

## **Forecasting Bangladesh's Inflation Using Time Series ARIMA Models**

Fahim Faisal<sup>1</sup>

*This study summarizes the steps for forecasting Bangladesh's inflation using Box-Jenkins autoregressive integrated moving average (ARIMA) time series model. For forecasting one year ahead consumer price index of Bangladesh a structure for ARIMA forecasting model, where a time series is expressed in terms of past values of itself plus current and lagged values of a 'white noise' error term is drawn up. Validity of the model was tested using standard statistical techniques and the best model is proposed on the basis of various diagnostic and selection & evaluation criteria. The findings of the study will provide policy makers a long term perspective of inflation in Bangladesh and assist in adopting proper strategies to contain inflation.*

**Field of Research:** Time series forecasting, Inflation Forecasting, Autoregressive Moving Average, Consumer Price Index, Inflation.

### **1. Introduction**

Around the world keeping a strong control over Inflation has turned out to be one of the primary objectives of the regulators as inflation increases uncertainty both in consumer's and producer's mind. As the economic effect of monetary policy have time lag policy makers and financial authorities require frequent updates to the path of inflation. Policy makers can get prior indication about possible future inflation through Inflation forecasting using univariate time series auto regressing integrated moving average (ARIMA) models. The intrinsic nature of a time series is that successive observations are dependent or correlated and therefore, statistical methods that rely on independent assumptions are not applicable. Time series analysis studies the stochastic mechanism of an observed series. The study of time series helps to understand and describe the underlying generating mechanisms of an observed series. This analysis assists in forecasting future values and to estimate the impact of events or policy changes. Results from analysis can give valuable information when formulating future policies.

Currently the financial regulatory authorities in Bangladesh are facing the twin challenge of maintaining price stability while accommodating higher growth in the economy. It is often a tough task to achieve a combination of the two goals. Like other developing countries, Bangladesh has three macroeconomic targets: a growth target to support

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higher employment and poverty reduction; an inflation target to maintain internal economic stability; and a target for stability of the balance of payments. To achieve these three targets, Bangladesh needs some combination of three policy instruments: monetary policy, fiscal policy, and policies for managing the balance of payments. However, with rising inflation Bangladesh is finding it difficult to properly coordinate all three macroeconomic targets in a sustainable manner.

As the primary objective of monetary policy is to lower inflation and maintain the stability of the exchange rate many expert is currently advocating for the use of monetary policy to control inflation in Bangladesh. But with the long time lag between monetary policy announcement and policy action, it's difficult for policymakers to properly coordinate their strategies. Under such situation, forecasting future inflation can assist policymakers in formulating their strategies. Along with the time lag, in reality inflation is often multi causal and prime cause of inflation can vary from year to year. The possible factors behind excessive inflation can include supply side factors including cost push relationship along with exchange rate effects, excessive borrowing by local government and demand pull inflation. Currently keeping stable inflation is one of the key objectives of the Bangladesh Bank. Successful implementation and persuasion of monetary policy in any economy largely depends on the efficiency and accuracy of forecasting macroeconomic variables like inflation.

Given the complexity of inflation controlling and time lag of monetary policy affect many monetary economists strongly advocated for inflation targeting to maintain stable aggregate price inflation. In his writing Svensson (1996) argued for inflation forecasting targeting where central bank tries to stabilize only inflation and resource utilization. However, before formulating strategy based on inflation forecast it's necessary to emphasize the structural soundness of inflation forecasting. This paper is one such attempt towards accurate univariate time series inflation forecasting in Bangladesh using monthly time series data from March 2001 to August 2011.

## 2. Literature Review

Several methods for identifying ARIMA models have been suggested by Box- Jenkins and others. Makridakis et al. (1982), and Meese and Geweke (1982) in their writings have discussed the methods of identifying univariate models. Among others Jenkins and Watts (1968), Yule (1926, 1927), Bartlett (1964), Quenouille (1949), Ljune and Bos (1978) and Pindyck and Tubinfeld (1981) have also emphasized the use of ARIMA models. For forecasting Irish inflation using ARIMA models Aidan Meyler, Geoff Kenny and Terry Quinn (1998) used two different approaches-the Box Jenkins approach and the objective penalty function methods for identifying appropriate ARIMA models. Toshitaka Sekine (2001) estimated an inflation function and forecasted one-year ahead inflation for Japan. In his study he found markup relationship, excess money supply and the output gap are of particular importance for determining long run equilibrium correlation model of inflation. He emphasized the importance of adjustment to a pure model-based forecast by utilizing information of alternative models. Muhammad Abdus

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Salam, Shazia Salam and Mete Feridun (2007) used autoregressive integrated moving average time series models for forecasting Pakistan's inflation.

It was the major contribution of Yule (1927) which launched the notion of stochasticity in time series by postulating that every time series can be regarded as the realization of a stochastic process. Based on this idea, a number of time series methods have been proposed. George E.P. Box and Gwilym M. Jenkins (1970) integrated the existing knowledge on time series with their book "Time Series Analysis: Forecasting and Control". First of all, they introduced univariate models for time series which simply made systematic use of the information included in the observed values of time series. This offered an easy way to predict the future development of the variable. Moreover, these authors developed a coherent, versatile three-stage iterative cycle for time series identification, estimation, and verification. George E.P. Box and Gwilym M. Jenkins (1970) book had an enormous impact on the theory and practice of modern time series analysis and forecasting. With the advent of the computer, it popularized the use of autoregressive integrated moving average (ARIMA) models and their extensions in many areas of science. Since then, the development of new statistical procedures and larger, more powerful computers as well as the availability of larger data sets has advanced the application of time series methods. After the introduction by Yule (1921), the autoregressive and moving average models have been greatly favored in time series analysis. Simple expectations models or a momentum effect in a random variable can lead to AR models. Similarly, a variable in equilibrium but buffeted by a sequence of unpredictable events with a delayed or discounted effect will give MA mode.

