

	Min.	1st Qu.	Median	Mean	3rd Qu.	Max.
BDT/USD	7.30	22.87	39.57	41.24	59.55	79.93

The minimum exchange rate is 7.30 which was in 1971-72 and the maximum value is 79.93 which was in the year of 2012-13. The Mean and Median exchange rate are 41.24 and 39.57. Based on the quartiles the deviation is 18.34. The Inter-bank exchange rate as on Nov 01, 2018 is BDT 83.50 (Source: Bangladesh Bank website).

To show the pattern and the stationary property of the data Augmented Dickey-Fuller Test is applied. The results of the test are as follows:
Dickey-Fuller = -1.7946, Lag order = 3, p-value = 0.6551
Alternative hypothesis: stationary

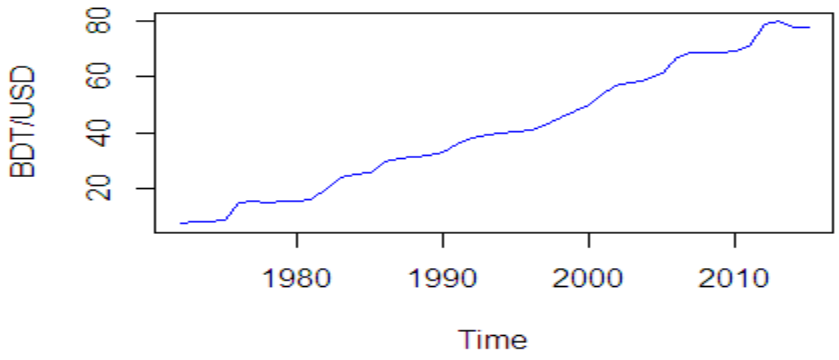

Fig.1: Trend of exchange rate BDT/USD per year

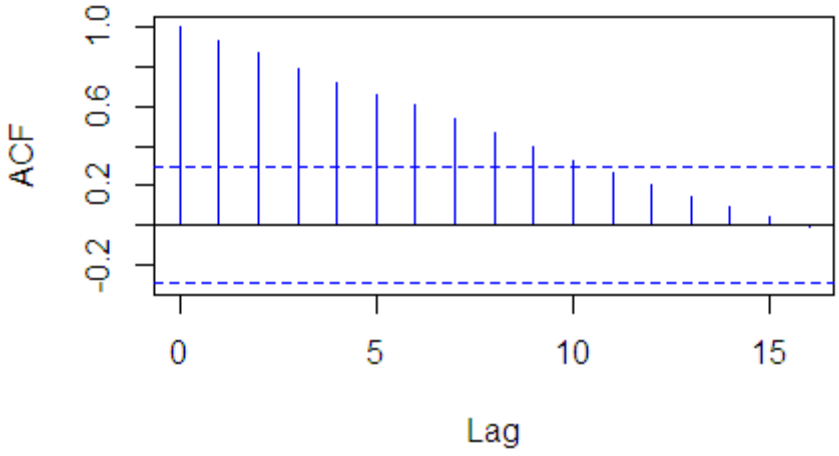

Fig.2: ACF plot for exchange rate of BDT/USD for yearly period average from 1971-72 to 2014-15

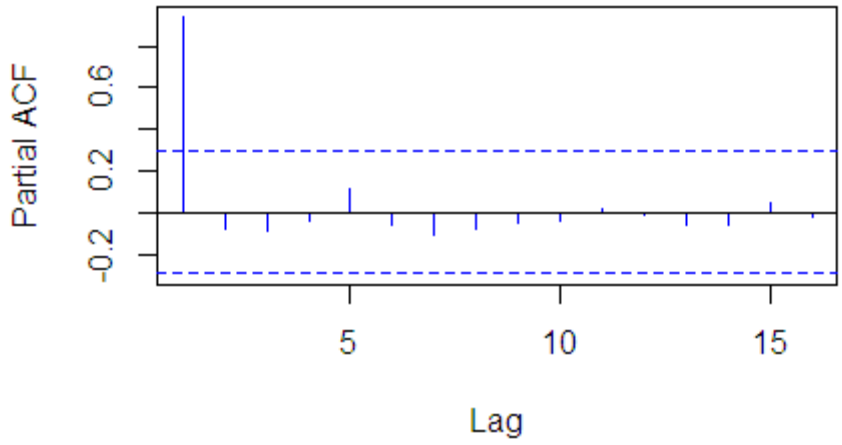

Fig.3: PACF plot for exchange rate BDT/USD for yearly period average from 1971-72 to 2014-15

From figure 1, we can see an increasing pattern of the exchange rate of BDT/USD over year. In figure 2, the ACF (Autocorrelation Function) plot shows that many points lie outside the significance line. PACF (Partial Autocorrelation Function) is also drawn in figure 3. In Augmented Dickey-Fuller test the p-value is greater than 0.05, therefore we fail to reject the null hypothesis. As a result, the data is not stationary.

