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Arma Modelling And Forecasting Of Nigerian Inflationary Index From 1961 – 2019

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Abstract
This paper shows the descriptive, prediction and the prescription of inflationary position in Nigeria using univariate annual time series data on inflation from 1961 to 2019, to model and forecast inflation rate with Box – Jenkins ARMA technique. Diagnostic tests indicate that the inflationary series are stationary at I(0). The model was further validated with the equation ($\alpha(B)x_t = \beta(B)\mathcal{M}$ and $p > 0.05$) with statistical significant, autocorrelation between residuals at different lag times and standard error bound. The effect of inflation within the time was rightly specified in their magnitude and dimension. Finally, five (5) years forecast was made, which showed an average increment of about 2.4% between 2019 and 2024 with the highest inflationary index being estimated as 13.10 in the year 2024. The following recommendation among others are made to avoid the plague of double digit inflation for a proper manageable single digit inflationary rate in Nigeria against persistence records we have in the document analysis, 1. That CBN should improve on the monetary policy particularly price stability and stabilizes the economy through sales of treasuring bills, certificates and other money market instruments to cushion money flow and stock in the system.

Keywords: ARMA, Forecasting, Inflation Modelling, Index and Nigeria

INTRODUCTION

The behavior of price in an increasing manner at general price level is referred to as inflationary taking cognized of the computational index of both consumer price, producer price indices and for an implicit case retail price index. In many fora of economic discourse and points of empirical outcome, inflation definitions seen to have agreement across board and centered on persistent upward in price of goods and services. Inflation is the most concepts that militant against money [12].

John Maynard Keynes in his General theory of employment, interest and money opted that inflation is occasion during full employment while Millton Friedman had tide inflation on issues of money supply [2], [12]. Inflation is the continuing rise in prices as measured by an index such as the consumer price index (CPI) or the implicit price deflator for gross national product [10].

Inflationary data could be in any of the form of time series. The time series conditioning values are correlated in time. This tendency is called autocorrelation. A time series is said to be stationary if and only if, it has a constant mean and variance. Moreover, the autocorrelation is a function of the lag separating the correlated values called the autocorrelation function (ACF), [9]. Modeling is the structural alignment of a set of problem using scientific method of mathematics and statistics techniques in the application. Description of how the situation functions. In the words of modeling is a translation of a set of beliefs into the language of mathematics [7].

Structural aspect of model building, anchored on the précised beliefs which could be tested hypothetically through a set of equation(s) with detail information on the subject matter then estimation before usage. ARIMA modeling projects the use of AR (Autoregressive) and MA (Moving Average) techniques (models) in the estimation of inflation in Nigeria at the level of this work. However, ARIMA or ARMA regressed on itself as it is a single variable case.

Statement of the Problem

Inflationary condition had been problem in Nigeria and indeed the world [14]. This condition had trouble economic system such that, inspect of the central Bank of nations' management strategy on core function such as, price stability; inflation is still not in its manageable form, in two-third countries of world. The Nigerian economy had suffered all forms of inflation including

the \hyper and running inflations and now settled in the working class, of inflation. However, it is possible for a manageably near free inflationary system, below creeping class of inflation in Nigeria as it is in some selected developed economy of single digit.

The Purpose of the Study

The main thrust of this paper is to apply autoregressive integrated moving average ARIMA or autoregressive integrated moving average ARMA in modeling, estimating and forecasting, within the context of the Nigerian economy of inflationary index, 1961 - 2019. Specifically put, is to:

1. ascertain the trend of, inflation in Nigeria.
2. establish the effects of inflation rate on the Nigerian economy.

Statement of the Hypotheses

H_1: There is no significant difference in inflation rates in Nigerian.

H_2**:** Inflation rates has no significant effect on the Nigeria economy

Limitation of the Study

This paper centered on the inflationary position of Nigeria and seeks to find out possible position through a fundamental descriptive statistic of mean, to predict and prescript method on the inflationary position in Nigeria within the study period.

Significant of the Study

The study practically base on ARMA Modelling and Forecasting of Nigerian Inflationary Index From 1961–2019. The motive of this study is to help educate young researchers on ARMA Modelling and Forecasting of Nigerian Inflationary Index. And to predict possible inflationary position of Nigerian in the next three years.