There have been very few studies on forecasting inflation in Bangladesh using Time Series techniques. In Thailand Tao Sun (2004) developed an approach for forecasting core inflation using monthly data from May 1995 to October 2003. The seasonally adjusted, monthly percent changes in Thailand's consumer price index after removing its raw food and energy components is used as the dependent variable. For Indonesia, Ramakrishnan and Vamvakidis (2002) estimated a multivariate model to identify the leading indicators that have predictive information on future inflation using quarterly data from 1980 to 2000. Hafer and Hein (2005) compared the relative efficiency of the widely used interest rate based forecasting model and univariate time series model based on monthly data from the United States, Belgium, Canada, England, France and Germany for the sample period from 1978 to 1986. Using monthly data on the Euro rates and the consumer price index (CPI) their results indicate that time series forecast of inflation model produces equal or lower forecast errors and has unbiased predictions than the interest rate based forecasts. Gavin and Kevin (2006), using Stock and Watson's (2005 and 1999) Dynamic Factor Models (DFM) forecast inflation and output with three alternative processes: a benchmark autoregressive model; a random walk; and a constant that presumes a fixed rate of growth of prices and output over the forecast horizon 3, 12 and 24 months with the monthly data from January 1978 to December 1996.

### 3. Data and Methodology

A time series model is useful in examining the dynamic determinants of economic series. The basic underlying assumption in time series forecasting is that the set of casual factors (Macroeconomic fundamentals) that operated on the dependent variable in the past will exhibit similar influence in some repetitive fashion in the future. In this research historical monthly national consumer price indices (general) data from (March 2001-August 2011) of Bangladesh ("Monthly statistical bulletin of Bangladesh") with 126 data points will be analyzed. Based on this data series, time series forecasting will be conducted to forecast CPI up to August 2012. In past studies of inflation forecasting of Bangladesh emphasis has been given on testing economic theory and on empirical analysis. Even though some of these studies have been used as an input into the forecasting process, they have not been subject to rigorous forecast evaluation techniques. This paper set out to redress this deficiency and explicitly use time series techniques solely for forecasting purposes.

The basic idea in developing univariate forecasting models is to extract a mathematical model that will pattern the data behavior. These models are equally useful as a starting point for forecasting since most forecasts are developed from historical trend relationships. Their disadvantage is that data availability usually limits the range of the determinants measuring the relationship. The analysis of time series helps to detect regularities in the observations of a variable and derive 'laws' from them, and/or exploit all information included in this variable to better predict future developments. The basic methodological idea behind these procedures, which were also valid for the Babylonians, is that it is possible to decompose time series into a finite number of independent but not directly observable components that develop regularly and can thus be calculated in advance.

The objective of analyzing economic data is to predict or forecast the future values of economic variables. In a series of articles and a subsequent book, Box and Jenkins (1970) describe in detail a strategy for the construction of linear stochastic equations describing the behavior of a time series. Box-Jenkins introduced a methodology is to fit data using ARIMA model. ARIMA approach combines two different parts into one equation; they are the Autoregressive process and Moving average process. The proposed BJ methodology for this research involves iterative three-stage cycles. The first step requires model identification. This stage finds the order of autoregressive, integration and moving average (p,d,q) of the ARIMA model. Having identified the values of ARIMA model, the second step will be diagnostic checking. One simple test to ensure the chosen model best fitted is to test the residuals estimated from this model and check whether or not they are white noise. If the residuals turned out to be white noise, then the model is accepted to have the particular fit; otherwise, the research process should restart over the selection process. The third step is the estimation of the parameters of the selected autoregressive and moving average forms included in the model. This step also involves forecasting the series based on the ARIMA model. To complete the work, the accuracy of forecasting will be investigated. A number of statistical measures will be used for this purpose. They are mean error (ME), mean absolute error (MAE), mean square error (MSE), mean percentage error (MPE), and

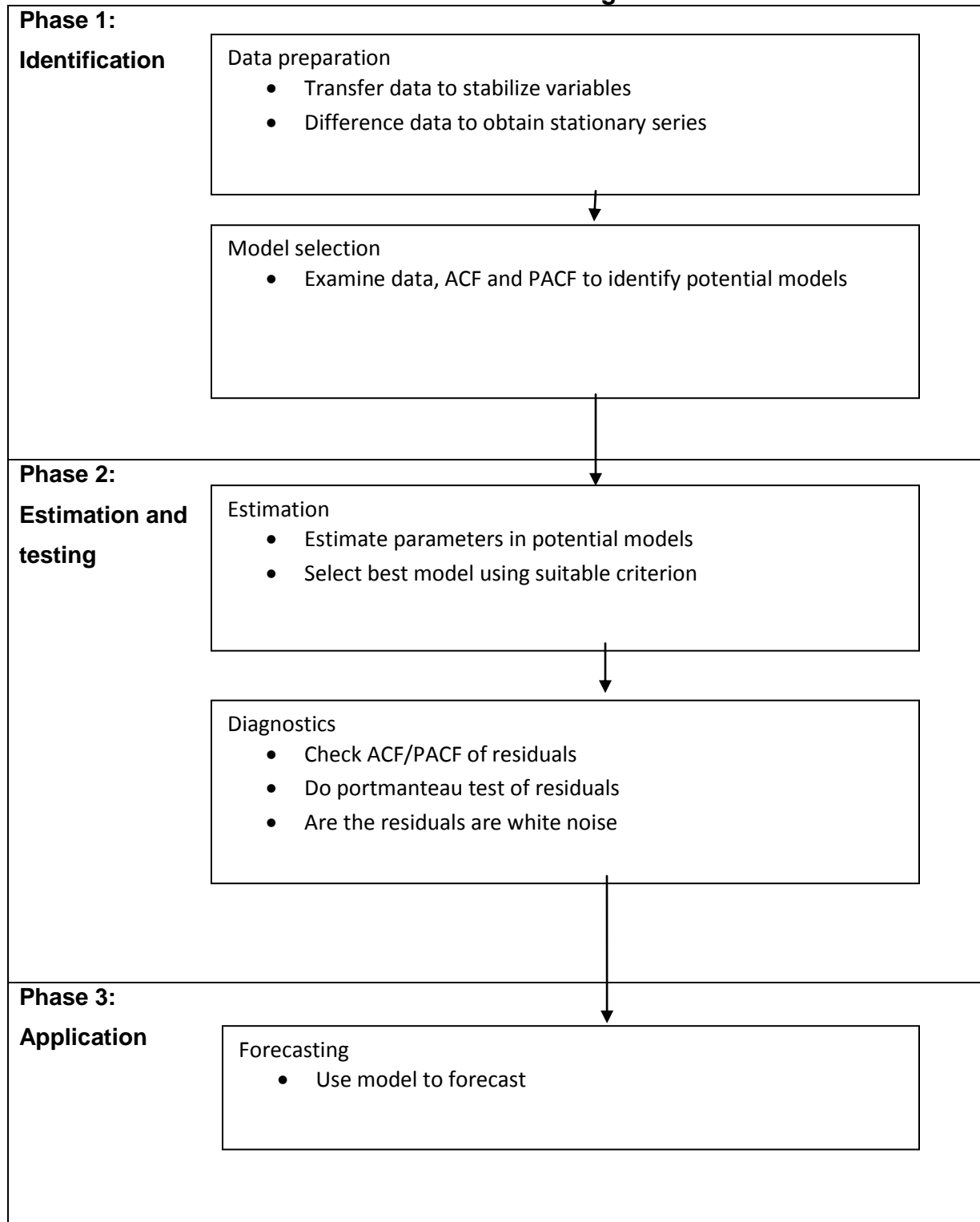
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mean absolute percentage (MAPE) and Theil's U statistic to compare the accuracy of various models.

