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MODELING NIGERIA'S CONSUMER PRICE INDEX USING ARIMA MODEL

[1]S.O. Adams [2] A. Awujola [3]A.I. Alumgudu
[1]Department of Statistics, University of Abuja, Abuja Nigeria
[2]Department of Economics, Bingham University, Nasarawa State, Nigeria
[3]Department of Mathematics and Statistics, Federal Polytechnic Nasarawa, Nasarawa, Nigeria

ABSTRACT: *This paper fit a time series model to the consumer price index (CPI) in Nigeria's Inflation rate between 1980 and 2010 and provided five years forecast for the expected CPI in Nigeria. The Box-Jenkins Autoregressive Integrated Moving Average (ARIMA) models was estimated and the best fitting ARIMA model was used to obtain the post-sample forecasts. It was discovered that the best fitted model is ARIMA (1, 2, 1), Normalized Bayesian Information Criteria (BIC) was 3.788, stationary $R^2 = 0.767$ and Maximum likelihood estimate of 45.911. The model was further validated by Ljung-Box test (Q = 19.105 and p>.01) with no significant autocorrelation between residuals at different lag times. Finally, the five years forecast was made, which showed an average increment of about 2.4% between 2011 and 2015 with the highest CPI being estimated as 279.90 in the 4th quarter of the year 2015.*

KEYWORDS: ARIMA, ACF, Box and Jenkins, CPI**,** CBN, PACF,

INTRODUCTION

Inflation is considered to be a major economic problem in transition economies and thus fighting inflation and maintaining stable prices is the main objective of monetary authorities like CBN. The negative consequences of inflation are well known, it can result in a decrease in the purchasing power of the national currency leading to the aggravation of social conditions and living standards. High prices can also lead to uncertainty making domestic and foreign investors reluctant to invest in the economy. Moreover, inflated prices worsen the country's terms of trade by making domestic goods expensive on regional and world markets.

To develop an effective monetary policy, Central Bank of Nigeria (CBN) should possess information on the economic situation in the country, the behaviour and interrelationships of major macroeconomic indicators. Such information would enable the Central Bank to predict future macroeconomic developments and to react in a proper way to shocks the economy is subject to. Thus, studying inflationary processes is an important issue for monetary economists all around the world. Conducting monetary policy is a difficult process because monetary policy affects the economy with a lag. Achieving goals requires some ability to peep into the future. Consequently, decision makers must make forecasts to help in decision-making. To conduct these forecasts, most central banks take a number of variables into account.

However, it is not an easy task, especially in developing countries, where economic processes are highly unstable and volatile. Moreover, the macroeconomic data on developing countries can be unreliable due to many reasons: measurement error, imperfect methods of measuring, etc. Nevertheless, there exist a number of empirical studies on inflation factors in developing countries. These studies show that inflation is a country-specific phenomenon, and its determinants differ across countries. Therefore, an effective monetary policy depends largely on the ability of economists to develop a reliable model that could help understand the ongoing economic processes and predict future developments. In this regard, this study is important since it is aimed at forecasting CPI, which is a component of inflation in the Nigeria economy. Consumer price index (CPI) is a measure that examines the weighted average of price of a basket of consumer goods and services, such as transportation, food and medical care; it is one of the most frequently used statistics for identifying period of inflation or deflation.

This paper therefore seeks to fit an ARIMA model to the quarterly data on Nigeria Consumer Price Index (CPI) from 1980 – 2010. The paper shall also provide five years forecast as well as the percentage increase or decrease within the forecast period. ARIMA model is used because of its generality, it can handle many series regardless of stationarity or not, with seasonal or without seasonal elements. The paper is structured as follows; the introduction is presented in section one, section two presents the modeling and methodology. The empirical results are presented in section three, section four dealt with the fitting the model and forecasting while the last section discussed the result obtained and the recommendation.