LITERATURE REVIEW

Stated and wildly believe that, in an inflationary economy, pareto concepts narrowly operate without such introduction and control. Some people are better off and others are worse off. Obafemi and Ifere, had rightly put, inflation mostly affect people with low and constant income, negatively and people with flexible income, positively [12].

Wiri investigate Seasonal Autoregressive Integrated Moving Average (SARIMA) in modelling inflation rate in Nigeria between January 2003 to December 2016. The study adopts both time plot and correlogram of the original series to revealed seasonality of order 12. Five models were estimated and the best model of the minimum Akaike information criterion (AIC) (SARIMA (011), $(211)_{12}$) with AIC of (3.320166) [14]. The plot of the residual correlogram show adequacy of the model. The model is adequate since there is no spike that cut the level of the correlogram and the histogram of the residual is normally distributed with probability values (0.000026) in table (4.10).The test statistics of the residual show that the data is normally distributed with constant mean and variance (White noise Process). A one-year (12 months) forecast from January 2017 to December 2017 is based on the best fitted model.

Anidiobu, Okolie, and Oleka, assessed the analysis of Inflation and Its Effect on Economic Growth in Nigeria using a yearly data set for time 1986 – 2015, from the Central Bank of Nigeria (CBN) Statistical Bulletin. The study employed ex-post research design. Ordinary Least Square (OLS) technique was used to estimate the variables, Inflation Rate (INFR), Interest Rate (Interest Rate) and Exchange Rate (EXCHR) made up the independent variables. Statistical outcomes were interpreted based on a 5 percent level of significance. The regression results indicated that INFR had a positive and non-significant effect on economic growth (measured by RGDP) in Nigeria for the period studied. The study recommended that government should adopt tight monetary policy measures to stabilize tide of inflationary pressures on our economy [3].

Investigating the effects of inflation rate on economic growth in Nigeria using time series data for the time 1986 – 2014 sourced from CBN Statistical Bulletin. The ADF econometric technique was used to determine the stationarity of the series, while Granger causality test was employed to ascertain the causal direction of dependent and independent variables. The study found out that inflation rate related negatively and significantly with economic growth. [4].

The act of assessing forecasted inflation using ARIMA models with quarterly data ranging over the period 1976 to 1998 in Ireland and illustrated some practical issues in ARIMA time series forecasting [13]. In Finland, forecasted consumer price inflation using Artificial Neural Network (ANN) models with a data set ranging over the period March 1960 – December 2009 and established that direct forecasts are more accurate than their recursive counterparts.

In Malaysia, analyzed the CPI using ARIMA models with a monthly data set ranging over the period January 2009 to December 2013 and revealed that the ARIMA (1, 1, 0) was the best model to forecast CPI in Malaysia [11]. In Zimbabwean study, examined inflation using GARCH models with a monthly data set ranging over the period July 2009 to July 2018 and established that there is evidence of volatility persistence for Zimbabwe's monthly inflation data. [13]. From the reviewed above, it was found that most of the studies adopt ARIMA, SARIMA, and GARCH statistics with particular interest to countries and study variables either by spitting inflation into indices of CPI and range

of time with short observable time, few consideration is under a year. This study is an inflationary aggregate of long span of years and proposed to adopt ARIMA or ARMA where necessary. However, all the previous studies to the best of the researchers' knowledge used very few observations in variable of choice with same statistics. Also the reviewed works and studies do not predict in a longitudinal form in spans as the study of forecast series assumed. This study laid claims to yearly inflationary flow to fifty-nine (59) series, forecasting and predictions for another five (5) years spans for policies for business and investment guides in Nigeria hence it is regarded relevance.

METHODOLOGY

This paper adopted the descriptive design. This is used because the paper seeks to find out the causes and effects of the variable. The design becomes necessary because the issue for investigation is empirical, quantitative and analytical in nature.

