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Time Series Modeling and Forecasting of CPI of Bangladesh

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Abstract:

Time series data is very important in the case of financial development of any economy. But it is very difficult to deal with time series data. This study is consists of time series modeling and forecasting of some economic variables of Bangladesh. For this study we have considered CPI as selected economic variables of Bangladesh. The variable was collected from the "Monthly Economic Trends" published by the Bangladesh Bank. For modeling purpose we have used Box-Jenkins Methodology which is very popularly known in the sector of time series modeling. On the study at first we have checked the stationarity. For checking stationarity we have used both graphical method and Dickey Fuller test. Then to find the appropriate model for CPI we have used the ACF, PACF curves. After finding the appropriate models we have performed the diagnostic checking for each of the fitted model, which was good. Then by using the best fitted model we have find some forecasted values for each of the variables.

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Introduction

Bangladesh is a small developing country with a huge population. Economic development of any country mainly depends on the development of various economic sectors of that country. In a small developing country like Bangladesh development may occurs very slowly with the contribution of different sectors such as agriculture sector, manufacturing and industry, investment sector, external trade, financial market etc. If one invests in a financial asset today the return received at some pre specified point in the future should be considered as a random variable. Such a variable can only be fully characterized by any model. There are various economic variables such as GDP, CPI, GNP, PDI etc. In this study we have choose CPI as our study variable. The main aim of this study is to determine the appropriate model for CPI and then forecast some future values of CPI for the next three years. Because if we are able to determine the appropriate model and can forecast these economic variables then it will be helpful to forecast the economic conditions in the future on the basis of the previous conditions. We have collected these data from the 'Monthly Economic Trends' published by the BBS and some of them has collected from the Internet. In 2009 R. Adhikari and R.K. Agarwal was worked with time series modeling and forecasting and published as "An Introductory Study on Time Series Modeling and Forecasting". M. Khairalla, Xu-Ning and N. T. Al-Jallad worked with advance time series modeling and forecasting and published as "Hybrid Forecasting Scheme for Financial Time-Series Data using Neural Network and Statistical Methods" in 2017. But in Bangladesh not so advanced work has been done so far. So initially we have just tried to find an appropriate model and forecast CPI of Bangladesh.

Objectives of the study

Main objectives of the study are stated below:

- to investigate stationarity and non-stationarity.
- to estimate the appropriate time series model for the variables.
- to forecast some future values by using the model.
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Methodology

To conduct the research at first we have to know about time series data. A time series is a set of observations on the values that a variable takes at different times. Such data may be collected at regular time intervals such as daily weekly, monthly, quarterly, annually, decennially etc. (D.N. Gujarati, 2003, page: 23). Time series process may be stationary and non-stationary. By using graphical method we can check the stationarity and also by using Augmented Dickey-Fuller test. Then we tried to find the appropriate model by using ACF and PACF curves. Several time series models are Moving average model or MA(q) process, Autoregressive process or AR(p) process, ARMA (p,q) process and ARIMA (p,d,q) process (Brockwell, 2002). After finding the model we have to perform diagnostic checking for the model accuracy and finally we can forecast by using the model. These steps are followed from a very popular method of time series analysis which is known as Box-Jenkins Methodology.

Box-Jenkins Methodology

The influential work of Box-Jenkins (1970) shifted professional attention away from the stationary serially correlated deviations from deterministic trend paradigm toward the $ARIMA(p,d,q)$ paradigm. It is popular because it can handle any series, stationary or not with or without seasonal elements. The basic steps in the Box-Jenkins methodology consist of the following five steps:

1. Identification of appropriate model: Once we have used the differencing procedure to get a stationary time series, we examine the Correlogram to decide on the appropriate orders of the AR and MA components. The Correlogram of a MA process is zero after a point that of an AR process declined geometrically. The Correlogram of $ARMA$ process show different patterns (but all dampers after a while). Based on these, one arrives at a tentative $ARMA$ model. This step involves more of a judgment procedure than the use of any clear-cut rules.

2. Estimation of the model: The next step is the estimation of the tentative $ARMA$ model identified in step-2. The estimation of AR model is straight forward. We estimate then by OLS by minimizing the error sum of squares $\sum Z_t^2$. In case of MA models, Box-Jenkins suggested a grid-search procedure. In this procedure we compute $\hat{Z}_t$ by successive substitution for each value of the MA parameters and choose the set of values of the parameters that minimizes the error sum of squares $\sum \hat{Z}_t^2$. For $ARMA$ models, both the AR and MA parts are to be estimated with the procedure discussed above.