METHODOLOGY

Model Specification

The model used in this study is the ARIMA proposed by Box and Jenkins (1976). The preliminary test for stationarity and seasonality of the data was conducted in which differences (d) as well as natural log were taken. After the stationarity of the series was attained, ACF and PACF of the stationary series are employed to select the order p and q of the ARIMA model. At this stage, different series are manifested and their parameters are estimated using the maximum likelihood method. Based on the principle of parsimony and model diagnostic tests, we obtained the best fitting ARIMA model.

Source of Data

The data used in this research work was extracted from the Central Bank of Nigeria bulletin (December, 2011 and the 3rd quarter of 2012, i.e. September, 2012 Edition). It is the monthly data of consumer price indices for all items (weight is 1000) AI1000, in Nigeria from 1980 – 2012.

Method of Estimation: ARIMA Methodology

The Box – Jenkins model building techniques consist of the following four steps:

Step 1: Preliminary Transformation: if the data display characteristics violating the stationarity assumption, then it may be necessary to make a transformation so as to produce a series compatible with the assumption of stationarity. After appropriate transformation, if the sample autocorrelation function appears to be non-stationary, differencing may be carried out.

Step 2: Identification: if $\{y_t\}$ is the stationary series obtained in step 1, the problem at the identification stage is to find the most satisfactory ARIMA (p,q) model to represent $\{y_t\}$. Box – Jenkins (1976) determined the integer parameters (p,q) that governs the underlying process $\{y_t\}$ by examining the autocorrelations function (ACF) and partial autocorrelations (PACF) of the stationary series, $\{y_t\}$. This step is not without some difficulties and involves a lot of subjectivity, hence it is useful to entertain more than one structure for further analysis. Salau (1998) stated that this decision can be justified on the ground that the objective of the identification phase is not to rigidly select a single correct model but to narrow down the choice of possible models that will then be subjected to further examination.
Step 3: Estimation of the model: This deal with estimation of the tentative ARIMA model identified in step 2. The estimation of the model parameters can be done by the conditional least squares and maximum likelihood.
Step 4: Diagnostic checking: Having chosen a particular ARIMA model, and having estimated its parameters, the adequacy of the model is checked by analyzing the residuals. If the residuals are white noise; we accept the model, else we go to step 1 again and start over.

EMPIRICAL RESULT

In this section the ARIMA modeling strategy discussed in section 2.3 is applied to analyze the data on consumer price index (CPI). In this framework, model building commences with the examination of the plot of the series, the second logged different plot, and sample plot of the autocorrelation (ACF), partial autocorrelation (PACF), model description and forecast value using the fitted model. As in the first step of the Box – Jenkins, we tested for stationary in the data on CPI, (see fig 3.1). An examination of Fig 3.1 clearly revealed that non statationarity is inherent in data, after second differencing and taking Natural logarithm of the series, (see fig 3.2); we observed that the data on the chart was stationary. From a close observation of the ACF and PACF of the second logged differenced series, we noticed that the ACF show significant peak at lag (1, 8), for the PACF plot, it is observed that it cut off at lag (1,2,3). This implies that the stochastic process that generate the second logged differenced of the average CPI rate data is an ARMA model which has at most an MA (3) component. Hence, a number of possible models manifest themselves; these are ARMA (1,‖ 1,2,3), ARMA(8,‖ 1,2,3) i.e, ARIMA (1,2,1), ARIMA (1,2,2), ARIMA (1,2,3), ARIMA (8,2,1), ARIMA (8,2,2), ARIMA (8,2,3). We proceeded to further statistical analysis with the six possible models; we summarized the result in Table 3.1.