This research paper utilized a yearly time series data on inflation in Nigeria for period from 1961 to 2019 collected from Central Bank of Nigeria statistical journal,[6]. The model used is the ARMA proposed by (Box and Jenkins 1976 cited in Adams, Awujola, and Alumgudu 2014). A stationary time series $\{x_t\}$ is said to follow an autoregressive average model of orders p and q (designated) as ARMA (p,q)) if it satisfies the following difference equations. The Box – Jenkins model building techniques considered in the following steps: Step 1: Preliminary Transformation, Step 2: Identification, Step 3: Estimation of the model and Step 4: Diagnostic Checking.

$$x_t + \alpha_1 x_{t-1} + \alpha_2 x_{t-2} + \ldots + \alpha_p x_{t-p} = \beta_t + \beta_1 \mathcal{M}_{t-1} + \beta_2 \mathcal{M}_{t-2} + \ldots + \beta_q \mathcal{M}_{t-q} \ldots. \quad (e_1)$$

or

$$\alpha(B)x_t = \beta(B)\mathcal{M}_t \quad (e_2)$$

These conditional equations for either (e_1) or (e_2) justified the ARMA models of (p, q).

RESULT AND DISCUSSIONS

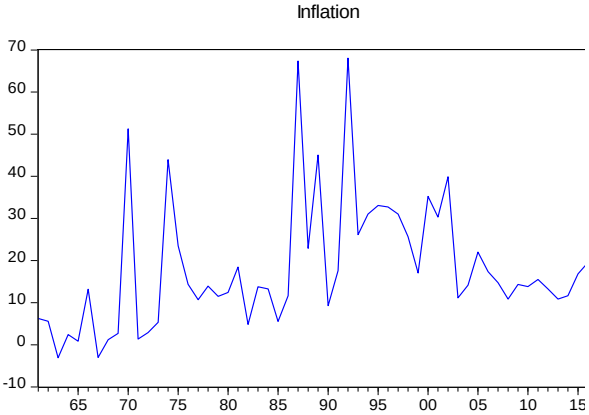


Figure 1. The time plot and trend

Where (β_t) is the white noise process and defined as a sequence of uncorrelated zero mean of random variables with constant variance in equation e_1. According Etuk (2013) seasonality refers to a tendency for a time series to fluctuate periodically. Hence many economic time series data are seasonal, fluctuating according to natural "seasons".

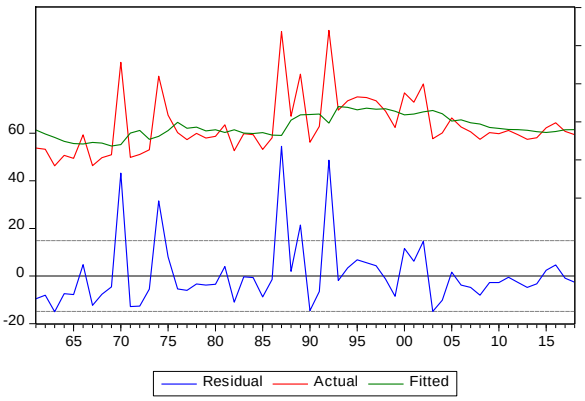
If p = 0, the model (1) or (2) becomes a moving average model of order q, designated MA(q). If, however, q = 0, the model (1) or (2) an autoregressive model of order p, designated AR(p). An autoregressive model of order p may be more specifically written as

$$x_t + \alpha_1 x_{t-1} + \alpha_2 x_{t-2} + \ldots + \alpha_p x_{t-p} = \beta_t \quad (e_3)$$

Assuming that s is the period of seasonality, a time series $\{x_t\}$ is said to follow a multiplicative (p, d, q) x (P, D, Q)s seasonal ARIMA. The equation of ARIMA (Autoregressive Integrated Moving Average) is conditions by the differential factor in the series. In the case of a non-stationary series $\{x_t\}$ differencing up to an appropriate order of stationary. The (d) representing the different order of stationary, is referred as the minimum order. The d^{th} difference of $\{x_t\}$ is denoted by $\{\Delta^d x_t\}$ where Δ^d is the difference operator defined by $\Delta^d = 1 - B$. If the series $\{\Delta^d x_t\}$ follows the model (e_1), then $\{x_t\}$ is said to follow an autoregressive integrated moving average model of order p, d and q designated as ARIMA (p, d, q).