3. Diagnostic Checking: When an $AR, MA, ARMA$ has been fitted to a given time series, it is a advisable to check that the model does really given an adequate description of the date. There are two criteria after used that reflect the closeness of fir and the number of parameters estimated. One is the Akaike information criterion (AIC) and the other is Schewatz Bayesian information criterion (BIC).

$$ACI(s) = n\log\hat{\sigma}^2 + 2s$$

$$and \qquad BIC(s) = n\log\hat{\sigma}^2 + s\log n$$

Here n is the sample size. If $RSS = \sum \hat{Z}_t^2$ is the residual sum squares, then

$$\hat{\sigma}^2 = \frac{RSS}{n-p}$$

If we are considering several ARMA models we choose the one with the lowest AIC of BIC. The two criteria can lead to different conclusions.

4. Forecasting: Suppose that we have estimated the model with n observations, we want to forecast Y_{n+k}. This is called a k-periods ahead forecast. First we need to write out the expression for Y_{n+k} and then replace all future values Y_{n+k} $(0<j<k)$ by their factors and Z_{n+j} $(j>0)$ by zero (since the expected value is zero). We also replace all Z_{n-j} $(j\geq 0)$ by the predicted residuals, (See for example, Gujarati, 2003).

Results and Discussions:

The data we analyses are collected from the 'Monthly Economic Trends' publishes by the Statistics Department of Bangladesh Bank. In this study at first we check whether the data is

stationary or not. If the data is non-stationary then we make them stationary by taking differences. Finally we fit ARIMA model for CPI data of Bangladesh.

Time series plots CPI:

Before approaching to the analysis we have to see the graphical pattern of CPI. This graphical pattern will help us to determine the stationarity of the variable. The time series plot of CPI is given below.

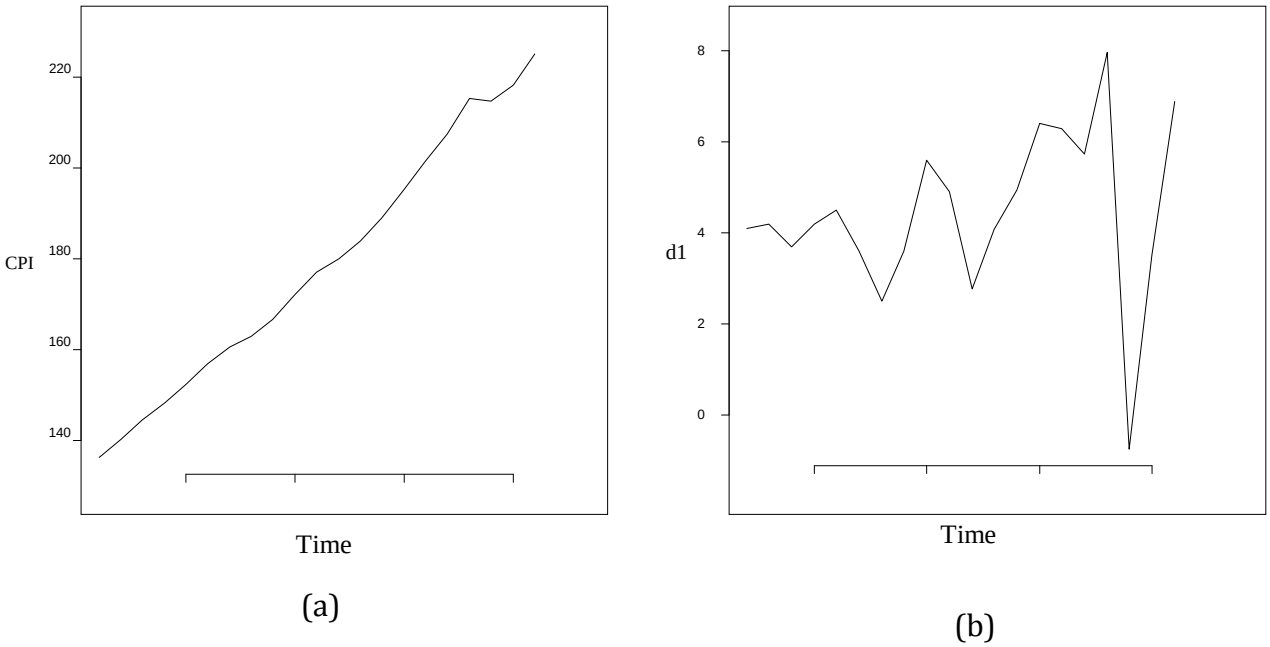

Figure1: Time series plot of CPI (a) and time series plot of first difference of CPI (b)

From the above Figure 1, the part (a) shows series CPI is non-stationary and (b) shows CPI becomes stationary after taking first difference.

Dickey Fuller test

The p-value of the Dickey Fuller tests for CPI series are stated below:

Variable	p-value	Decision
CPI	0.60	Non-stationary

The above table shows that our selected variable CPI is non-stationary because the p-value is much higher than 0.05.