Figure 3.1: Time Series plot of CPI rate in Nigeria Economy (1980–2010)

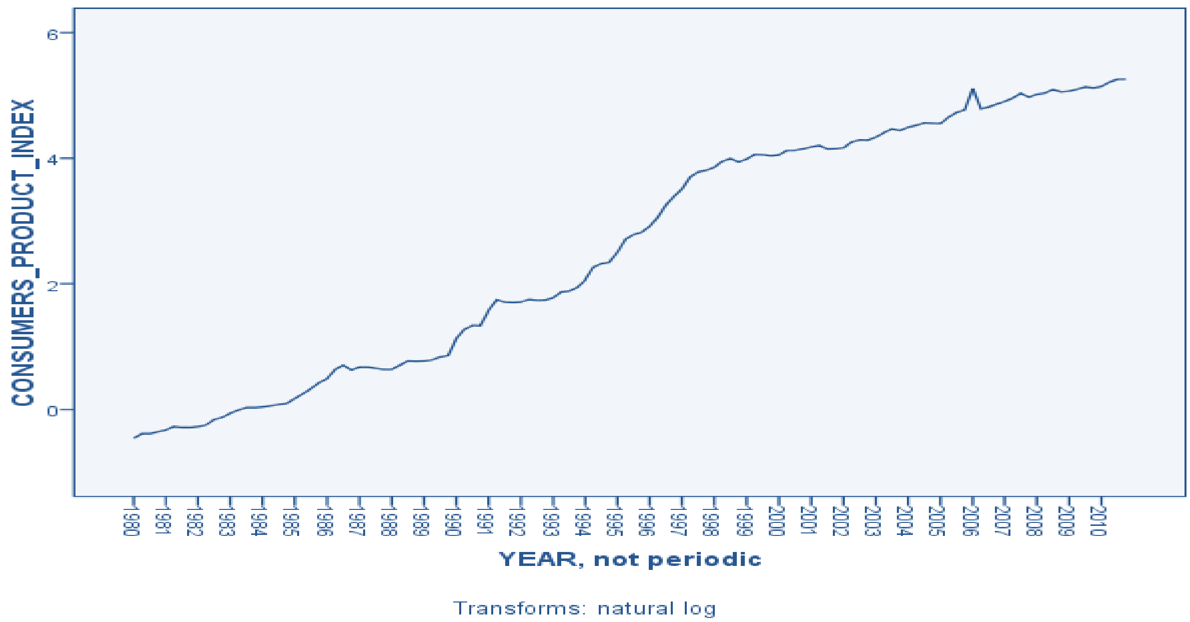


Figure 3.2: Time Series plot of second logged difference

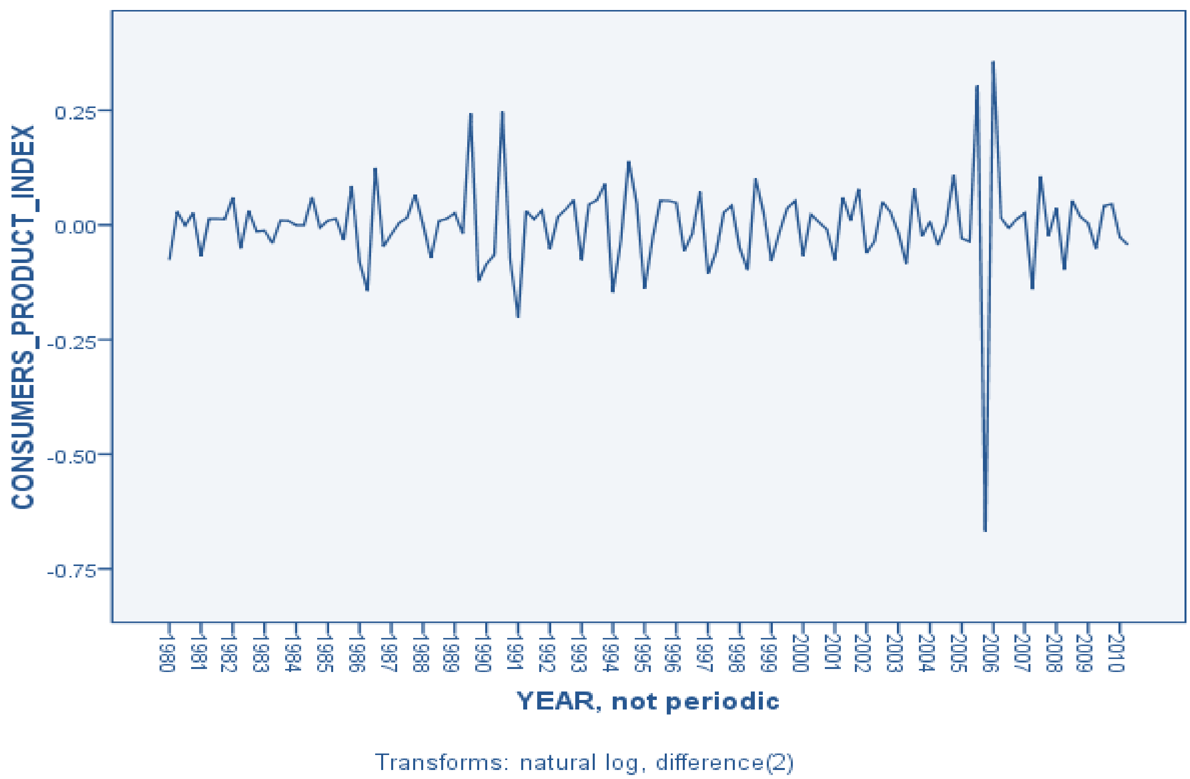


