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MODELLING NIGERIA'S URBAN AND RURAL INFLATION USING BOX-JENKINS MODEL

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Abstract

This is time series paper modelling Nigeria's urban and rural inflation using monthly CPI data from January 2001 to December 2015. Consumer Price Index (CPI) is a measure of the average change overtime in the prices of consumer items, that is, goods and services that people buy for day-to-day living. Box-Jenkins ARIMA Model was used to model 180 monthly CPI data and was forecasted to 29 CPI monthly data which actually fitted with two quarterly CPI data. The model identified that the data are dependent and not identically distributed, both the mean and variance are increasing through time. ARIMA (0, 1, 0), ARIMA (0, 1, 13) were selected and proved to be correct, residuals were showing insignificant auto-correlated residual and followed a normal distribution with mean zero and constant variance. This research finds of high inflation in urban and rural areas of Nigeria which serves as an indicator to the economy situation of Nigeria.

Key words**:** *consumer price index (CPI), time series, autoregressive integrated moving average (ARIMA), forecast*

INTRODUCTION

A consumer price index (CPI) measures changes in the price level of consumer goods and services purchased by households. The CPI uses data from survey of consumption pattern of households to produce a timely and precise average price change for the consumption sector of any economy like the Nigerian economy. The CPI is a statistical estimate constructed using the prices of a sample of representative items whose prices were collected periodically. It is one of several price indices calculated by most national statistical agencies. Inflation is a persistent rise in the general price levels of goods and services in an economy over a period of time. Inflation rate has been regarded as one of the major economic indicators in any country. Inflation is undeniably one of the leading and most dynamic macro-economic issues confronting almost all economies of the world [9]. It will be one of the obstacles for development and hurt people's living standard. The high inflation will also bring unemployment crisis and even social crisis. It has been pointed that core inflation has played an important role in the deliberations of monetary policymakers [13]. Upward or downward movements in CPI sometimes persist for a very long period and also tend to retrace back and forth. As a result, world economies witness periods of boom and recession or downturn. Consequently, it is of importance to analyze and forecast CPI.

Nigeria's CPI contains the following thirteen categories: All Items, All Items less Farm Produce, All Items less Farm Produce and Energy, Imported Food, Food, Food and Non Alcoholic Beverage, Alcoholic Beverage, Tobacco and Kola, Clothing and Footwear, Housing water, Electricity, Gas and Other Fuel, Furnishings and Household Equipment Maintenance, Health, Transport, Communication, Recreation and Culture, Education, Restaurant and Hotels and Miscellaneous goods and services. Many researchers and economists apply various time series and econometric models to forecast or model inflation rates of countries because of CPI importance to countries' economic growth. The dynamic and simultaneous interrelationship between inflation and its determinants – growth rate of Gross Domestic Product (GDP), growth rate of money supply (M2), fiscal deficit, exchange rate (U.S dollar

to Naira), importance and interest rates was determined using econometric time series model [8]. This study will not just research on composite CPI data rather will look at urban and rural CPI data as to have an in-depth understanding for good forecast. The error levels will be critically assessed to select the best which will guide prediction and policy formulation and implementation in Nigeria. At the end of this research, this study would provide answer to the following question; 1. What is the model for Nigeria urban and rural inflation? The main objective of this study is to model and forecast Nigeria inflation rate with Box-Jenkins ARIMA Model using urban and rural CPI of 2001-2015. Other specific objectives of the study are as follows;

1.Model identification/selection for urban and rural CPI data.

2.Model estimation for urban and rural CPI data.

3.Model checking/diagnostic for urban and rural CPI data.

4.Predicting and forecasting urban and rural inflation.

Factors affecting inflation in Nigeria had been examined using cointegration and descriptive statistics and were observed to have variations in the trend pattern of inflation rates and some variables considered were significant in determining inflation in Nigeria [9]. These variables include annual total import, annual consumer price index for food, annual agricultural output, interest rate, annual government expenditure, exchange rate and annual crude oil export.