To make the data stationary, we applied first differencing. After first differencing of the data, we again applied Augmented Dickey Fuller test. The results are as follows:

Dickey-Fuller = -5.0471, Lag order = 3, p-value = 0.01
Alternative hypothesis: stationary
The test is significant ($p<0.05^*$), that is the data is stationary at 1% level of significance.

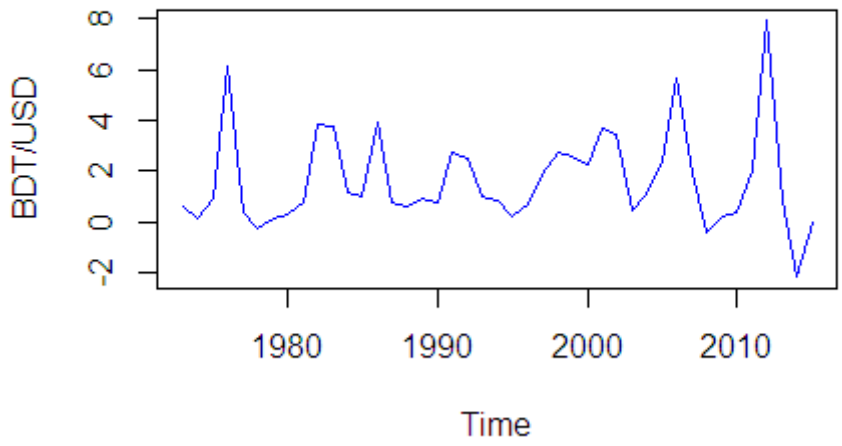

Fig.4: Time series plot for exchange rate of BDT/USD from 1971-72 to 2014-15 after first differencing

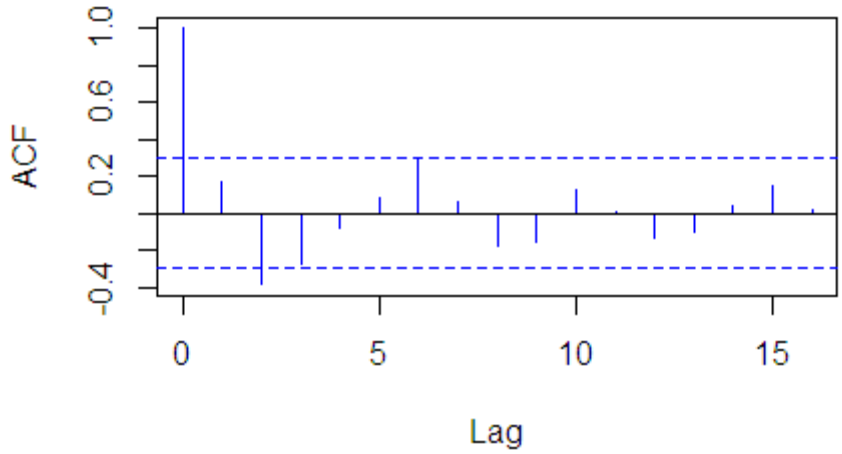

Fig.5: ACF plot for exchange rate of BDT/USD for yearly period average from 1971-72 to 2014-15 after first differencing

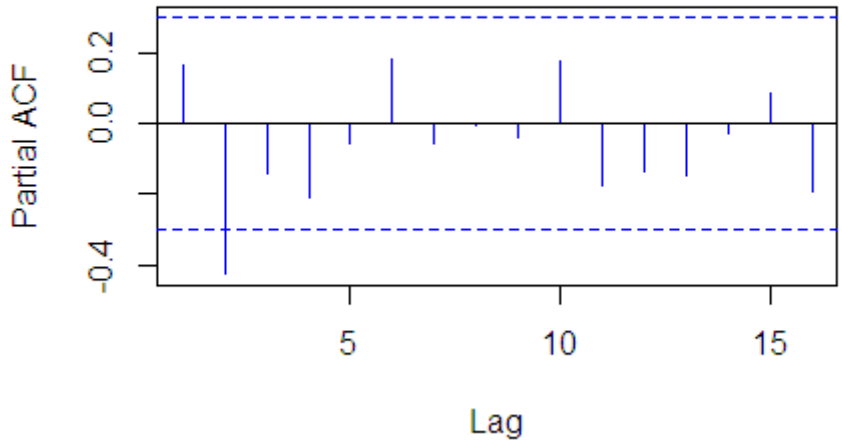

Fig.6: PACF plot for exchange rate BDT/USD for yearly period average from 1971-72 to 2014-15 after first differencing

