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TIME SERIES ANALYSIS OF NIGERIAN EXTERNAL RESERVES

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ABSTRACT
The need for proper understanding of the trend of the Nigeria's external reserves can not be over emphasized, as it would help the Central Bank of Nigeria (CBN) and the Federal Government of Nigeria to make policies that would grow her economy. In view of this, this paper attempts to identify and build a suitable and reliable Box-Jenkins model for modeling the Nigeria's external reserves. Nigeria's 34 years external reserve data from January, 1981 to December, 2014 was used to perform analysis in E-views. The ARIMA (4,1,0) model with the smallest AIC and BIC statistics was found to out-perform the ARIMA (4,1,1) model. This paper therefore proposes the ARIMA (4,1,0) model for forecasting Nigeria's external reserves.

Keywords: Time series, Box-Jenkins model, ARIMA, External Reserves

INTRODUCTION AND LITERATURE REVIEW

External Reserves (ER), variously called international reserves foreign reserves or foreign exchange reserves, has different definitions. However, in this paper, we have continuously used external reserves instead. The most widely accepted definition of external reserves is the one proposed by the IMF (2009), in its 5th edition of the balance of payments. It defined external reserves as those external assets that are readily available to and controlled by monetary authorities for meeting balance of payments financing needs, for intervention in foreign exchange markets to affect the currency exchange rate, for other related purposes such as maintaining confidence in the currency and the economy, and serving as a basis for foreign borrowing. In his opening remarks at IMF/World Bank International Reserves Policy Issues forum, Fisher (2001) writes:

> *"Reserves matter because they are the key determinant of a country's ability to avoid economic and financial crisis. This is true of all countries, but especially of emerging markets open to volatile international capital flows. The availability of capital flows to offset current account should, on the face of it, reduce the amount of reserves a country needs. But access to private capital is often uncertain, and inflows are subject to rapid reversals, as we have seen all too often in recent years. We have also seen in the recent crises that countries that had big reserves, by and large, did better in withstanding contagion than those with smaller reserves- to an extent that is hard to account for through our usual analyses of the need for reserves".*

For Nigeria, Act No. 41 (Central Bank of Nigeria, 1991) vested the custody and management of Nigeria's External Reserve to the Central Bank of Nigeria (CBN). Before financial globalization, reserves were held by countries mainly to manage external exchange demand and supply arising from current account transactions. Virtually, every country of the world for one reason or the other hold external reserves. Nigeria holds hers to: (i) Finance government spending abroad like importation of goods and services, (ii) Service liabilities and pay debts of foreign currencies (iii) Have defence against emergencies, (iv) Provide a buffer against external shocks, (v) Serve as wealth accumulation etc.

Government statisticians and accountants gauge and record the levels of domestic output and external Reserve, national income and prices o the economy. Certainly, with such information in hand the country can gauge her economic wealth (McConnell and Brue (1986).

Time series analysis, especially the Box-Jenkins (ARIMA) modeling of the Nigeria's external reserves has appeared in many scholarly articles.
Zubair and Olarenwaju (2014) tentatively identified ARIMA (1,2,2) model as a suitable model for modelling and forecasting Nigeria"s external reserves using a monthly 50 years data (January, 1960 – December, 2008). The Nigeria's external reserves was found to be on the increase and the paper further called on the Nigerian government to exercise fairness, justice, and equity for an in order to strengthen her economy. The model was fitted with over differenced log-transformed series which could affect the forecasting

power of the ARIMA (1,2,2) model, therefore, the ARIMA (1,1,2) model would have been preferred since a single ordinary difference would have rendered the series stationary.

Akpanta and Okorie (2015) identified ARI (5, 1,0) model as a suitable model for modeling and forecasting the Nigeria's external reserves. Nigeria's 54 years external reserve data from January, 1960 to December, 2013 was used to perform analysis in R. The ARI (5,1,0) model with the smallest AIC and BIC statistics was found to out-perform the ARIMA (5,1,1) model. One year forecast was made with the best ARI (5,1,0) model and the Nigeria's external reserves was trending upwards. From the paper, the point forecast values are higher than the observed values. Interestingly the observed values are found to lie within the 90% confidence intervals.