Therefore, this study uses expert modeller in selecting the best fitted model for Nigeria urban and rural CPI that will serve as an indicator of rate of inflation, used to adjust wages to compensate for lost purchasing power due to inflation, used to convert a price or wage to a real price or real wage to show the equivalent amount in a base period after adjusting for inflation. Though this work was on Nigeria Urban and Rural All Items Consumer Price Index (NURAICPI) data, the comparisons are also relevant to other situations where data contain a trend, seasonal, or other cyclic, pattern, for example in geology [11], biology [1], atmospheric science [12] [5] [4].

MATERIALS AND METHODS

The study was conducted in Nigeria. Nigeria is located at the extreme inner corner of the Gulf of Guinea on the west coast of Africa, occupies an area of 923,768 sq. km (356,669 m^2), extending 1,127 km (700 m) East-West and 1,046 km (650 m) North-South with total population of 184,635,279 people [10]. It has 36 states and FCT Abuja. Its currency is Naira. Consumer Price Index Data of urban and rural Nigeria All Items for the period of January 2001 to December 2015 were collected from National Bureau of Statistics publication as at March 2016 [6]. It is a monthly time series data. The sample size of 180 was used. Statisticians George Box and Gwilym Jenkins developed a practical approach to build ARIMA model, which best fit to a given time series and also satisfy the parsimony principle.

$$\phi(B)\Phi(B)\nabla^d\nabla_S^D Y_t = \theta(B)\Theta(B)a_t \quad (1)$$

$$X_t = \nabla^d\nabla_S^D Y_t \quad (2)$$

Box-Jenkins Model was used to make sure data is stationary (check a time plot. If not, differentiate), used ACF & PACF, guess small values for p & q, estimate order p, q and run diagnostic tests on residuals. Also whether there is noise, If not, add lags (p or q, or both). Then if order choice not clear, use AIC, AIC Corrected (AICc), BIC, or HQC.

RESULTS AND DISCUSSIONS

This study is to model Nigeria's urban and rural inflation rate from 2001-2015 CPI data using Box-Jenkins' model. The model fitting of this data can provide a better understanding of the dynamics of Nigerian economy through solid underlying theory, stable estimation of time-varying trends, relatively few parameters and the summary Statistics (Table 1).

The NURAICPI time series plot indicates local trends from 2001 to 2015 and a general most likely linear upward trend from 2001 to 2015 (Fig. 1).

The positive significant skewness of 0.329 for urban CPI and 0.417 for rural CPI suggest that NURAICPI is a normal distribution and right skewed. Kurtosis measures the extent to which observations cluster around a central point. The value of the kurtosis statistic is zero for a normal distribution. Negative kurtosis of -1.073 for UCPI and -1.117 for RCPI indicates that, relative to a normal distribution, the observations cluster less and have thicker tails.

Table 1. Summary of descriptive statistics of NURAICPI data

	N	Mean	Std. Deviation	Skewness		Kurtosis	
	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic	Std. Error
UCPI	180	94.290	42.5968	0.329	0.181	-1.073	0.360
RCPI	180	95.911	42.5544	0.417	0.181	-1.117	0.360
Valid N (listwise)	180						

Source: Own determination.

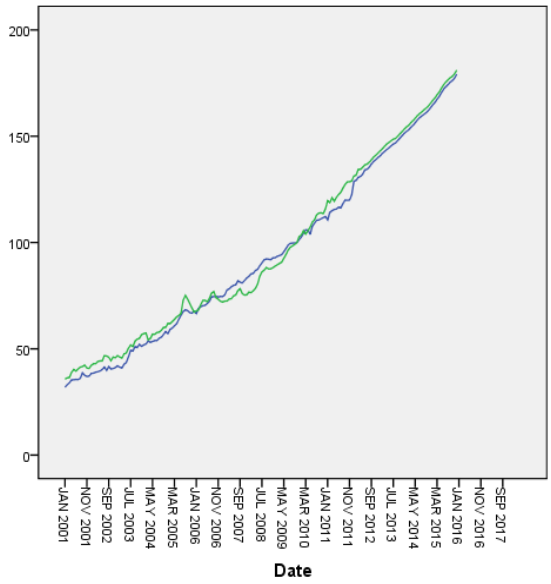

Fig. 1. Nigeria Urban and Rural Inflation Rate from2001-2015
Source: Own calculation

Model identification

The ACF and PACF do not tail off, but instead have values that stay close to 1 over many lags (Fig. 2, Fig. 3, Fig. 4 and Fig. 5). The series is non-stationary and differencing will be needed. First difference will be tried and then look at the ACF and PACF of the differenced data. Haven taken first differences the series become stationary and all autocorrelations are non-significant (Fig. 6, Fig. 7, Fig. 8 and Fig. 9). The series is now called a random walk. A possible model for a random walk is $x_t = \delta + x_{t-1} + w_t$. The data are dependent and are not identically distributed; in fact both the mean and variance are increasing through time.