Now we think about different types of tentative models in so far as possible from which we can go for the best model using the model selection properties. As the distinctiveness of a good ARIMA model is economical, avoiding the higher order of p and q, the tentative models based on model selection properties are as follows:

Table 2: All possible ARIMA models along with the best model

ARIMA(2,1,2) with drift	: 178.006
ARIMA(0,1,0) with drift	: 181.1785
ARIMA(1,1,0) with drift	: 182.2997
ARIMA(0,1,1) with drift	: 180.1172
ARIMA(0,1,0)	: 202.9887
ARIMA(1,1,2) with drift	: Inf
ARIMA(3,1,2) with drift	: Inf
ARIMA(2,1,1) with drift	: 175.4389
ARIMA(2,1,1)	: 194.9028
ARIMA(1,1,1) with drift	: 181.5228
ARIMA(3,1,1) with drift	: Inf
ARIMA(2,1,0) with drift	: 175.4912

Best model: ARIMA (2, 1, 1) with drift.

Table 3: Estimate of the coefficients of the best model

Coefficients:	AR (1)	AR (2)	MA (1)	DRIFT
Estimate	0.5850	-0.5202	-0.4878	1.7173
S.E.	0.2107	0.1342	0.2266	0.1400
sigma^2 estimated as 2.866		log likelihood=-81.91		
AIC=173.82		AICc=175.44	BIC=182.62	

From Table 2, we can see that 12 ARIMA models are generated. ARIMA (2, 1, 1) with drift is the best tentative model based on the smallest AICc (175.44) for forecasting purpose.

Table 4: Point and Interval estimation of the forecast of exchange rate of BDT/USD for the year of 1971-72 to 2014-15

Point	Forecast	Lo 80	Hi 80	Lo 95	Hi 95
2015-16	80.62520	78.45560	82.79480	77.30709	83.94332
2016-17	83.98599	80.76508	87.20690	79.06004	88.91194
2017-18	86.02079	82.51851	89.52307	80.66452	91.37707
2018-19	87.06894	83.50170	90.63617	81.61332	92.52455
2019-20	88.22964	84.57547	91.88381	82.64107	93.81821

It is found from table 4 that, exchange rate of BDT/USD is growing every year and exchange rate will be 88.22964 in 2019-20.

Recommendations

It is obvious from the result that the exchange rate of USD in terms of BDT is showing upward trend over the years. It is high time to take steps to reduce this gap. Further research may be suggested; however, working on the already known factors is the demand of time now. Bangladesh Bank could come forward by working with the policies and financial system efficiency; that would be useful in improving the mechanisms for inflation. Besides, a good number of people from Bangladesh work outside the country including United States; their financial assets will undoubtedly have impact on the exchange rate. So, a proper plan for monetary policy is required to reduce the gap between the values of dollar and taka. And, last but not the least; government should be aware of any faults – such as government debt, political instability, etc. from their side that might influence the exchange rate.

Conclusion

The time series plot of the exchange rate shows upward trend. That is, the gap between the value of American dollar and Bangladeshi taka has been increasing over the years. After following Box Jenkins methodology for the time series data of exchange rate of Bangladeshi taka per US dollar, it has been found that there are twelve models that can be fitted for the time series data of exchange rate. The models are: ARIMA (2,1,2), ARIMA(0,1,0), ARIMA(1,1,0), ARIMA(0,1,1), ARIMA(0,1,0) without drift, ARIMA(1,1,2), ARIMA(3,1,2), ARIMA(2,1,1), ARIMA(2,1,1) without drift, ARIMA(1,1,1), ARIMA(3,1,1), and ARIMA(2,1,0). The best one out of total twelve possible models has been obtained as ARIMA (2, 1, 1) model. Both the point estimate and interval estimate are computed to forecast the value of BDT for each unit of USD from year 2015-16 to year 2019-20. For the year 2015-16, the forecast value tells that one US dollar equals to BDT 80.63, and 95% confidence interval gives that the rate between BDT 77.31 – BDT 83.94. In the year 2016-17, the forecast value suggests that one US dollar will be equal to BDT 83.99, and 95% confidence interval of the rate is BDT 79.06 – BDT 88.91. For the year 2017-18, the prediction is that one US dollar implies to BDT 86.02, and 95% confidence interval shows that the rate is between BDT 80.66 – BDT 91.38. In the year 2018-19, the model predicts that one US dollar will be same as BDT 87.07, and 95% confidence interval gives that the rate will be BDT 81.61 – BDT 92.52. And, for the year 2019-20, the forecast value is suggesting that one US dollar will be equal to BDT 88.23, and 95% confidence interval gives that the rate will be BDT 82.64 – BDT 93.82.

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