To employ Box-Jenkins process to forecast a time series, the stationarity of the series must be maintained. Therefore, the first step in the process begins with testing for stationarity of the series. A time series is said to be stationary if both the mean and the variance are constant over time. Through the stationarity test we will also examine the properties of the time series variable, in order to have a reliable regression tests to make sure that the CPI inflation forecasting model could not be subjected to "Spurious Regression". The problem of spurious regression arises because time series data usually exhibit non-stationary tendencies and as a result, they could have non-constant mean, variance and autocorrelation as time passes. This can lead to non-consistent regression results with misleading coefficients of determination and other statistical test.

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**Table 1: Schematic representation of the Box-Jenkins methodology for time series modeling**



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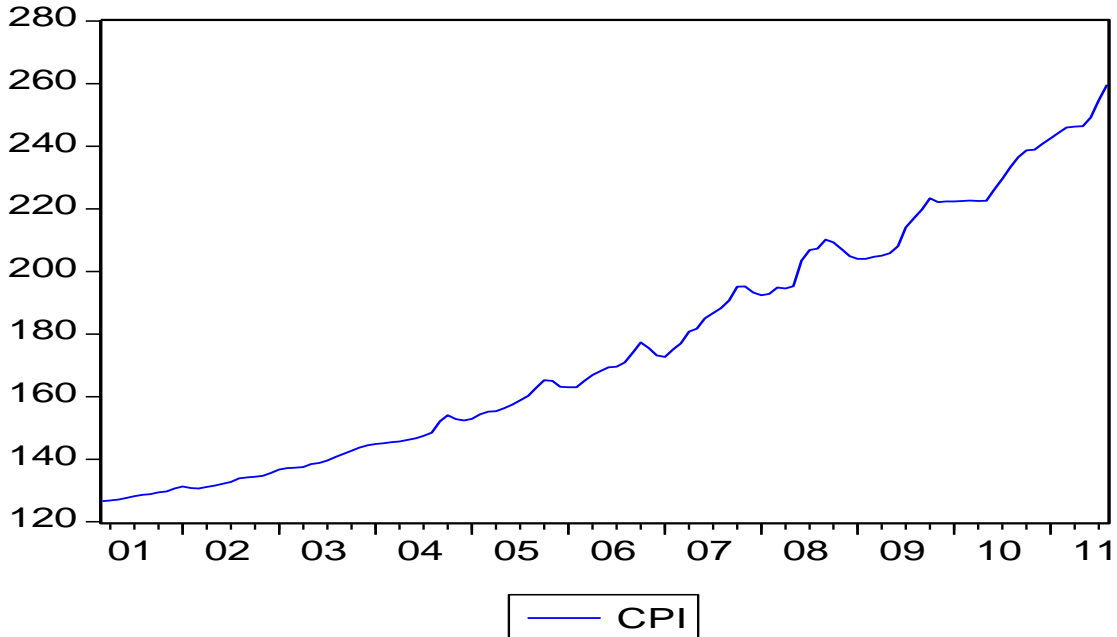
In practical term, to make the series stationary requires performing three processes: removing the trend, having a constant variance and finally, removing the seasonality. The visual representation, correlogram analysis where non-stationary series is having a slowly decaying ACF and PACF, Philips- Perron test and the unit-root tests of the data provide the tool for determining whether the series is stationary or not. A plot of the series against time gives an idea about the characteristics of the series. If the time plot of the series shows that the data scattered horizontally around a constant mean, then the series is stationary at it levels. On the other hand if the time plot is not horizontal the series is non-stationary. Equivalently, the graphical representation of the autocorrelation functions (ACF & PACF) can be employed to determine the stationarity of the series. If the ACF and PACF drop to or near zero quickly, this indicates that the series is stationary. If the ACF and PACF do not drop to zero quickly, then the non-stationarity is applied to the series. The order of integration (d) identified the differencing times to make the series stationary and the series contains (d) unit roots and the series is said to be integrated of order (d). If the t-ratio of the estimated coefficient is greater than the critical t-value, the null hypothesis of unit root (non stationary variable) is rejected indicating the variable is stationary at level and integrated of degree zero denoted by  $I(0)$ . On the hand if the series found to nonstationary at levels, a transformation of the variable by differencing is need until we achieve stationarity that is non-autocorrelated residuals.

### 4. Discussion

For time series, the most obvious graphical form is a time plot in which the data are plotted over time. The basic features of the data including patterns and unusual observations are most easily seen through graphs. So to identify the best forecasting model, it is important to focus on the consumer price index data pattern of Bangladesh. In figure 1, the total consumer price index (base 1995-96) data of Bangladesh (March 2001 to August 2011) were plotted where we cannot actually observe a clear specific pattern of consumer price index data due to non stationary. However, the trend is upward for the whole series.