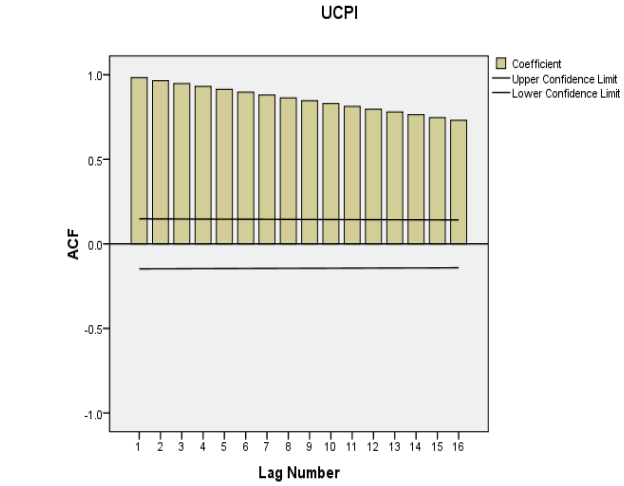

Fig. 2. UCPI ACF
Source: Own calculation

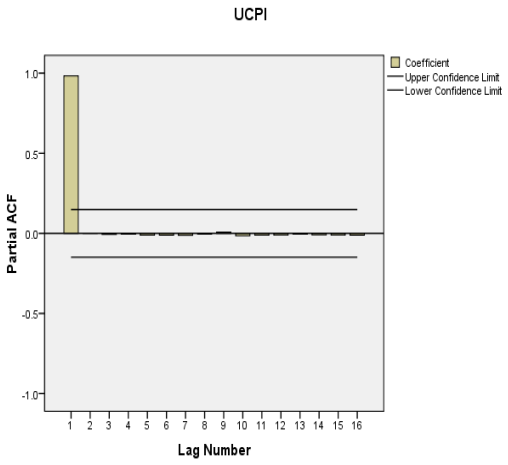

Fig. 3. UCPI PACF
Source: Own calculation.

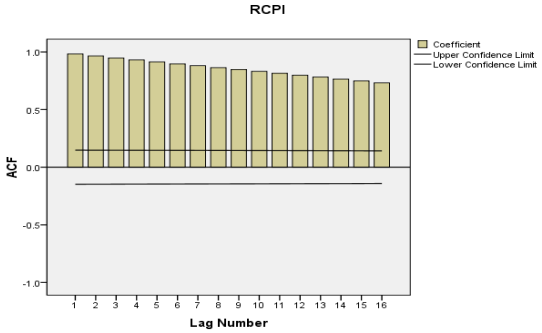

Fig. 4. RCPI ACF
Source: Own calculation.

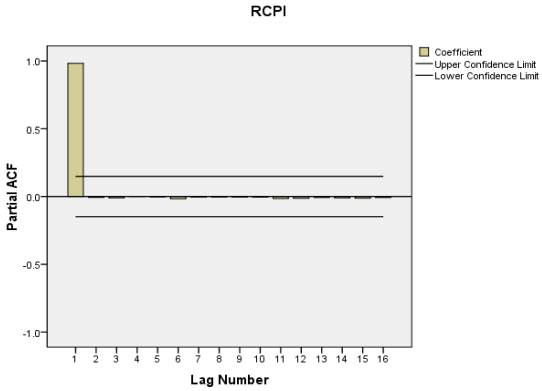

Fig. 5. RCPI PACF
Source: Own calculation.