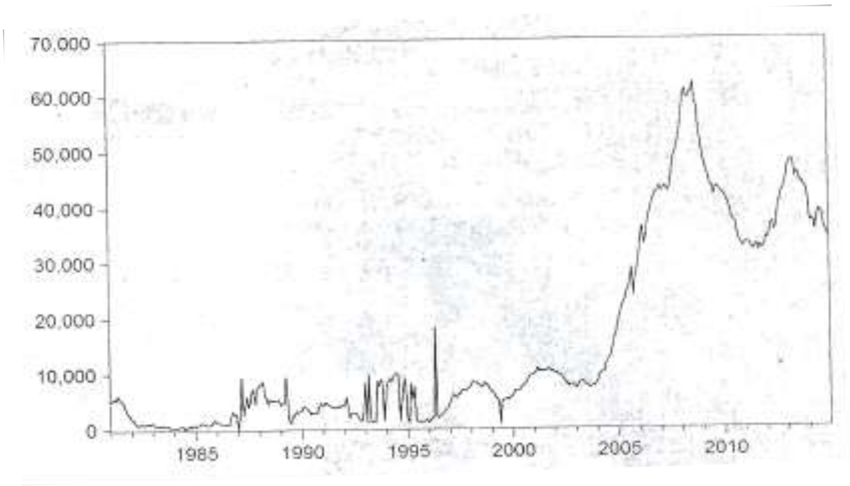
Iwueze et al, (2013) recommended the Auto Regressive integrated moving average (ARIMA) process of order (2,1,0) for forecasting the natural log-transformed Nigeria's external reserves, using II years data (from January, 1999 – December, 2008), where the Nigeria's foreign reserves was found to be on the increase. However, the point forecast from this model shows a large discrepancy from the observed and was attributed to the fall in income from petroleum products which is the main source of the Nigeria's external reserves. In the paper the ARIMA (2,1,0) though a candidate model could not have been the best. Instead the ARIMA (2,1,2) would have been considered because the ACF plot of the first ordinary differenced log-transformed series showed a significant spike at lag 2 and cut-off thereafter.

Ohakwe et al, (2013) modeled Nigerian External Reserves from the period of 1960 – 2010 using descriptive time series technique and Box-Jenkins (ARIMA) model. Applying the descriptive time series technique on the transformed data, a linear trend was found adequate which suggest an exponential trend for the untransformed data. However, the seasonal indexes were found to be insignificant which implies that the data is completely dominated by the trend. Furthermore from the paper, considering that the model obtained using the descriptive time series technique was found inadequate as suggested by the autocorrelation function (ACF) of the irregular component and therefore cannot be used for forecasting, a Box-Jenkins model was then fitted and was found adequate as suggested by the P-value = 0.00 for the model significance. Also using the relative percentage change (RPC) to assess the impact of the various regimes on the Nigerian. External Reserve data, it was found that the regimes of General Yakubu Gowon (Rtd) and Alhaji Shehu Shagari respectively has the most positive, and negative impact on the External Reserve data. Finally using the cumulative RPC in assess sing the impact of civilian and military regimes on the External Reserves data, it was discovered that the military had a higher positive impact than the civilian regimes.

Etuk et al, (2013) identified and established the adequacy of the seasonal ARIMA (5,1,0) (0,1,1). For modeling and forecasting the amount of monthly rainfall in Port Harcourt, Nigeria. This paper therefore attempts to identify and construct a more reliable Box-Jenkins ARIMA (p,d,q) model that would best explain the underlying generating process and make forecast into the future of the Nigerian External Reserves.

MATERIALS AND METHODS

The data used in this article which is a monthly sequential record of the Nigeria's external reserves constitutes a time series data. The Box-Jenkins, Auto Regressive Integrated moving Average (ARIMA) time series modeling technique for stationary time series has been adopted for the analysis. The monthly Nigeria's external reserves data, used in this work was obtained from the official website of the Central Bank of Nigeria (http://www.cbn.gov.ng), for the period of 55 years (January, 1981-December, 2014). Analysis has been performed using E-views.