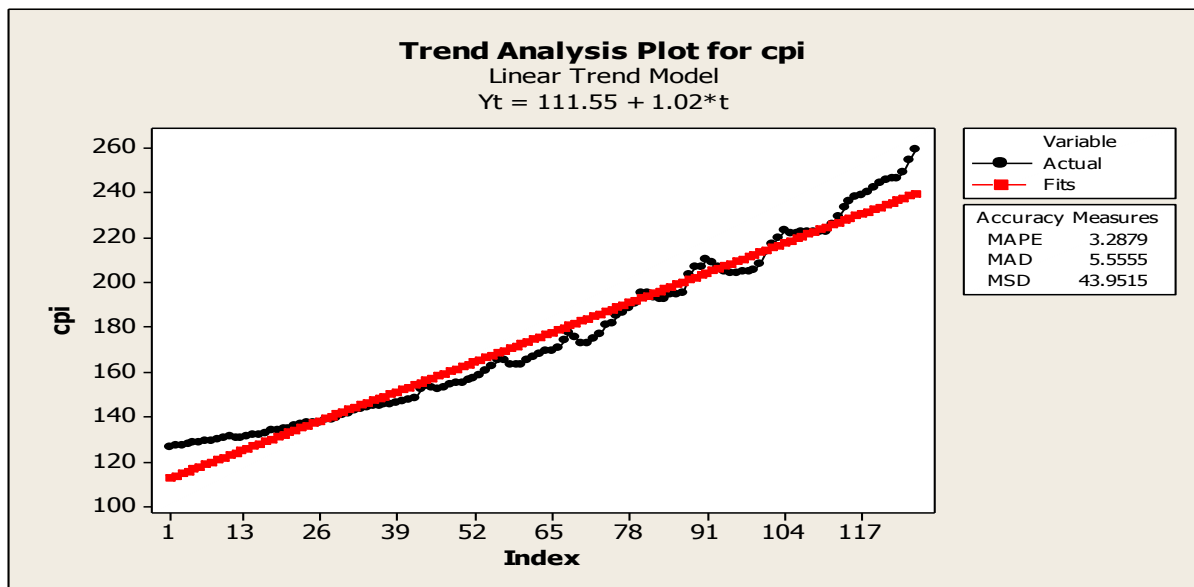
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**Figure 1: Time series (March 2001- August 2011) plot of consumer price index (general 12 month point to point basis) of Bangladesh (base 1995-96)**



To get better insights about the data trend analysis plot of original CPI series, seasonal analysis of CPI, component analysis of CPI and time series decomposition plot of CPI series is also being checked in figure 2, 3 and 4:

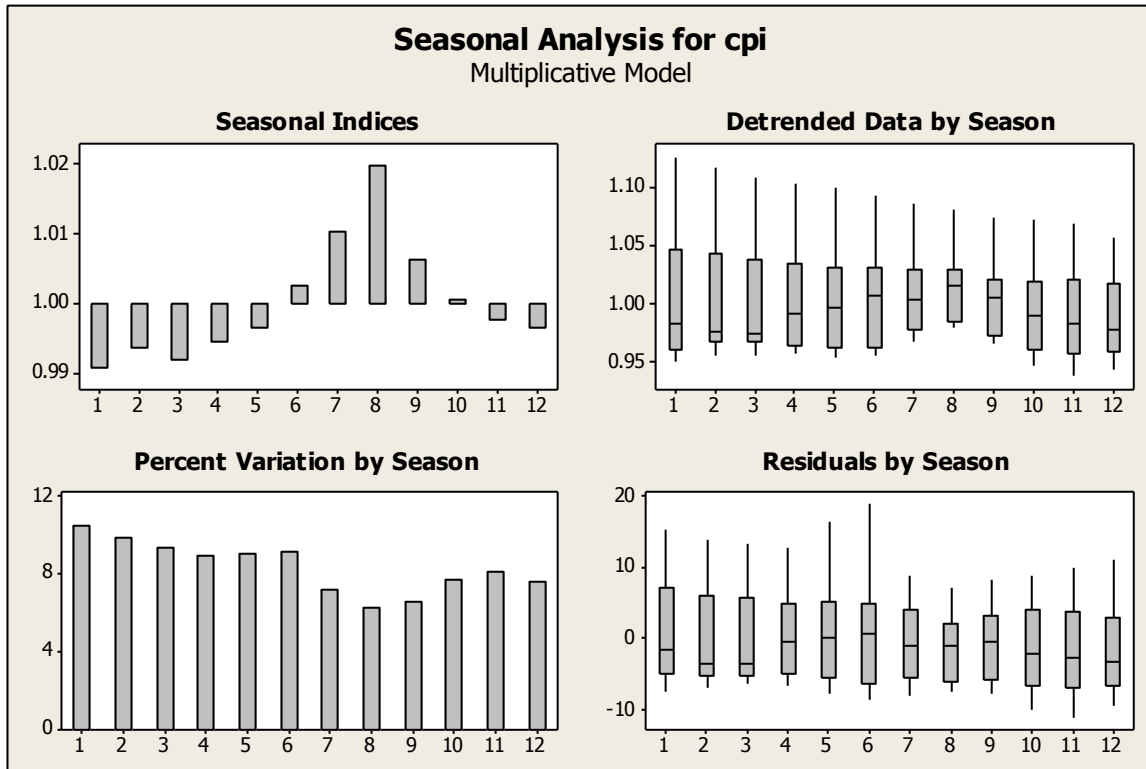
**Figure 2: Trend Analysis Plot (March 2001- August 2011) of Consumer Price Index (general 12 month point to point basis) of Bangladesh**





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**Figure 3: Seasonal Analysis Plot of Consumer Price Index of Bangladesh (March 2001- August 2011)**