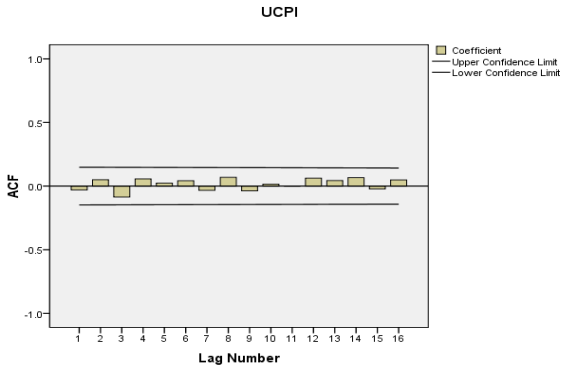

Fig. 6. UCPI differenced ACF
Source: Own calculation

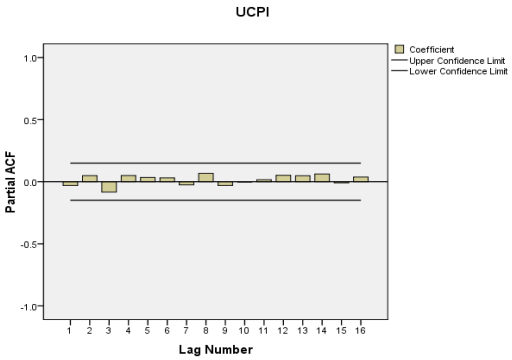

Fig. 7. UCPI differenced Partial ACF
Source: Own calculation

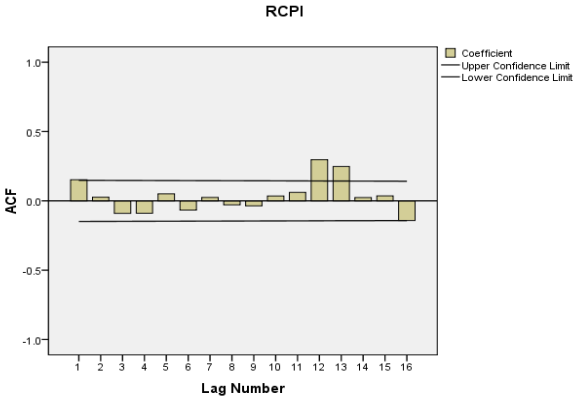

Fig. 8. RCPI differenced ACF
Source: Own calculation

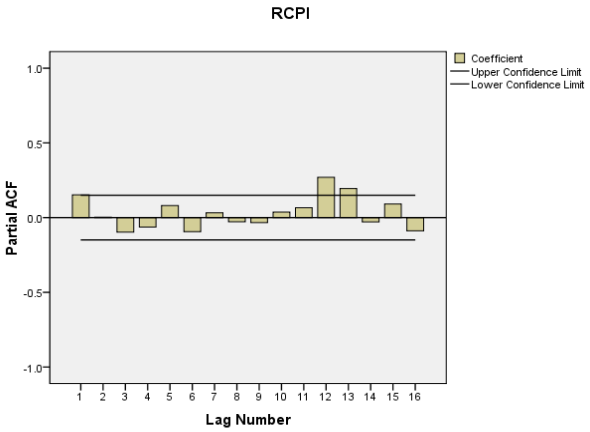

Fig. 9. RCPI differenced Partial ACF
Source: Own calculation.

Model estimation

At this stage the parameters of all the selected models that seem to provide statistically adequate representation of the available data were estimated by the maximum likelihood method as advocated by Box and Jenkins model using standard computer packages like SPSS 16.0 [2]. ARIMA (0, 1, 0), ARIMA (0, 1, 13), were selected by expert modeler (Table 2). For all these models values of R^2, RMSE, MAPE, MaxAPE, MAE, MaxAE and normalized BIC were calculated and compared.

Table 2. Result of the Model Description

			Model Type
Model ID	UCPI	Model_1	ARIMA(0,1,0)
	RCPI	Model_2	ARIMA(0,1,13)

Stationary R^2 value revealed the stationarity of the model. Further the value of Ljung-Box

Q (18) was compared to critical values from chi-square distribution. If model is correctly specified residuals should be uncorrelated and Q should be small (the probability value should be large). A significant value indicated that the chosen model did not fit well. All these criteria revealed that ARIMA (0, 1, 0) and ARIMA (0, 1, 13) were the best fitted models for forecasting of the CPI (Table 3).