Figure 3.3: ACF of the second logged difference of Inflation rate in Nigeria Economy

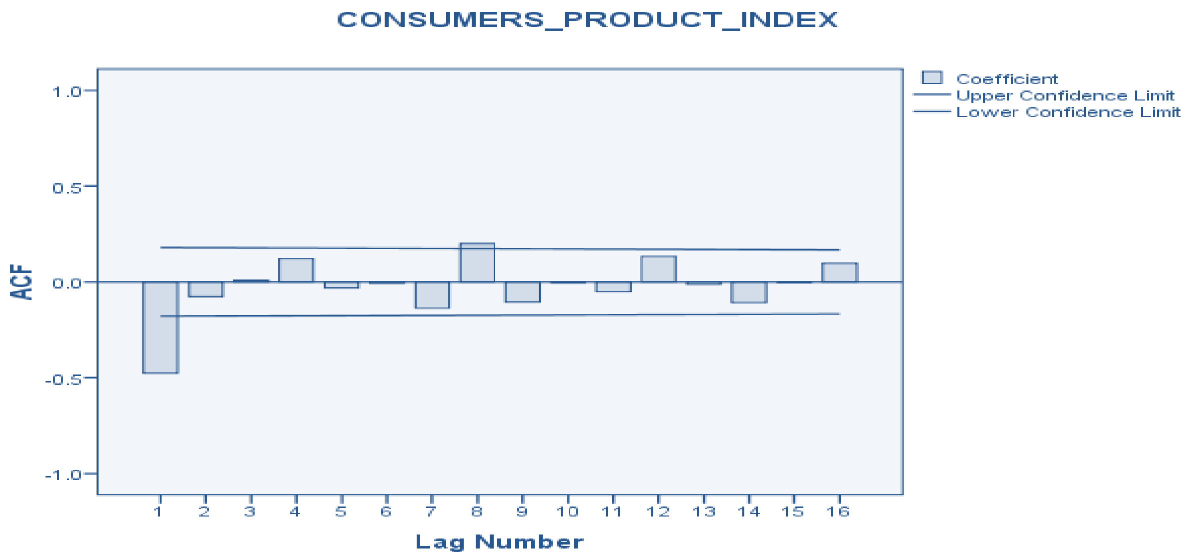


Figure 3.4: PACF of the second logged difference of Inflation rate in Nigeria Economy