**Figure 4: Component Analysis Plot of Consumer Price Index of Bangladesh (March 2001- August 2011)**

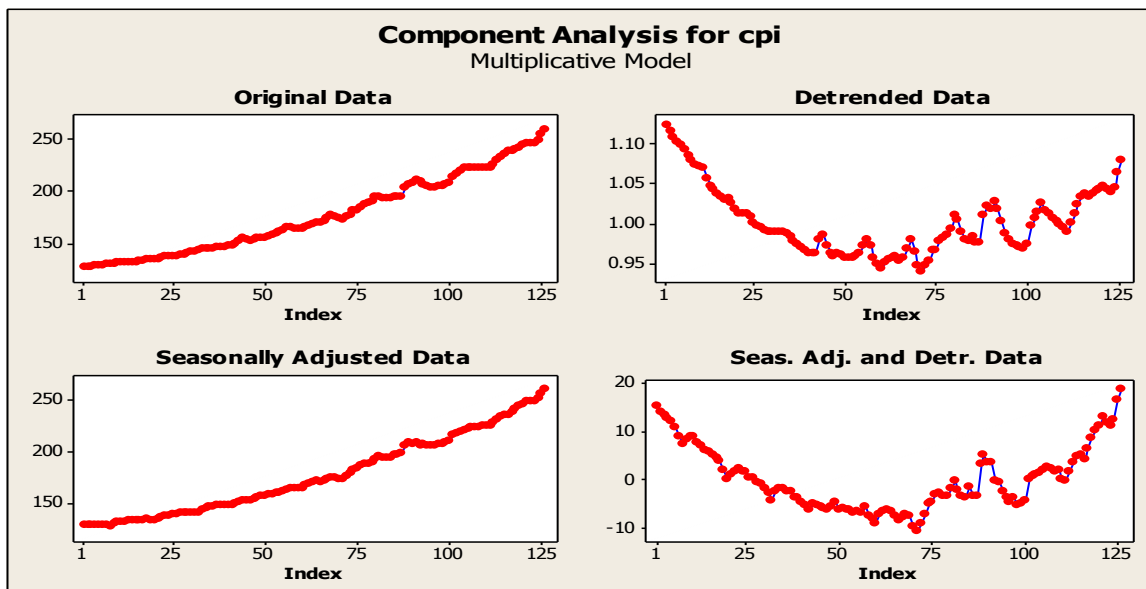
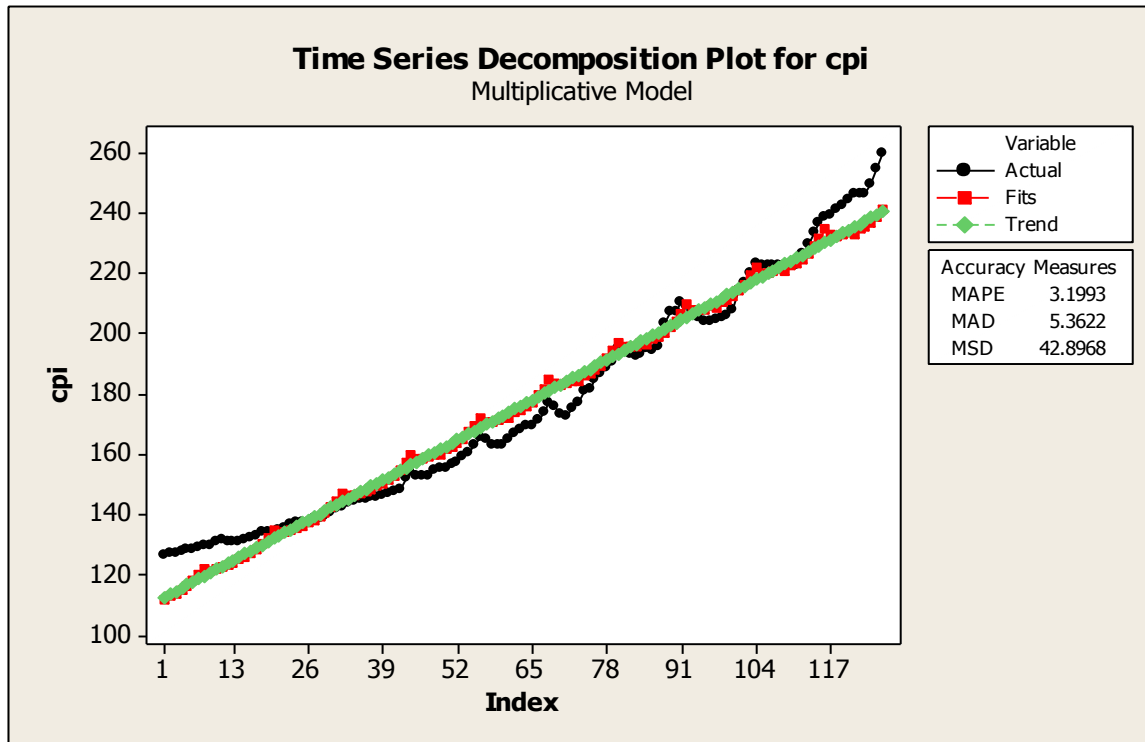


Figure 5: Time Series Decomposition Plot of Consumer Price Index of Bangladesh (March 2001- August 2011)



The forecasting model was selected based on identification, estimation, and diagnostics. Trend, cycle and model selection criteria (AIC, SIC, R-Square and Adjusted R-Square) were also used. The processes are explained below-

### TESTING FOR STATIONARITY

The foundation of time series analysis is stationarity. Trends or other non stationary patterns in the level of a series can result in positive autocorrelation that dominate the autocorrelation diagram. Therefore, it's important to remove the non stationarity. One way of removing non stationarity is through the method of differencing. Unit Root test has been conducted to find out the stationarity of the CPI series. For the unit root test of CPI series of Bangladesh the method being used is the Augmented Dickey Fuller Test (ADF). The null and the alternatives are:

- H<sub>0</sub>:** Consumer Price Index series have unit root;
- H<sub>a</sub>:** Consumer Price index series do not follow unit root

The decision rule here is if and only if the "P-value from ADF test > .05" then null (H<sub>0</sub>) is accepted. Otherwise the null hypothesis will be rejected.

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**Table 2: Unit Root Test of Original Consumer Price index (general 12 month point to point basis) series (March 2001- August 2011)**

Null Hypothesis: CPI has a unit root			
Exogenous: Constant			
Lag Length: 12 (Automatic based on SIC, MAXLAG=12)			
Augmented Dickey-Fuller test statistic		t-Statistic	Prob.*
		2.620575	1.0000
Test critical values:	1% level	-3.489117	
	5% level	-2.887190	
	10% level	-2.580525	

For the unit root test of CPI series the null hypothesis is being rejected. So, the CPI series is not unit root and first differencing the CPI series removes the trend and makes the series variance constant. After first differencing the CPI series becomes stationary.