In order to make these variables stationary it is necessary to take difference. Now the p-value of the ADF test for CPI after taking one difference for CPI is stated below:

Variable	p-value	Decision
ΔCPI	0.03771	Stationary

Above table shows that CPI data becomes stationary after first difference which gives similar decision with the graphical checking.

Correlogram Analysis

In order to determine the ARIMA model it is needed to perform correlogram analysis. Correlogram analysis will help us to determine the orders of the ARIMA model. From which we can select a specific model.

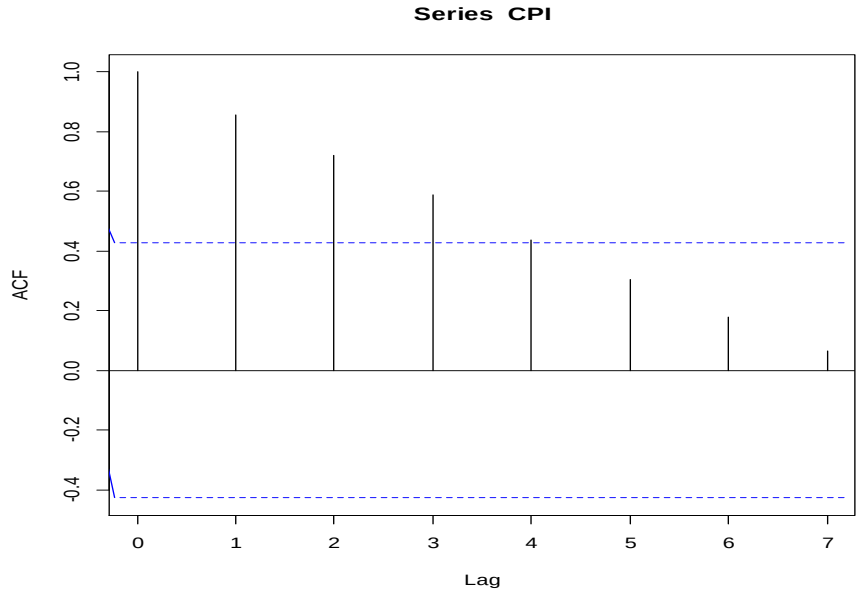

Figure 2: ACF of CPI data

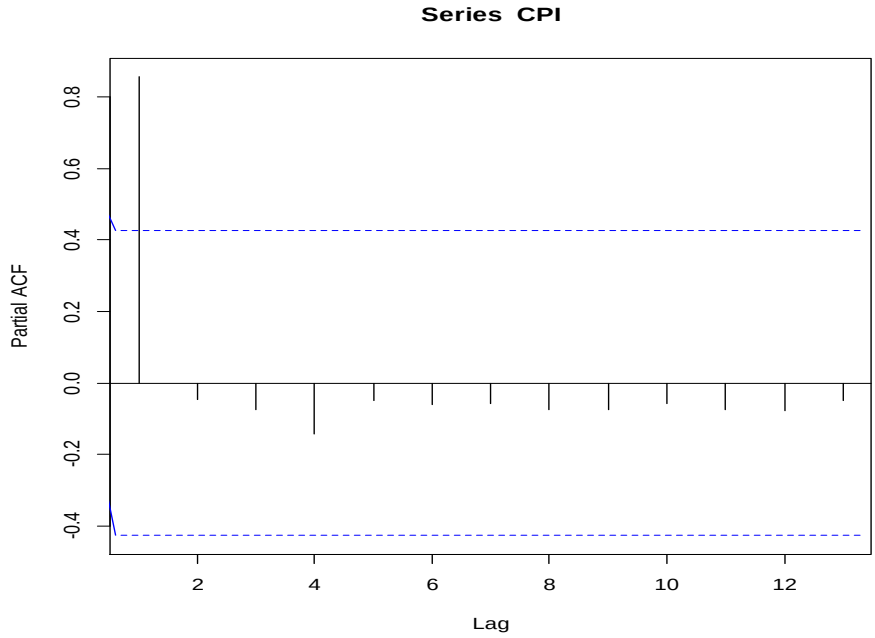

Figure 3: PACF of CPI data

Figure 2, indicates that the ACF of CPI decays exponentially and from figure 3 we can see that the PACF curves CPI contains one significance lag. Hence, by analyzing the above graphs we can say that CPI follows AR(1) process. That is the variables follows the model,

$$y_t = \alpha + \Phi_1 y_{t-1} + z_t$$

So, from the above graphical analysis and the correlogram analysis we observe that the series CPI follows ARIMA(1,1,0) model. The estimation of the models are stated below.