Figures 1: Time Plot of Nigerian External Reserves

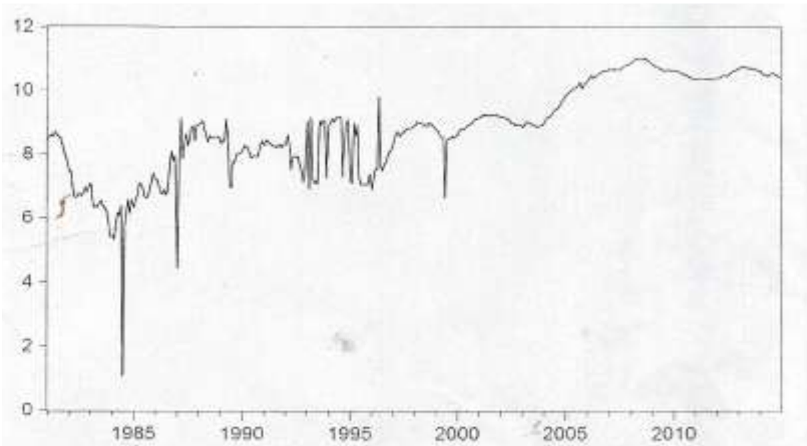


Figure 2: Logarithm of Nigerian External Reserves

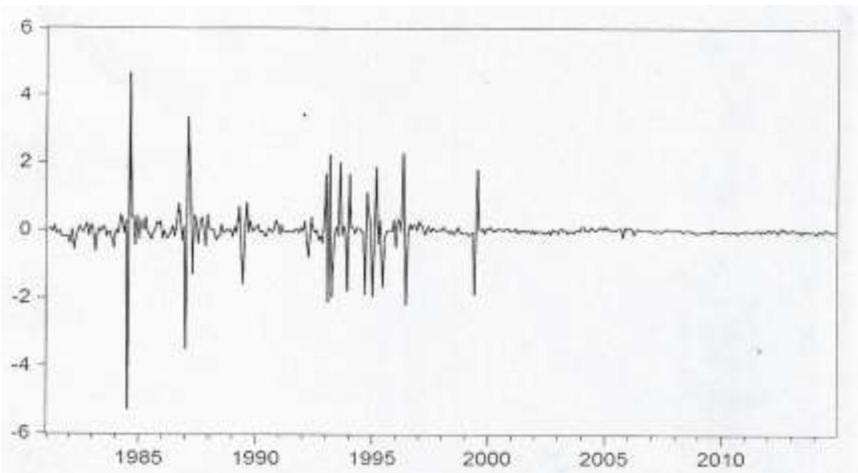
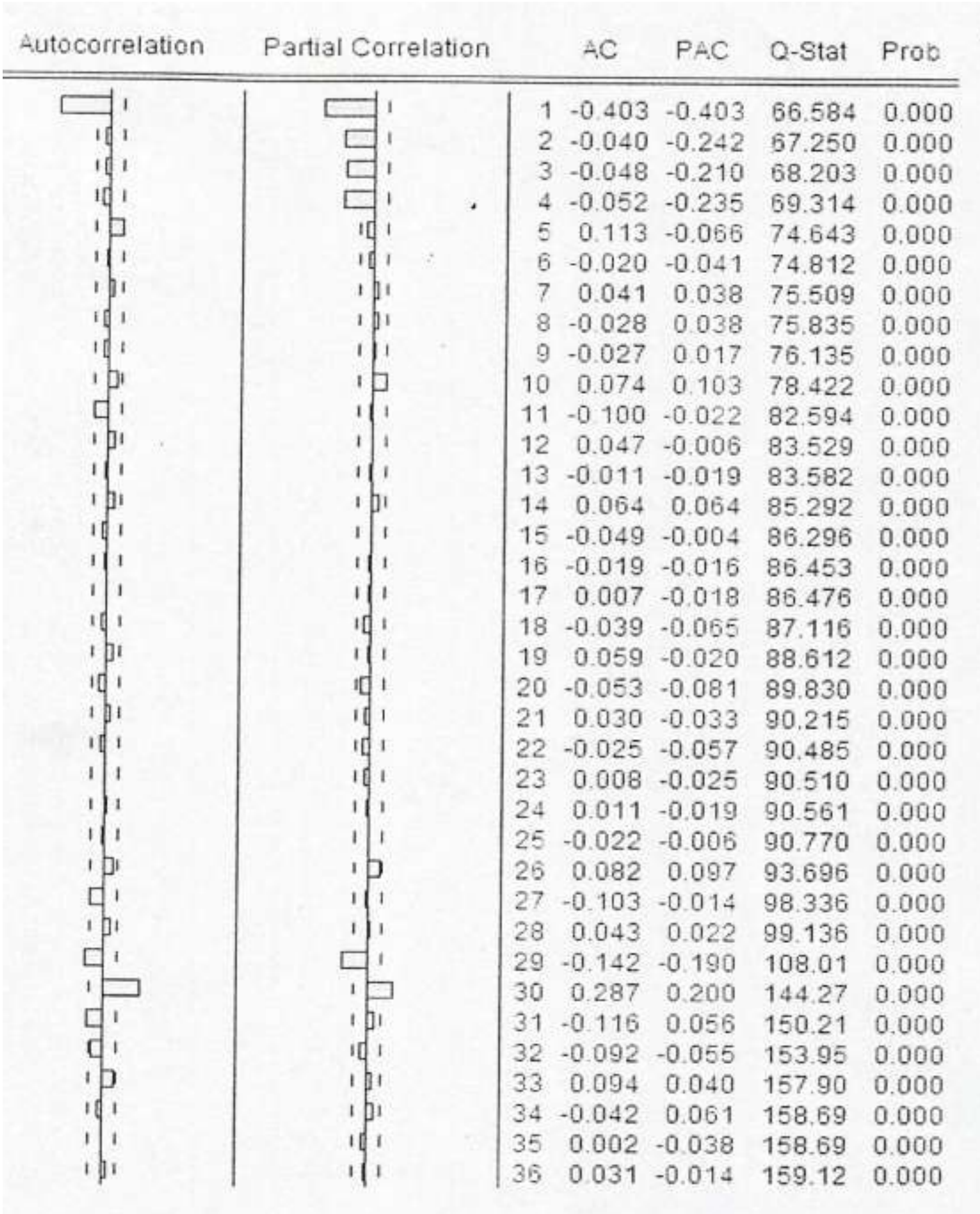