**Table 3: Unit Root Test (After first Difference)**

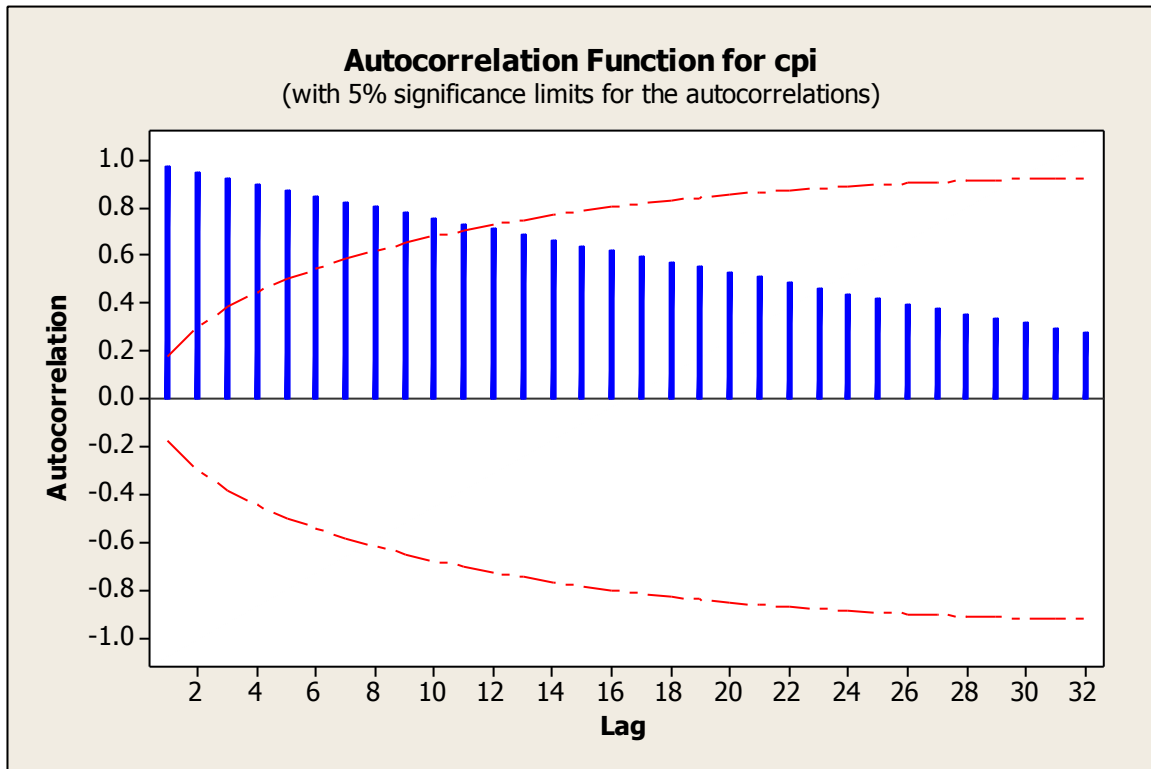
Null Hypothesis: D(CPI) has a unit root			
Exogenous: Constant			
Lag Length: 1 (Automatic based on SIC, MAXLAG=12)			
Augmented Dickey-Fuller test statistic		t-Statistic	Prob.*
		-6.660977	0.0000
Test critical values:	1% level	-3.484198	
	5% level	-2.885051	
	10% level	-2.579386	

### MODEL IDENTIFICATION AND ESTIMATION

ARIMA methodology emphasizes on analyzing the stochastic, properties of economic time series rather than constructing single or simultaneous-equation models. The examination of the autocorrelation and partial autocorrelation function of original CPI series of Bangladesh reveals the following:

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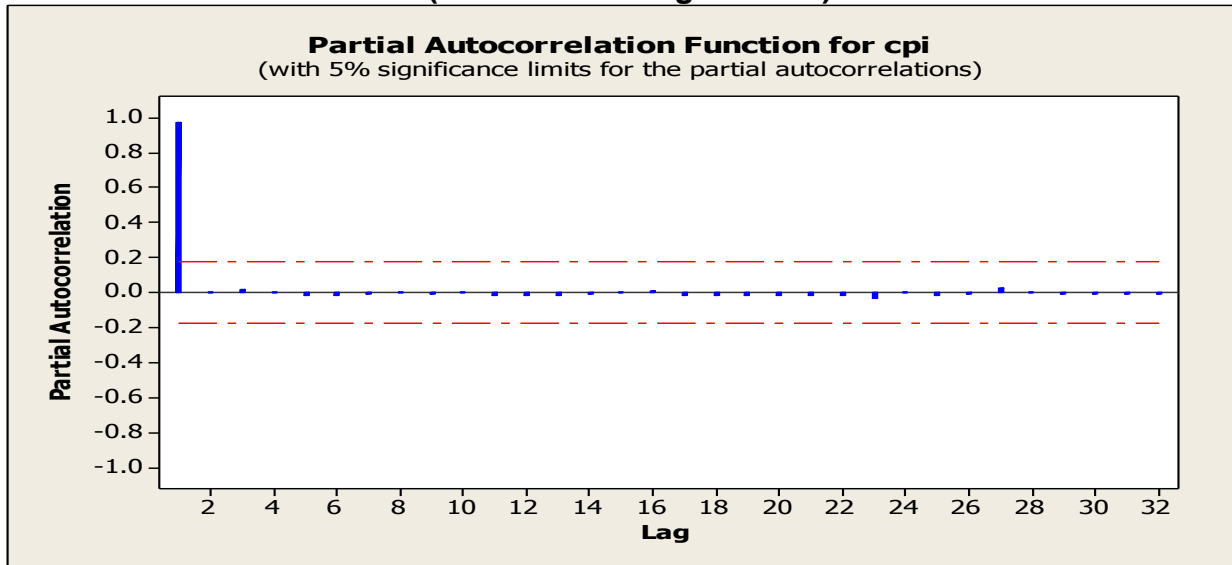
Figure 6: Autocorrelation Function Of Consumer Price Index (base 1995-96) of Bangladesh (March 2001-August 2011)



ARIMA models allow each variable to be explained by its own past or lagged, values and stochastic error terms. The great beauty of the Box-Jenkins approach is in the wide choice of forecast functions availability.