Diagnostic Checking

The diagnosis of the model to the data that satisfied the test for goodness-of-fit, automatic order determination criteria AIC, Adj-R^2, $\square^2$ and SIC (Akaike Information Criterion Adjusted-Rsquare SIGMASQ(volatility) and Bayesian Statistics respectively), are applied to justified the model, where the Box and Jenkins1976 cited early suggest the least of all criteria. Other consideration are the test of residuals of the model to proves validity of the model, the residuals would be uncorrelated and would follow a normal distribution with mean zero and constant variance



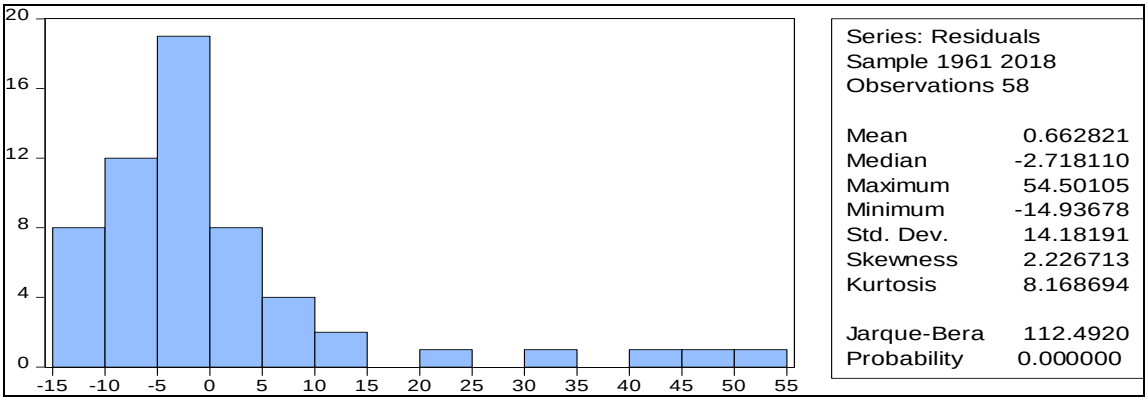
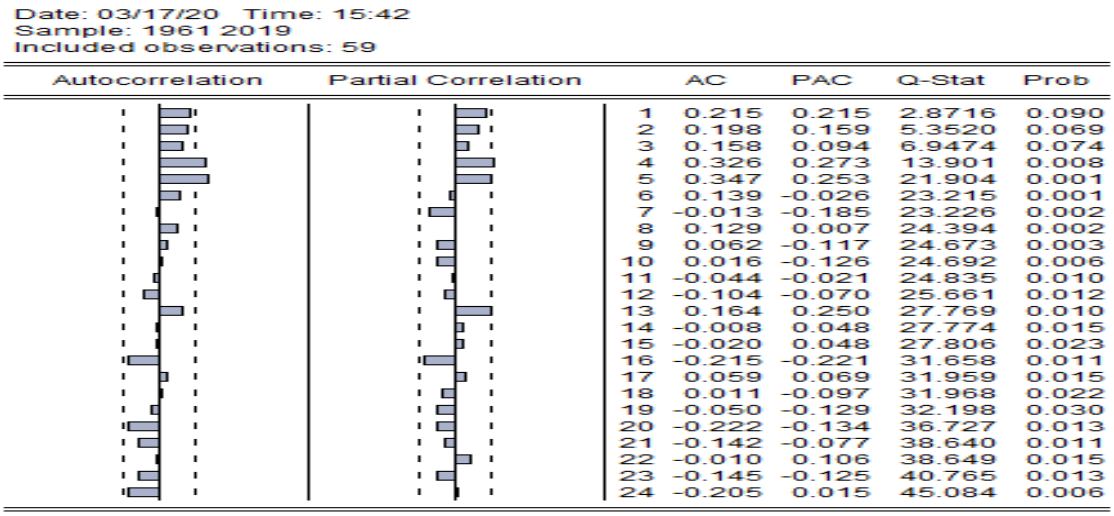