Figure 3: Difference of Log of Nigerian External Reserves



Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
		1	-0.403	-0.403	66.584	0.000
		2	-0.040	-0.242	67.250	0.000
		3	-0.048	-0.210	68.203	0.000
		4	-0.052	-0.235	69.314	0.000
		5	0.113	-0.066	74.643	0.000
		6	-0.020	-0.041	74.812	0.000
		7	0.041	0.038	75.509	0.000
		8	-0.028	0.038	75.835	0.000
		9	-0.027	0.017	76.135	0.000
		10	0.074	0.103	78.422	0.000
		11	-0.100	-0.022	82.594	0.000
		12	0.047	-0.006	83.529	0.000
		13	-0.011	-0.019	83.582	0.000
		14	0.064	0.064	85.292	0.000
		15	-0.049	-0.004	86.296	0.000
		16	-0.019	-0.016	86.453	0.000
		17	0.007	-0.018	86.476	0.000
		18	-0.039	-0.065	87.116	0.000
		19	0.059	-0.020	88.612	0.000
		20	-0.053	-0.081	89.830	0.000
		21	0.030	-0.033	90.215	0.000
		22	-0.025	-0.057	90.485	0.000
		23	0.008	-0.025	90.510	0.000
		24	0.011	-0.019	90.561	0.000
		25	-0.022	-0.006	90.770	0.000
		26	0.082	0.097	93.696	0.000
		27	-0.103	-0.014	98.336	0.000
		28	0.043	0.022	99.136	0.000
		29	-0.142	-0.190	108.01	0.000
		30	0.287	0.200	144.27	0.000
		31	-0.116	0.056	150.21	0.000
		32	-0.092	-0.055	153.95	0.000
		33	0.094	0.040	157.90	0.000
		34	-0.042	0.061	158.69	0.000
		35	0.002	-0.038	158.69	0.000
		36	0.031	-0.014	159.12	0.000

Figure 4: ACF and partial ACF Plots pf the Differenced Logged – data

RESULTS

Figures (1) shows the plot of the original time series of Nigeria's external reserves, from which a slight linear trend could be seen suggesting non-stationarity in the mean level while the variance appears to be relatively stable. In order to make the series stationary, we adopt the Box-Cox, log-transformation. Figures (2) shows the log-transformed data indicating non-stationarity. Figures (3) shows that the first ordinary difference (i.e. d = 1) was enough to convert the non stationary (non constant mean) log-transformed series to a stationary one. Figure 4 shows the ACF and PACF of the differenced log-transformed series which shows that a cut-off a lag 1 in the ACF (indicating MA(1), i.e. q = 1) and a cut-off at lag 4 in the PACF (indicating AR (4), i.e. p = 4, however ARIMA (4,1,1) should be considered as a candidate model.