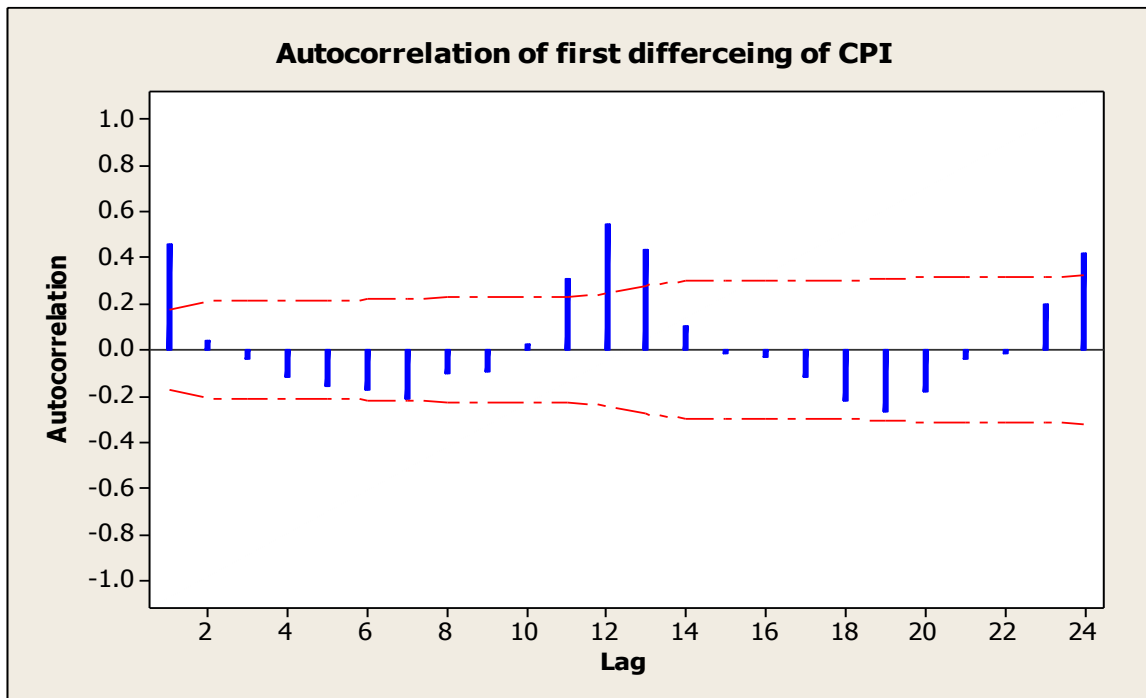
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**Figure 7: Partial Autocorrelation Plot of Consumer Price Index of Bangladesh (March 2001- August 2011)**



In any particular case, the data themselves are allowed to suggest the eventual form of the forecast function employed, and such freedom would be reflected in the accuracy of the forecasts obtained. As the original CPI series is non stationary its necessary to check the autocorrelation and partial autocorrelation function of first difference of original CPI series:

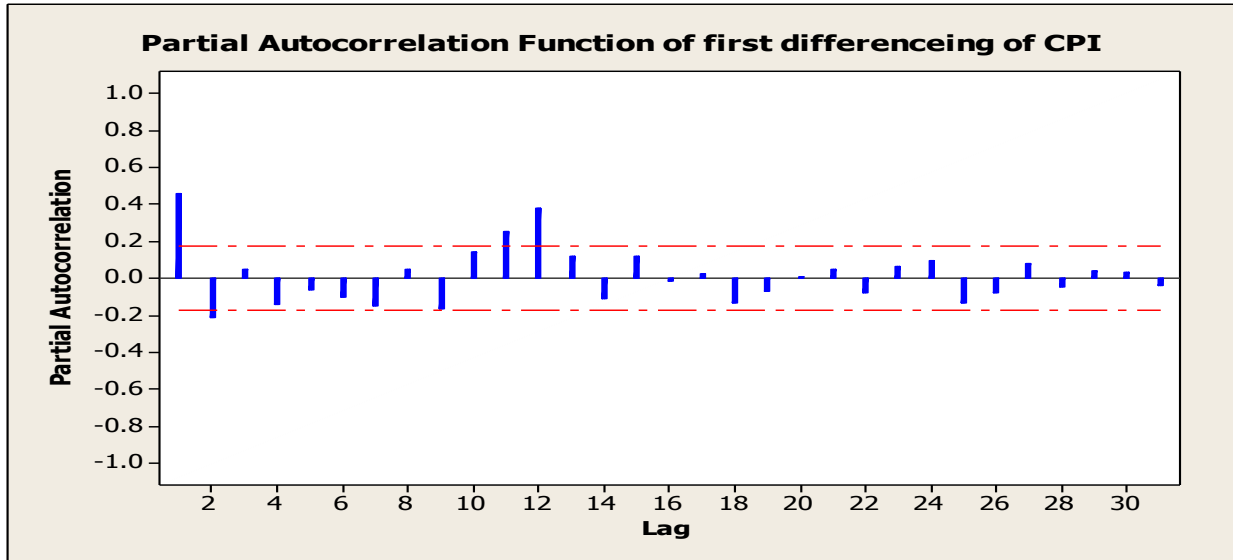
**Figure 8: Autocorrelation Plot of First Difference of CPI series**



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The parameter in the identified model is estimated by minimizing the sum of squares of the fitting errors. As the data has seasonal pattern observations for the same months in different years are correlated.

**Figure 9: Partial Autocorrelation Function of First Differencing of CPI series.**



### MODEL DIAGNOSTICS and FORECASTING

After choosing a particular ARIMA model and estimating the parameters it's necessary to check whether the model fits the CPI data. As the data has seasonal pattern seasonal model has been applied for the forecasting. Seasonal ARIMA model contains regular autoregressive and moving average items that account for the correlation at low lags and seasonal autoregressive and moving average terms that account for the correlation at the seasonal lags. The Box-Jenkins approach is an iterative process where its possible that another ARIMA model can fit the CPI data well, then its necessary to revise the model to get more efficient forecast. For carrying out model diagnostics plotting the residuals of the estimated model is a useful diagnostic check through checking the white noise requirement of residuals. The ACF and PACF of residuals for forecasted CPI series in examined below:

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Figure 10: ACF of Residuals for Forecasted CPI series