Figure 2. Histogram of the Resident



Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
		1	0.215	0.215	2.8716	0.090
		2	0.198	0.159	5.3520	0.069
		3	0.158	0.094	6.9474	0.074
		4	0.326	0.273	13.901	0.008
		5	0.347	0.253	21.904	0.001
		6	0.139	-0.026	23.215	0.001
		7	-0.013	-0.185	23.226	0.002
		8	0.129	0.007	24.394	0.002
		9	0.062	-0.117	24.673	0.003
		10	0.016	-0.126	24.692	0.006
		11	-0.044	-0.021	24.835	0.010
		12	-0.104	-0.070	25.661	0.012
		13	0.164	0.250	27.769	0.010
		14	-0.008	0.048	27.774	0.015
		15	-0.020	0.048	27.806	0.023
		16	-0.215	-0.221	31.658	0.011
		17	0.059	0.069	31.959	0.015
		18	0.011	-0.097	31.968	0.022
		19	-0.050	-0.129	32.198	0.030
		20	-0.222	-0.134	36.727	0.013
		21	-0.142	-0.077	38.640	0.011
		22	-0.010	0.106	38.649	0.015
		23	-0.145	-0.125	40.765	0.013
		24	-0.205	0.015	45.084	0.006

Figure 3. Correlogram of the Residuals
Source: Researchers' computation with Eviews 10.0

Table 1. **Model Estimation**

Dependent Variable: INFLATION
Method: ARMA Maximum Likelihood (OPG - BHHH)
Included observations: 59

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	17.91149	3.592982	4.985133	0.0000
AR(4)	0.328757	0.182844	1.798019	0.0781
AR(5)	-0.290981	0.173778	-1.674437	0.1002
AR(16)	-0.213151	0.275653	-0.773259	0.4429
MA(4)	-0.053324	0.281763	-0.189250	0.8506
MA(5)	0.933202	4.598870	0.202920	0.8400
MA(16)	-0.013475	0.089903	-0.149882	0.8814
SIGMASQ	133.6459	48.32421	2.765609	0.0079

R-squared	0.406253	Mean dependent var	18.01864
Adjusted R-squared	0.324758	S.D. dependent var	15.13174
S.E. of regression	12.43422	Akaike info criterion	8.157916
Sum squared resid	7885.106	Schwarz criterion	8.439616
Log likelihood	-232.6585	Hannan-Quinn criter.	8.267880
F-statistic	4.985017	Durbin-Watson stat	1.908338
Prob(F-statistic)	0.000238		

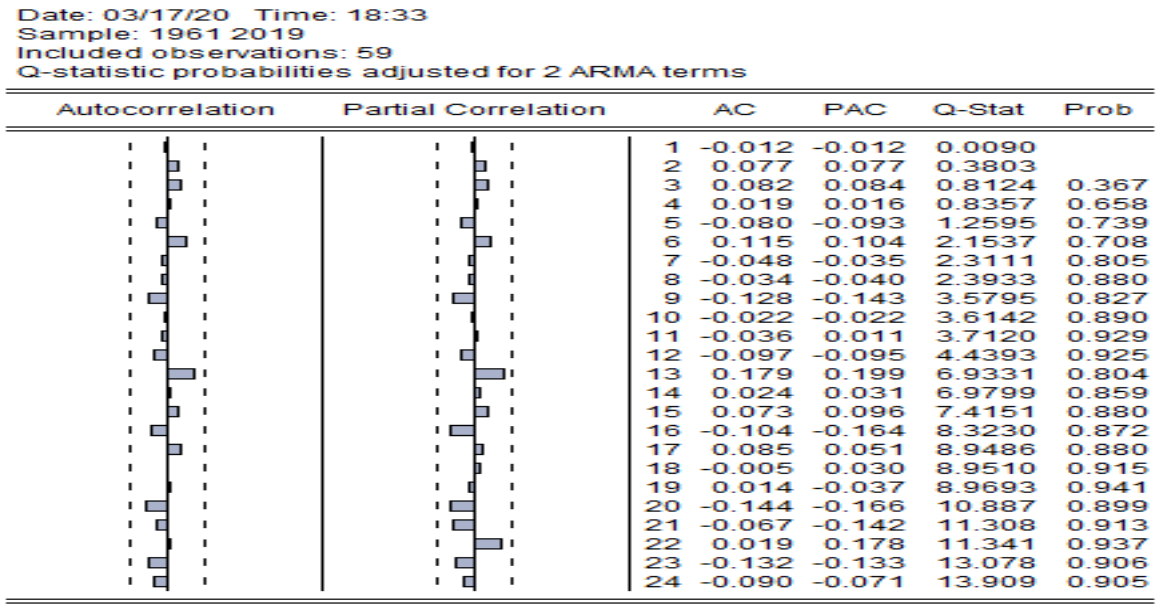
Source: Researchers' computation with Eviews 10.0