There are various sets of rules to guide p and q fitting in lower order processes, but generally the statistical software was allowed to fit up to 12-14 orders for AR and MA, and suggest combinations that minimize an AIC or BIC criterion.

This part is as much as an art-form as it is a structured process. The goal during this phase is to minimize the AIC/BIC criterion. Positive values of Stationary R-squared (0.098) mean that the model under consideration is better than the baseline model.

R-squared (0.999) shows that 99.9% variation in UCPI and RCPI series is explained by the regression model and the model fit the model fit the data well.

RMSE (1.055) shows that UCPI and RCPI varies from its model-predicted level by ₦1.05k.

MAPE (1.012) indicates that UCPI and RCPI varies from its model-predicted level by ₦1.01k and can be used to compare series with different units.

The MaxAPE (6.551) indicates that 6.6% is largest forecasted error and show the worse-case scenario for the forecast.

MAE (0.734) indicates that UCPI and RCPI used 73k to vary from its model-predicted level.

MaxAE (5.579) indicates that the largest forecast error is ₦5.58k.

Normalized BIC (0.192) the overall model shows the overall fit of the model that attempts to account for model complexity and well fitted.

It is a score based upon the mean square error and includes a penalty for the number of parameters in the model and the length of the series.

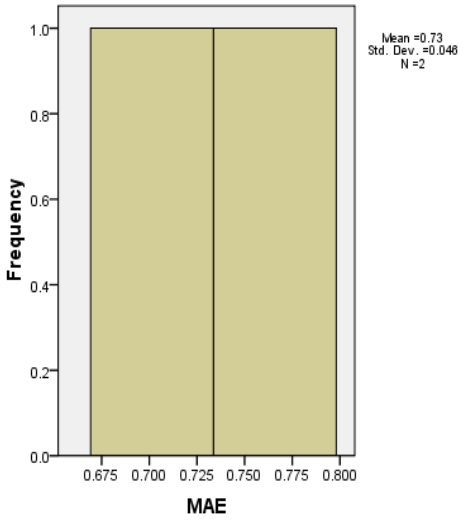

Fig. 10. Mean Absolute Error
Source: Own calculation.

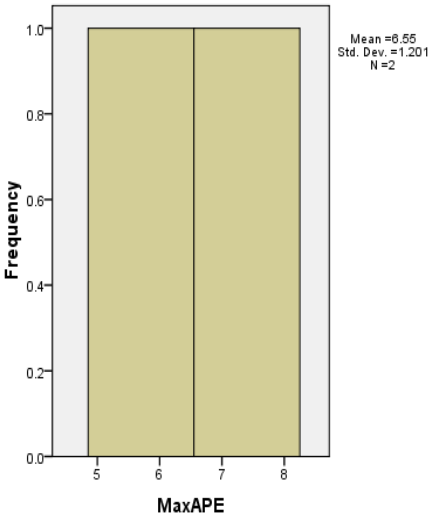

Fig. 11. Maximum Absolute Percentage Error
Source: Own calculation.

Diagnostic Checking

Some residual analysis was done to test for the goodness of fit (Fig. 12 and Fig. 13). Boxplot histogram residual ACF and PACF and their correlogram were analyzed (Fig.14). The model is correct, since the residuals were uncorrelated and followed a normal distribution with mean zero and constant variance. Secondly the model is adequate since, the autocorrelations of the residuals were not significantly different from zero i.e. Most of the sample autocorrelation coefficients of the residual are within the limits $\pm 1.96/\sqrt{N}$ where N is the number of

observations upon which the model is based then the residuals are white noise indicating that the models are correct and are good fit.