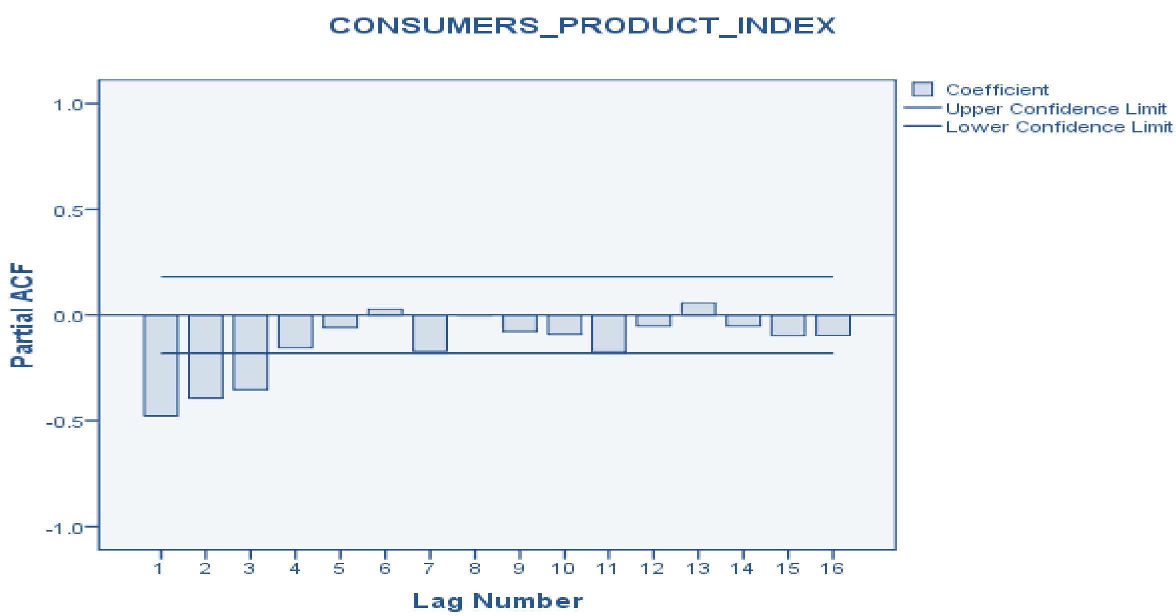


Table 3.1: Model Description

ARIMA STRUCTURE	Parameter Estimate	P-value	Stationary R^2	Likelihood & BIC	Standard of Error Estimate	Q-Statistics
ARIMA (1,2,1)	AR{1} = -0.382 MA{1}=-0.999	0.023† 0.397	0.767	45.911 BIC=3.788	0.089 1.175	19.105 (0.263)
ARIMA (1,2,2)	AR {1}=-0.536 MA{1}= 0.792 MA{2}= 0.205	0.015† 0.136 0.527	0.697	45.468 BIC=3.870	-2.457 1.503 0.634	23.862 (0.067)
ARIMA (1,2,3)	AR {1} =-0.941 MA{1} = 0.619 MA{2} = 0.885 MA{3} =-0.505	0.045† 0.352 0.259 0.130	0.733	48.614 BIC=3.789	0.465 0.663 0.780 0.332	14.415 (0.419)
ARIMA (8,2,1)	AR {1} = 0.000 AR {2} =-0.309 AR {3} =-0.171 AR {4} =-0.131 AR {5} =-0.048 AR {6} = 0.137 AR {7} = 0.040 AR {8} = 0.082 MA{1} = 0.995	0.000‡ 0.023† 0.242 0.375 0.738 0.322 0.742 0.426 0.000‡	0.742	48.335 BIC=3.998	0.109 0.134 0.145 0.147 0.144 0.138 0.123 0.102 0.249	13.297 (0.150)

ARIMA (8,2,2)	AR {1} =-1.093 AR {2} =-0.280 AR {3} = 0.086 AR {4} =-0.178 AR {5} =-0.221 AR {6} = 0.392 AR {7} = 0.301 AR {8} = 0.122 MA{1} = 0.202 MA{1} = 0.795	0.022† 0.593 0.873 0.711 0.590 0.242 0.202 0.310 0.913 0.577	0.712	45.379 BIC=4155	0.469 0.522 0.539 0.481 0.409 0.333 0.235 0.120 1.833 1.420	15.730 (0.046)
ARIMA (8,2,3)	AR {1} =-1.985 AR {2} =-1.807 AR {3} =-1.012 AR {4} =-0.651 AR {5} =-0.449 AR {6} =-0.114 AR {7} = 0.116 AR {8} = 0.118 MA{1} =-0.479 MA{2} = 0.736 MA{3} = 0.743	0.001‡ 0.023† 0.069 0.159 0.289 0.762 0.656 0.358 0.955 0.953 0.906	0.747	47.675 BIC=4.075	0.554 0.781 0.551 0.459 0.421 0.376 0.260 0.128 8.547 12.51 6.273	12.497(0.085)

Notes: ‡ and † denote significant at the 1% and 5% levels respectively. Figures in parenthesis also denote P-values.