Table 2. Parsimonious Estimation
Dependent Variable: INFLATION
Method: ARMA Maximum Likelihood (OPG - BHHH)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	16.90160	5.929584	2.850386	0.0061
AR(4)	0.342254	0.126391	2.707906	0.0090
MA(5)	0.524452	0.114110	4.596042	0.0000
SIGMASQ	161.8775	23.64034	6.847512	0.0000

R-squared	0.280828	Mean dependent var	18.01864
Adjusted R-squared	0.241601	S.D. dependent var	15.13174
S.E. of regression	13.17765	Akaike info criterion	8.096003
Sum squared resid	9550.772	Schwarz criterion	8.236853
Log likelihood	-234.8321	Hannan-Quinn criter.	8.150985
F-statistic	7.158953	Durbin-Watson stat	2.009019
Prob(F-statistic)	0.000383		

Source: Researchers' computation with Eviews 10.0



	AC	PAC	Q-Stat	Prob
1	-0.012	-0.012	0.0090	
2	0.077	0.077	0.3803	
3	0.082	0.084	0.8124	0.367
4	0.019	0.016	0.8357	0.658
5	-0.080	-0.093	1.2595	0.739
6	0.115	0.104	2.1537	0.708
7	-0.048	-0.035	2.3111	0.805
8	-0.034	-0.040	2.3933	0.880
9	-0.128	-0.143	3.5795	0.827
10	-0.022	-0.022	3.6142	0.890
11	-0.036	0.011	3.7120	0.929
12	-0.097	-0.095	4.4393	0.925
13	0.179	0.199	6.9331	0.804
14	0.024	0.031	6.9799	0.859
15	0.073	0.096	7.4151	0.880
16	-0.104	-0.164	8.3230	0.872
17	0.085	0.051	8.9486	0.880
18	-0.005	0.030	8.9510	0.915
19	0.014	-0.037	8.9693	0.941
20	-0.144	-0.166	10.887	0.899
21	-0.067	-0.142	11.308	0.913
22	0.019	0.178	11.341	0.937
23	-0.132	-0.133	13.078	0.906
24	-0.090	-0.071	13.909	0.905

Figure 4. Correlogram of the Residuals for the best model Inflation = α_1 + ar(4) + ma(5)
Source: Researchers' computation with Eviews 10.0

The time plot of inflation in Figure 1 shows a depression in 1963 and 1968, an increasing trend in the other period with seasonality of differencing within the period. Also available in the correlogram of the seasonal MA component and a seasonal AR component meanwhile the PACF suggest the involvement of the product of two autoregressive components. Practically from the coefficients of the model three lags are statistically significant as they falls above the 95% confident interval and standard error bound and moves in the same direction. Hence work adopt an ARMA models and spilt in the following ARMAs: ARMA(4, 4), ARMA (4, 5), ARMA (5, 4); ARMA (5, 5), ARMA (4, 12) ARMA (12, 4), ARMA (12, 12), ARMA (5, 12) and ARMA (12, 5). ARMA (4, 5) is the best filled model for analysis; base on the least criteria assumptions it attributes, listed in the diagnostic section. The lags of 4 and 5 are statistically significance, with least adjusted Rsquare of 0.24, AIC=8.09, Bayesian 8.23 and volatility level of 161.87. Figure 1 again shows a very close agreement between the model and the data. Figure 2 is a histogram of the residuals. The probability curve shows a nearly normal distribution of mean zero (apart from the outlier of value close to 20, 30 and 40). The correlogram of the residuals in Figure 3 is such that all the correlation is statistically significant expected for the first-three. All these show that the model is adequate.