Table Fitted ARIMA (4,1,1) Model

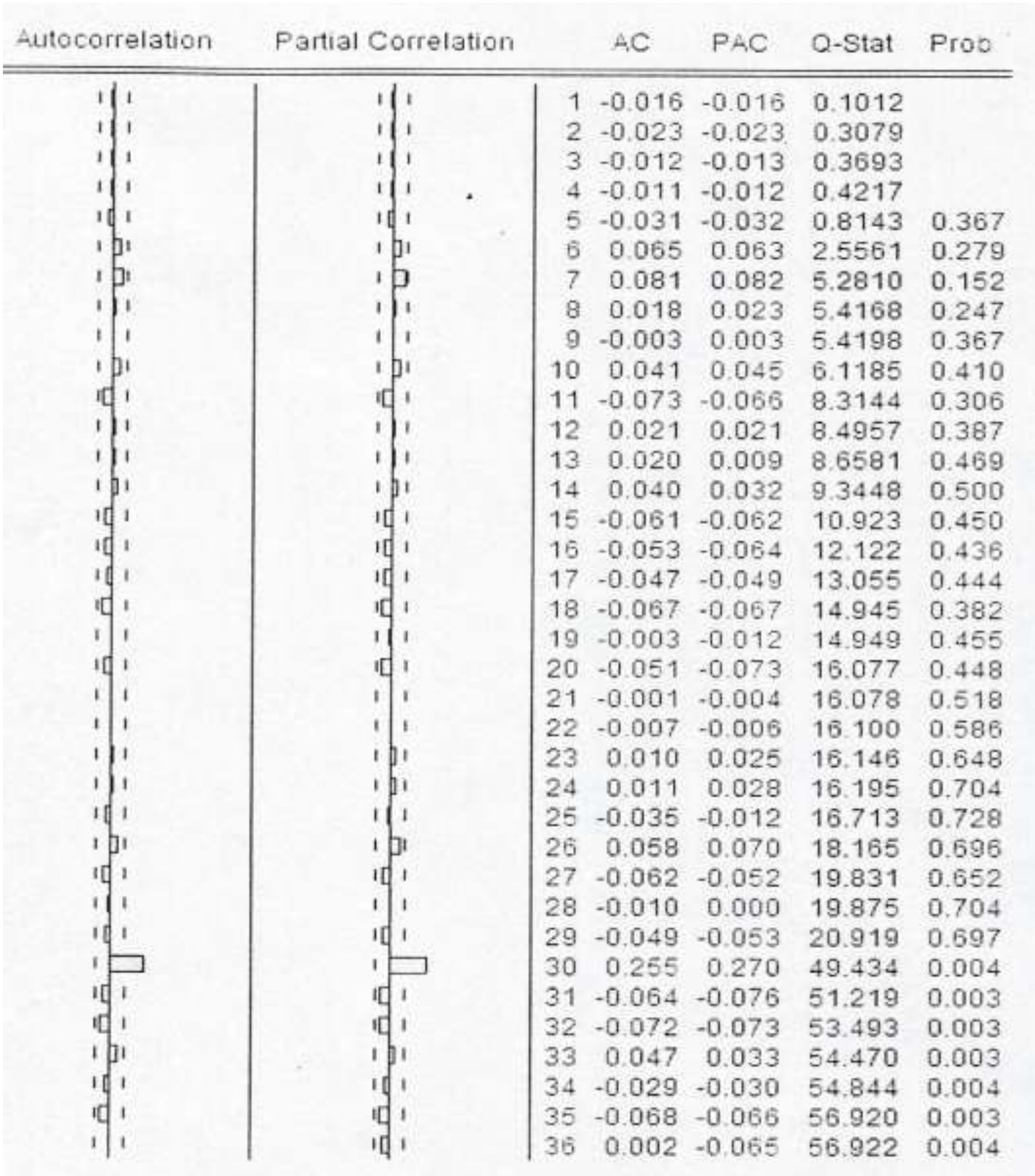
Parameters	**$\phi 1$**	**ϕ_2**	**ϕ_3**	**ϕ_4**	**θ_1**
Estimates	-0.347328	-0.289045	-0.251923	-0.182373	-0.269212
Std Error	0.188616	0.114946	0.085622	0.070126	0.190881
AIC	= 1.516928	and BIC = 1.566543			

All the variables of the fitted ARIMA (4,1,1) model are statistically significant expect θ_1 whose absolute Z-value is 1.41037 which is less than the 5% upper tail critical value of 1.96 leaving θ_1 from the fitted model will result in fitting a reduced ARIMA (4,1,0) model as shown in table 2.