Estimation of ARIMA model for CPI

The fitted ARIMA(1,1,0) model for CPI data is

$$\Delta Y_t = 0.8642 * \Delta Y_{t-1}$$

By simplification we get,

$$Y_t = (1 + 0.8642) * Y_{t-1} - 0.8642 * Y_{t-2}$$

$$Y_t = 1.8642 * Y_{t-1} - 0.8642 * Y_{t-2}$$

Where, Y_t represents the CPI of Bangladesh over years.

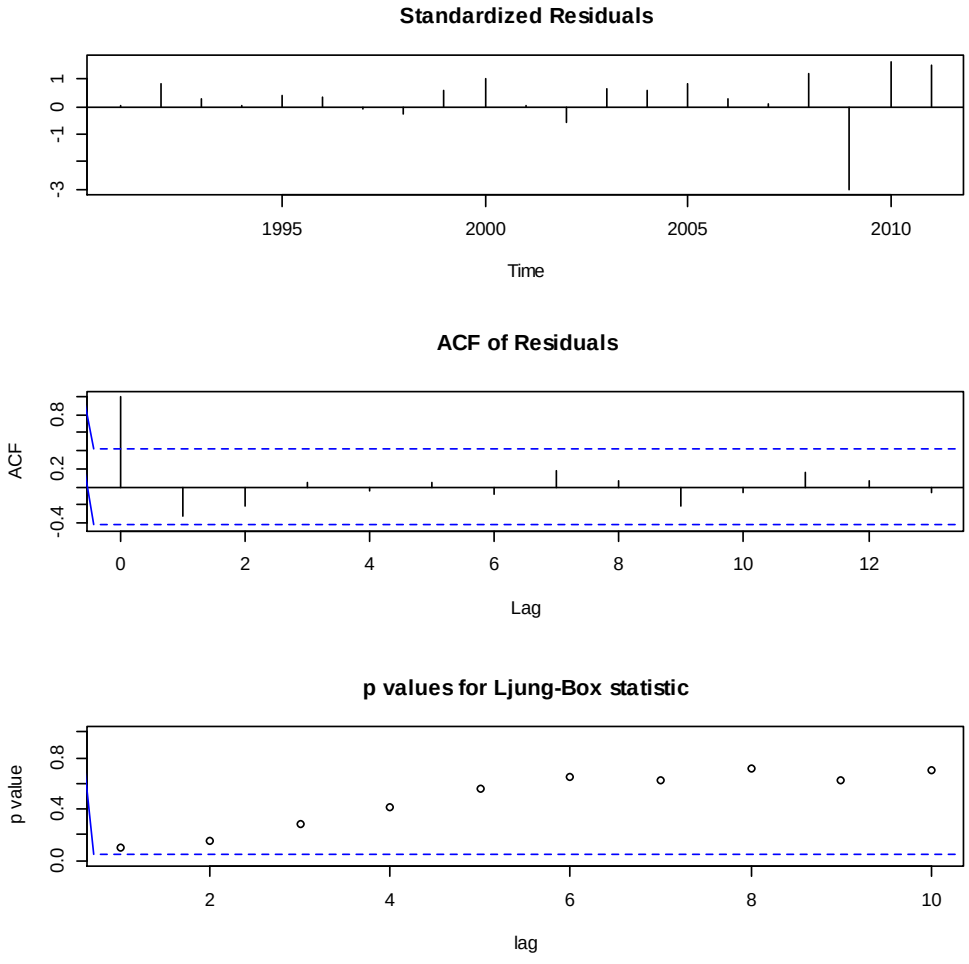

Figure 4: Diagnostic checking for ARIMA(1,1,0) model of CPI data

Diagnostic checking

The above fitted model is needed to be tested. To test the validity of the model we have to perform diagnostic checking. The diagnostic checking contains three parts: standardized residual plot, ACF of the residuals and the plot of the p-values. The diagnostic checking of the fitted model for CPI is given below.

From above diagnostic checking graph (Figure 4) shows that the estimated ARIMA(1,1,0) model for CPI are correctly specified because all the p values are over the significance level.

Forecasting of the CPI

As we estimated different models of the time series data correctly, so we can predict future values of the variables. The data we analyses is up to 2017. Now we are going to predict future values of CPI of Bangladesh for 2019, 2020 1nd 2021. The predicted values are stated below.

Years	CPI
2019	255.09
2020	256.94
2021	258.55

From our prediction we can see that the CPI of Bangladesh is increasing gradually.

Conclusions

At first we test the stationarity of the data by using graphical approach and ADF test. We found that our CPI series is non-stationary. Then we have used Box-Jenkins methodology to estimate appropriate ARIMA models for each set of data. We have found that CPI follows ARIMA(1,1,0) model. The diagnostic checking shows that model fitting was appropriate. We used these appropriate models to predict future values. In this study we predicted future values CPI of Bangladesh up to 2021.

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