From Table 3.1, the ARIMA structure 1 seems to be the most competitive model. The parameter estimates are all significant, the value of its stationary R^2 is the highest and the Q statistics are also insignificant. The most important summary statistics for measure of goodness of fit are the R^2, likelihood function (for maximum likelihood estimation), standard error of estimate and the Q statistic. For a well-fitted model, the Q statistic is expected to be statistically insignificant. Another important criterion for checking the adequacy of a fitted model is the Normalized Bayesian Information Criteria (BIC). When considering several ARMA models, we choose the one with the lowest BIC. Based on these four important statistics and BIC, ARIMA structure 1 i.e. ARIMA (1,2,1) seems to provide the best satisfactory fit to the second logged differenced CPI rate. This model has the highest likelihood function and the smallest standard error of estimate among all the ARIMA structures considered. Besides, the Q statistics is statistically insignificant suggesting that the residuals do not suffer from autocorrelation.

Forecasting with the Fitted Models

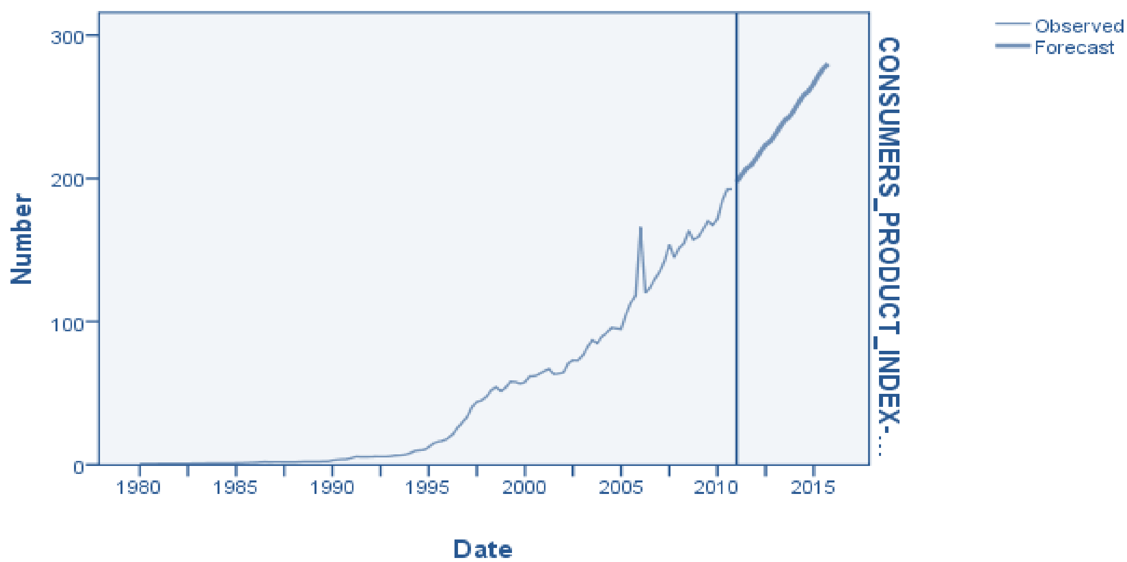
In time series modeling researchers are motivated by the desire to produce a forecast with minimum error as possible. In this section, we assess the forecasting performance of Box-Jenkins models. The traditional Box-Jenkins approach is general and can handle effectively many series encounter in reality. Besides, previous research has demonstrated that the Box-Jenkins forecast out performs the Holt-Winters and stepwise auto regression forecasts, (Newbold and Granger, 1974). In addition, Naylor, T.H. et al. (1972) also showed the Box-Jenkins method give better forecasts than traditional econometric methods. Forecast from ARIMA model can be computed directly from the ARIMA model equation by replacing, (1) future values of the error term by zero (2) future values of the y_t by their Forecasting CPI rate in Nigeria using Time Series Models. Conditional expectation (3) present and past values of y_t and ε_t by their observed values.