Table 2: Fitted ARIMA (4,1,0) Model

Parameters	**$\phi 1$**	**ϕ_2**	**ϕ_3**	**ϕ_4**
Estimates	-0.600269	-0.4228208	-0.339168	-0.234511
Std Error	0.048663	0.054617	0.054617	0.048668
AIC	**1.516732**		**BIC**	**1.556423**

All the parameters of the fitted ARIMA (4,1,0) model in table 2 are statistically significant at α = 5%. The estimated parameters are more than two times larger than their corresponding standard errors hence, having absolute Z – value above 1.96 (5% upper tail critical value.



Lag	AC	PAC	Q-Stat	Prob
1	-0.016	-0.016	0.1012	
2	-0.023	-0.023	0.3079	
3	-0.012	-0.013	0.3693	
4	-0.011	-0.012	0.4217	
5	-0.031	-0.032	0.8143	0.367
6	0.065	0.063	2.5561	0.279
7	0.081	0.082	5.2810	0.152
8	0.018	0.023	5.4168	0.247
9	-0.003	0.003	5.4198	0.367
10	0.041	0.045	6.1185	0.410
11	-0.073	-0.066	8.3144	0.306
12	0.021	0.021	8.4957	0.387
13	0.020	0.009	8.6581	0.469
14	0.040	0.032	9.3448	0.500
15	-0.061	-0.062	10.923	0.450
16	-0.053	-0.064	12.122	0.436
17	-0.047	-0.049	13.055	0.444
18	-0.067	-0.067	14.945	0.382
19	-0.003	-0.012	14.949	0.455
20	-0.051	-0.073	16.077	0.448
21	-0.001	-0.004	16.078	0.518
22	-0.007	-0.006	16.100	0.586
23	0.010	0.025	16.146	0.648
24	0.011	0.028	16.195	0.704
25	-0.035	-0.012	16.713	0.728
26	0.058	0.070	18.165	0.696
27	-0.062	-0.052	19.831	0.652
28	-0.010	0.000	19.875	0.704
29	-0.049	-0.053	20.919	0.697
30	0.255	0.270	49.434	0.004
31	-0.064	-0.076	51.219	0.003
32	-0.072	-0.073	53.493	0.003
33	0.047	0.033	54.470	0.003
34	-0.029	-0.030	54.844	0.004
35	-0.068	-0.066	56.920	0.003
36	0.002	-0.065	56.922	0.004

Figure 5: Correlogram of Residuals

In order to check the adequateness of the model, figure 5 shows the correlogram of the residuals. The plot shows that the ARIMA (4,1,0) model is adequate. It is adequate because most of the correlations are not significant. The goodness of fit of the two tentatively identified model statistics (AIC and BIC). The ARIMA (4,1,0) model with smaller AIC and BIC statistics is preferred over the ARIMA (4,1,1) model. Hence, it is recommended for forecasting the future of Nigeria’s external reserves.

ARIMA (4,1,0) model is given as:
Let the first ordinary differenced log-transformed series y_t be;
$W_t = (1 – B)Y_t$ (1)

Then
$W_t = \hat{\phi}_1 W_{t-1} + \hat{\phi}_2 W_{t-2} + \hat{\phi}_3 W_{t-3} + \hat{\phi}_4 W_{t-4}$
(2)
Equation (2) is the fitted ARIMA (4,1,0) model and e_t is the error term which is white noise process i.e. $e_t \sim IID\ (0,\sigma)$.

DISCUSSION OF RESULTS AND CONCLUSION

This paper adopted the Box-Jenkins three step iterative model building procedure of identification, estimation and diagnostic checking to model and the Nigeria's external reserves using the monthly data from January, 1981 to December, 2014. Two models ARIMA (4,1,1) and ARIMA (4,1,0) were entertained. The ARIMA (4,1,0) model was found to provide the best-fit to the external reserve data, because of its small information criteria statistics (AIC and BIC) in comparison to the ARIMA (4,1,1). This means that the differenced log transformed series at time t depends on four (4) past values (t-1, t-2, t-3 and t-4) of the process. The moving average parameter (i.e. MA = 1) in ARIMA (4,1,1) model was found statistically insignificant and this led to the reduced ARIMA (4,1,0) model.

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