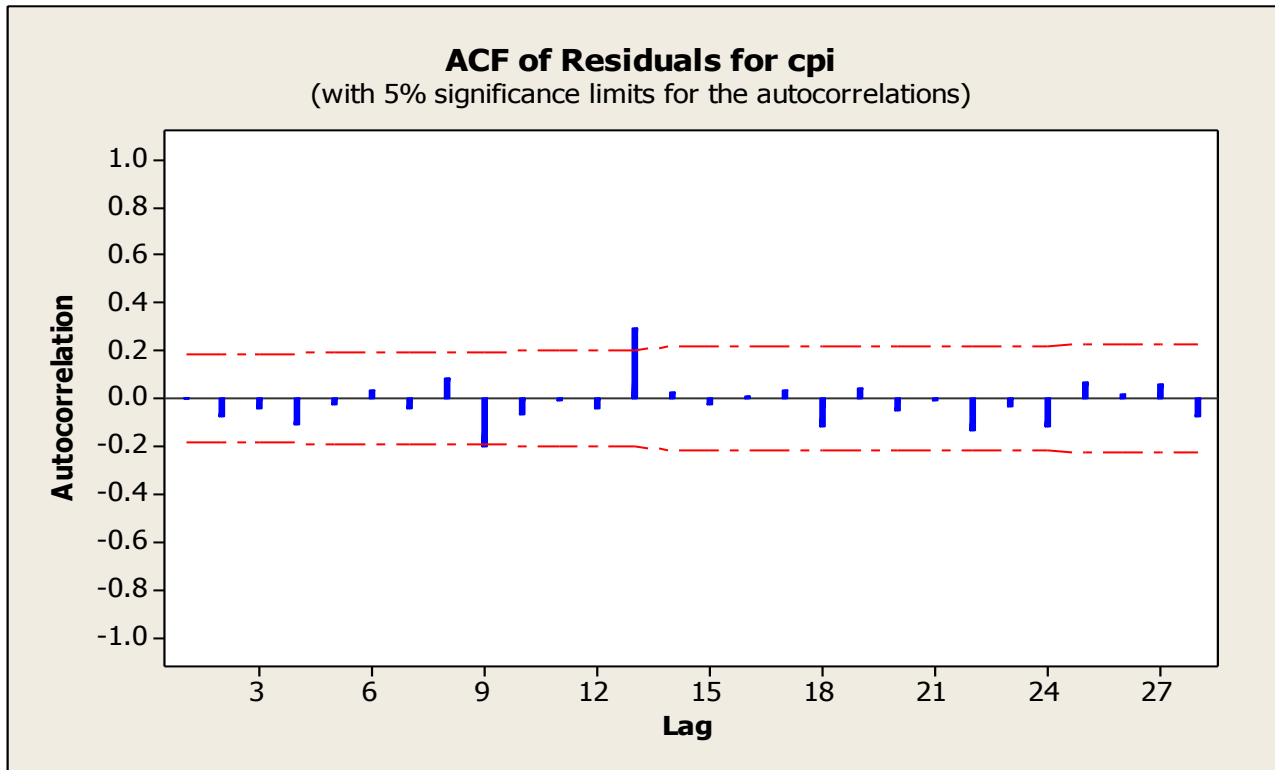
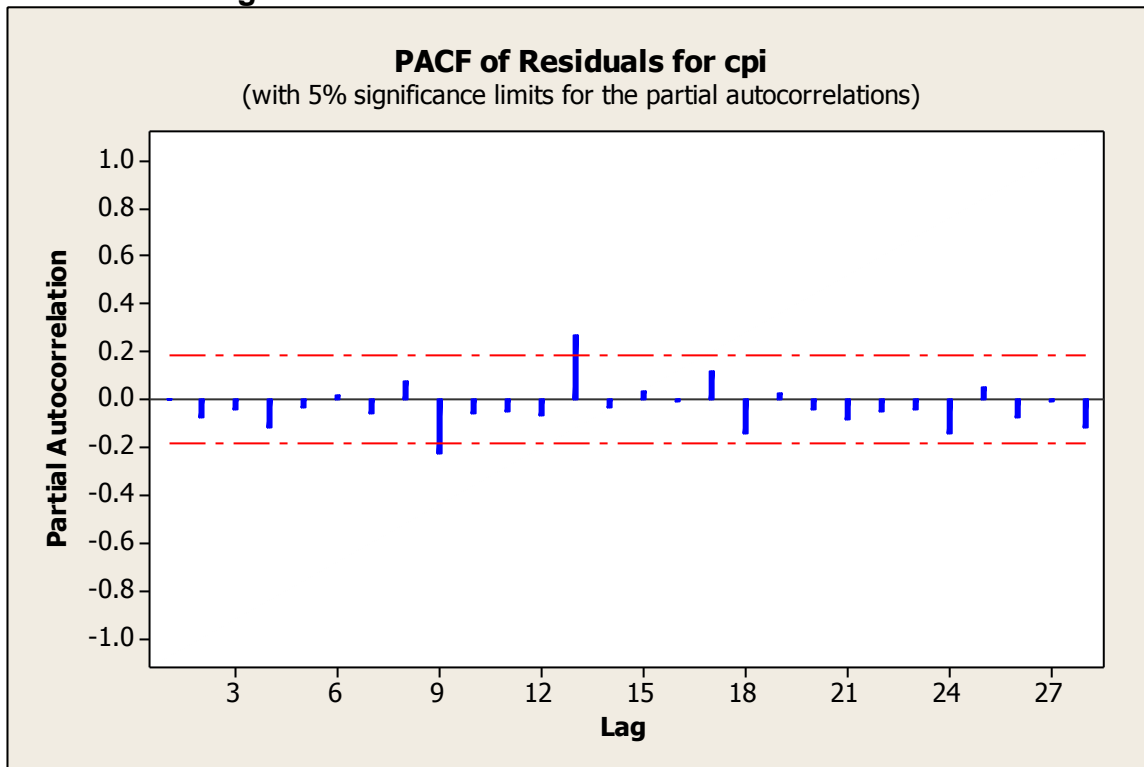


Figure 11: PACF of Residuals for Forecasted CPI series



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Here the model is adequate as the residuals cannot be used to improve the forecast. Finally the comparative performance of the selected ARIMA (AR1, SAR 12) model have been checked along with other initial models by using the statistics; AIC, RMSPE, MAE, MPB and MAPE. Final Estimates of Parameters of the selected model (AR1, SAR 12) is:

**Table 4: Coefficient of Final Selected Model for Forecasting**

Type	Coef	SE Coef	T	P
AR 1	0.2559	0.0923	2.77	0.007
SAR 12	-0.4713	0.0878	-5.37	0.000

**Table 5: Forecasted Inflation from September 2011-August 2012**

Time Period	Forecasted Inflation
2011M09	263.012
2011M10	265.925
2011M11	265.487
2011M12	266.566
2012M01	267.506
2012M02	268.514
2012M03	269.460
2012M04	269.546
2012M05	269.673
2012M06	272.764
2012M07	277.346
2012M08	281.709

The forecasted outcome for inflation of the current study, indicate that the yearly rate of inflation for Bangladesh in August 2012 will be about 7.11 percent.

## 5. Conclusion

In this research through using the Box-Jenkins approach of time series forecasting, the best forecasting model has been selected. Econometric forecasting models usually comprise systems of relationships between variables of interest where the relations are estimated from available data. In practice, it has been observed, however, that reasonably good forecasts can be made with simple rules of thumb that are extrapolations of a single data series. As studies on inflation forecasting rarely exist in Bangladesh, further investigations are needed in this arena as forecasting is an integral part of the decision making process of financial regulators, policy makers.



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