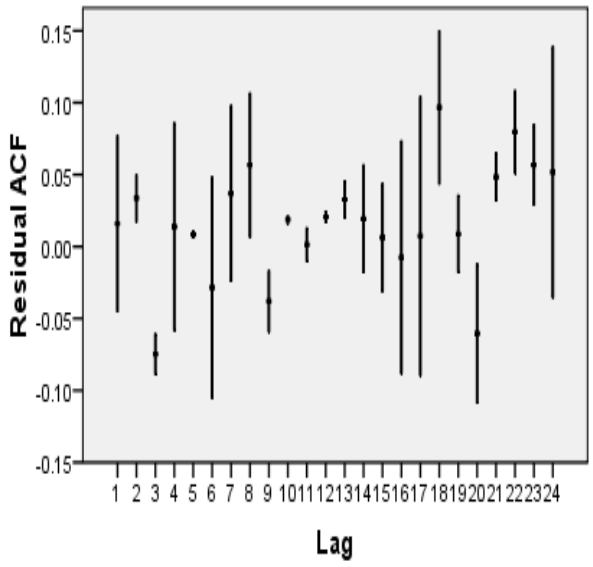

Fig. 12. Residual ACF
Source: Own calculation.

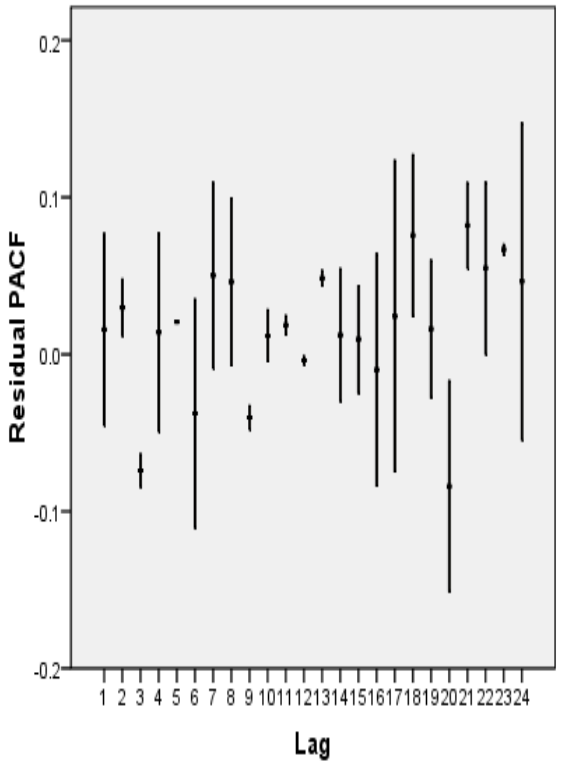

Fig. 13. Residual PACF
Source: Own calculation.

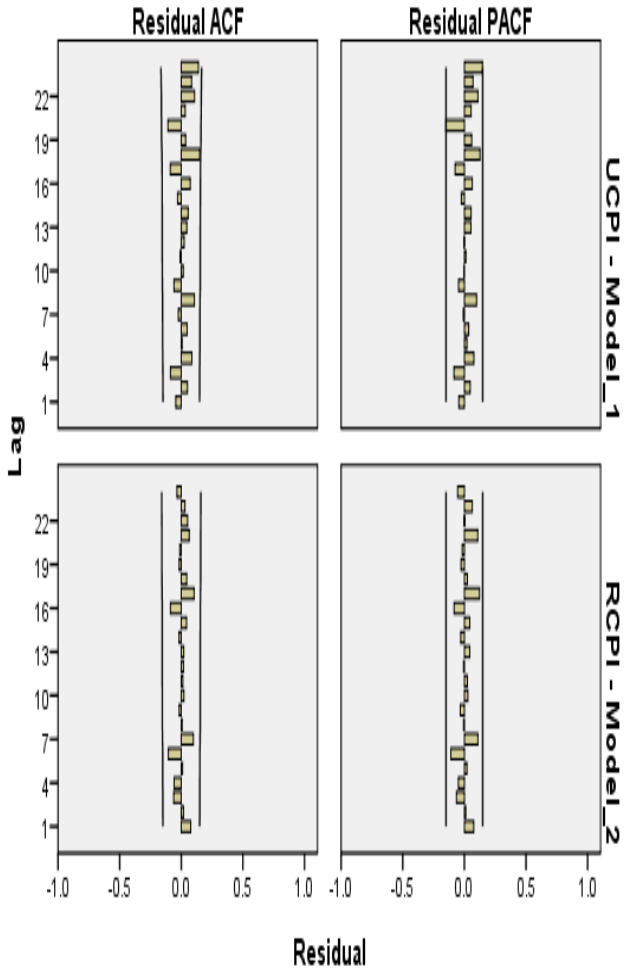

Fig. 14. Residual Histogram.
Source: Own calculation.