Figure 4, the second correlogram from the chosen model of ARMA (4, 5) shows the feted of all the lags laid between the confident interval and standard error bound.

The effects of inflation in Nigeria had been enormous which had cushioned the problem more on the citizenry. In the multi-parameter model of table 1, shows non statistically significant of the chosen model AR(4) and MA(5) while in the parsimonious model of AR(4) and MA(5) is statistically significant. More lower sigmaSquare, high adjusted Rsquare and Rsquare in the over-parameters model of table 1. This situation explained the disguised inflationary situation in Nigeria occasion by panic and speculative purchasings which shows the unknown effect of inflation on the citizenry through the compensation effect of other variables and attributes. From the data used in the analysis and interpretation of this work, the 1961, inflationary index was on a manageable single digit until 1965 but 1963 was a dysflationary stock of -3.09% while in 1966 it jumped to 13.19% which suspect to be the panic buying occasion by the 1966 coup and the rumor of war that eventually breakup in 1967 but the whole civil war era was digit but negative in 1967 and double in 1970 at 51.28%. Single digit till 1973 and 1974 it jumped to 43.95 and maintained double digits in a flexible decaying till 1981 at 18.46% and single digit in 1982 at 4.83% double digits for two moving years in almost same magnitude and again in 1985 at 5.54% the flow continues in double till 1989 at 45.04 but in 1987 at 67.40%.

In 1990 inflationary stock was 9.20% and started in doubling rate till 2019 at 11.40% and with its highest flow stock in 2002 at 39.90%.

The chosen model as summarized in Table 1 is ARMA (4, 5) and is given by

$$INFLATION = c + \alpha_1 INFLATION_{t-4} + \alpha_2 INFLATION_{t-5} + \alpha_3 INFLATION_{t-16} + \alpha_1 INFLATION_{t-4} + \alpha_2 INFLATION_{t-5} + \alpha_3 INFLATION_{t-16} \beta_t \quad (e_4)$$

The equation (e_4) estimated and summarized of the least square in Table 1 is given by

$$INFLATION = 17.91149 + 0.328757 INFLATION_{t-4} - 0.290981 INFLATION_{t-5} - 0.013475 INFLATION_{t-16} + \beta_t \quad (e_5)$$

(3.592982) (0.182844) (0.173778) (0.275653) (4.598870) (0.089903) (0.089903)

The parsimonious equation for the most suitable model ARMA (4, 5)

$$INFLATION = 16.9016044289 + 0.342253929878 INFLATION_{t-4} + 0.524452408347 INFLATION_{t-5} + \beta_t$$

(5.929584) (0.126391) (0.114110)

FORECASTING

Table 3 Forecast value of inflation from 2017 to 2022

2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
10.87	11.66	10.86	19.54	15.00	13.30	11.40	13.1	14.00	14.54	15.32	14.59

Source: Researcher Computation With calculator Detail

CONCLUSION

It may be concluded that the data of inflation follows the multiplicative seasonal (x, $\mathcal{M}$) x (4, 5)59 model. This model has been shown to be adequate. Diagnostic tests indicate that the inflation series is I(0). The model was further validated with the equation ($\alpha(B)x_t = \beta(B)\mathcal{M}_t$ and $p > 0.05$) with statistically 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 2019 and 2024 with the highest inflationary index being estimated as 15.32% in the year 2023.

RECOMMENDATION

The following recommendations were made to avoid the plague of double inflation that affects Nigeria.

1. That CBN should improve on the monetary policy particularly price stability and stabilizes the economy through sales of treasuring bills, certificates and other money market instruments to cushion money flow and stock in the system.
2. That CBN should also improves on the current intervention programs to encourage immediate consumable produce of agriculture to reduce increase in of inflations in the system.
3. That federal government of Nigeria (FGN) should grand tax holidays for agro-business manufactories, food producing and processing firms to enhance food sufficiency and security for the consumable population such that, the available money supply is equal to the demand for goods and services in the system.

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