By applications of the procedures discussed above, we computed one-step ahead forecasts for the fitted mode, i.e. ARIMA (1,2,1). These quarterly forecasts and their 95% confidence interval i.e. Lower confidence limit (LCL) and upper confident limit (ULC) for 5 years (i.e. 2011 – 2015) are summarized in Table 4.1, while Figure 4.1 depicts the observed and forecast plots of CPI in Nigeria

Table 4.1: Forecasted value with the fitted model

YEARS	*QUARTERS*	*LUL*	*FORECAST*	*UCL*
2011	1st	185.52	197.67	209.82
2011	2nd	188.15	202.49	216.80
2011	3rd	189.83	206.99	224.14
2011	4th	189.95	209.24	228.53
2012	1st	192.39	213.74	235.09
2012	2nd	195.76	218.97	242.19
2012	3rd	198.56	223.54	248.51
2012	4th	199.34	225.98	252.62
2013	1st	202.39	230.65	258.85
2013	2nd	206.27	236.02	265.76
2013	3rd	209.52	240.73	271.94
2013	4th	210.71	243.33	275.95
2014	1st	214.13	248.13	282.12
2014	2nd	218.35	253.68	289.01
2014	3rd	221.93	258.55	295.18
2014	4th	223.41	261.31	299.20
2015	1st	227.13	266.25	305.39
2015	2nd	231.62	271.96	312.30
2015	3rd	235.46	276.96	318.52
2015	4th	237.20	279.90	322.60

Figure 4.1: The plot of the observed and forecast value of CPI rate in Nigeria



From the forecast value of the CPI rate presented in the table above, we can deduce that the CPI rate increased gradually all through the Period from the year 1990 –2010. Taken the forecast into consideration (2011, 2012 and 2013) we can deduce that the CPI rate also increased gradually through the period that was considered with an average increment of about 2.4%.

CONCLUSION AND RECOMMENDATION

From the research, it was known that the data was a quarterly data with the period of 1980 to 2010 and the data was extracted from the centre bank of Nigeria (CBN) bulletin. The paper examined the appropriate model that fits the inflation rate in Nigeria Economy between 1980 and 2010. It was discovered that ARIMA (1,2,1) is the most suitable model for the series with the Normalized Bayesian Information Criteria (BIC) of 3.788, stationary $R^2 = 0.767$ and Maximum likelihood estimate of 45911 and the Ljung-Box test ($Q = 19.105$ and $p>.10$) was also estimated. The ARIMA model revealed that the inflation rate in Nigeria Economy on core and food is moving gradually. Having had a critical study of the CPI rate in the Nigeria economy, we now profess some recommendations to the government.

Base on the monetary policy as part of the key variable used in this project i recommend that CBN needs to address the issue of policy transparency. Transparency tends to lower inflationary expectations by providing an implicit commitment mechanism on the part of the central bank. This way policy will become more credible and the public can now form expectations that are closer to the policy targets.

In addition, there is also need to increase central bank independence in order to reduce the effect of fiscal pressure on monetary policy. The conduct of domestic monetary policy is dictated or constrained by fiscal demands and the country becomes vulnerable to inflationary pressures of a fiscal nature. This has induced the creation of formal and informal indexation mechanism, which has led to inflation persistence. Widespread formal indexation is absent in Nigeria, but informal indexation is likely to exist. Wage and salary negotiations are infrequent in the public sector, which is still the largest employer in the country. In the private sector, trade unions negotiate for wage increases almost every year, which in a way provides an implicit wage indexation. One way of reducing these fiscal effects is to increase central bank independence.

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