Forecasting

Since the models are assured to be stationary and fitted such that there is no information in the residuals, forecasting is carried out. Forecasting assesses the performance of the model against real data. Usually the utility of a specific model or the utility of several classes of model to fit actual data can be assessed by minimizing a value of such as root mean square (Table 3).

Table 3. Presents the forecast from January 2016 to May 2018 and it fitted the actual series.

	Forecast Model		UCL Model		LCL Model	
	UCPI-Model_1	RCPI-Model_2	UCPI-Model_1	RCPI-Model_2	UCPI-Model_1	RCPI-Model_22
Jan 2016	180.0	182.1	181.9	184.3	178.0	179.9
Feb 2016	180.8	183.0	183.5	186.2	178.0	179.9
Mar 2016	181.5	184.1	184.9	187.9	178.1	180.2
Apr 2016	182.3	185.1	186.2	189.5	178.4	180.6
May 2016	183.1	186.1	187.4	191.1	178.7	181.2
Jun 2016	184.6	187.3	189.3	192.7	179.8	181.9
Jul 2016	185.3	188.8	190.5	194.7	180.2	183.0
Aug 2016	186.1	189.6	191.6	195.9	180.6	183.4
Sep 2016	186.9	190.5	192.7	197.1	181.0	183.9
Oct 2016	187.6	191.2	193.8	198.2	181.4	184.3
Nov 2016	188.4	192.1	194.9	199.4	181.9	184.8
Dec 2016	189.2	193.2	195.9	200.8	182.4	185.5
Jan 2017	189.9	194.1	197.0	202.2	182.9	186.0
Feb 2017	190.7	194.9	198.0	203.6	183.4	186.1
Mar 2017	191.5	195.6	199.0	204.9	183.9	186.3
Apr 2017	192.2	196.4	200.0	206.3	184.4	186.5
May 2017	193.0	197.1	201.0	207.5	184.9	186.7
Jun 2017	194.5	197.9	202.8	208.8	186.2	187.0
Jul 2017	195.3	199.4	203.8	210.8	186.7	188.0
Aug 2017	196.0	200.1	204.8	212.0	187.3	188.3
Sep 2017	196.8	200.9	205.7	213.2	187.8	188.6
Oct 2017	197.6	201.7	206.7	214.4	188.4	188.9
Nov 2017	198.3	202.4	207.7	215.5	188.9	189.3
Dec 2017	199.1	203.2	208.7	216.7	189.5	189.6
Jan 2018	199.8	203.9	209.6	217.8	190.1	190.0
Feb 2018	200.6	204.7	210.6	219.0	190.7	190.4
Mar 2018	201.4	205.4	211.5	220.1	191.2	190.8
Apr 2018	202.1	206.2	212.5	221.2	191.8	191.2
May 2018	202.9	207.0	213.4	222.3	192.4	191.6

Source: Own calculation.

CONCLUSIONS

The NURAICPI data have been fitted with Box-Jenkins ARIMA model successfully with the urban inflation model is ARIMA(0,1,0) while the rural inflation model is ARIMA(0,1,13) (Table 2). The upward trend of CPI from 2001-2015 and positive significant skewness proves the report that Nigeria inflation rate hits 16.5% in June 2016 which is highest in almost 11 years [7]. As at June 2016, inflation rate hits 16.5% year-on-year from 15.6% May 2016 and 1.7% month-on-month from 2.8% May 2016. Urban index hits 18.1% year-on-year from 17.1% May 2016, 2.9% month-on-month from 2.2% May 2016. While rural index hits 15.1% year-on-year from 14.3% May 2016, 2.5% month-on-month from 1.4% May 2016.

The fluctuation in food prices lead to variation of wages. The trend in urban CPI and rural CPI can be said that economic policies, activities, implementation of policies, budgets, etc of government administration influence inflation rates in Nigeria. Economists have confirmed that an expansionary budgetary provision cum other factors increase inflation rates [3]. November 2006 and July 2008 shows trend in urban CPI and rural CPI while there is a persistence increase inflation rate from July 2013 which might be caused by transition in government, economic policies, withdrawals of foreign investors etc. (Fig. 1).

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