Time Series Modeling of Nigeria External Reserves

[1]Iheanyichukwu S. Iwueze, Eleazar C. Nwogu and Valentine U. Nlebedim

This paper discusses the levels and trend of external reserves in Nigeria. The relevance of this lies in the fact that it could help to monitor the reserves and throw early warning signal about any economic crisis. Monthly data on Nigeria external reserves for the period January 1999 to December, 2008 derived from the 2008 CBN Statistical Bulletin was analyzed using ARIMA model. Results of the analyses show that (i) the data requires logarithmic transformation to stabilize the variance and make the distribution normal (ii) the appropriate model that best describes the pattern in the transformed data is the Autoregressive- Integrated Moving Average process of order (2,1,0). This model is recommended for use until further analysis proves otherwise.

Keywords: External Reserves, Autoregressive Process, Transformation, Variance Stability, Payment Imbalances.

JEL Classification: C22, C51, C53, F30, F31

1.0 Introduction

External reserves, also known as International Reserves, Foreign Reserves or Foreign Exchange Reserves, "consists of official public sector foreign assets that are readily available to and controlled by the monetary authorities for direct financing of payment imbalances and regulating the magnitude of such imbalances through intervention in the exchange market to affect the currency exchange rate and/or for other purposes" (CBN 2007). By this definition, external reserves include international reserve assets of the monetary authority but exclude the foreign currency and the securities held by the public including the banks and corporate bodies.

External reserves are needed to guard against possible financial crisis (Mendoza, 2004). National reserves are also seen as a store of assets that central banks could use to influence the exchange rate of their domestic currency (Nugee, 2000; Williams, 2003; IMF, 2004). Several authors (Yuguda, 2003; Soludo, 2005 and Nda, 2006) noted that external reserves help to build international community confidence in the nation's policies and creditworthiness. Adequate reserves do contribute to confidence in a nation by guaranteeing the availability of foreign exchange to domestic borrowers to

[1] Department of Statistics, Federal University of Technology, P. M. B. 1526 Owerri

meet international debt servicing and enhance its credit rating (Humphries, 1990; Archer and Halliday, 1998), the confidence is often influenced by the soundness of a nation's economic policies and overall investment climate (UNCTAD, 2007). In his opinion, Dooley *et al.* (2004) argued that reserve accumulation agenda in Asian central banks was to prevent their currencies from appreciating against the U.S. dollar in order to promote their export-led growth strategy.

Conventionally, countries hold external reserves in foreign currencies in order to maintain a desirable exchange rate policy by interfering significantly in foreign exchange markets. The main reasons for a country holding external reserves include foreign exchange market stability, exchange rate stability, exchange rate targeting, creditworthiness, transactions buffer, and emergency such as natural disasters (Archer and Halliday, 1998 and Humphries, 1990). The external reserve holding has generated serious global interest, as different economies search for alternative strategies that will protect their economies against financial instability and stimulate economic growth. Using data from four Asian countries- Indonesia, South Korea, Malaysia, and Thailand (1997–1998), Turner (2007) identified accumulation of external reserves, among others, as one of the factors associated with banking and currency crises management. Using data from122 emerging market economies (1980‑1996), IMF (2003) observed that the factors that determine reserve holdings includes: real per capita GDP, population level, ratio of imports to GDP, volatility of the exchange rate, opportunity cost and capital account vulnerability. Among these determinants, GDP per capita, population level, ratio of import to GDP and the volatility of exchange rate were shown to be statistically associated with external reserves while opportunity cost and capital account vulnerability were not.

Nigeria's external reserves derive mainly from the proceeds of crude oil production and sales. From the figure of$3.40billion in 1996 ,Nigeria's external reserves rose to about $28.28 billion in 2005 and further to about $47.00 billion in 2007 (CBN (2005). However, with the global financial crisis Nigeria's foreign reserves declined, following the decline in exchange rate, exports, foreign currency inflows (AfDB *et al*., 2011; World Bank, 1999). As a consequence, Nigerian Stock Exchange (NSE) was negatively affected by the global fall in investor confidence (UNECA (2009)). The withdrawal of investors from the NSE is evident in figures on Nigerian market capitalization, with the market capitalisation index falling from Nigerian Naira 12,640 trillion in March 2008 to 4,900 trillion in March 2009, a 62 percent loss (Ajakaiye and Fakiyesi, 2009).

From the foregoing, it is clear that the growth or decline of a country's external reserves is an indispensable aspect of her economy. In this study our, interest is to determine the existing levels and trend of external reserves in Nigeria. Therefore, the ultimate objective of this study is to construct a statistical model that could be used to monitor the growth of external reserves in Nigeria necessary for economic policy formulation, implementation and monitoring. Specifically, the study (i) evaluated the data for the assumptions of ARIMA model, (ii) determined the appropriate model for the study data and (iii) constructed a statistical model that could be used to describe the pattern in the external reserves in Nigeria. Using this model, forecasts of future external reserves situation in Nigeria were obtained and recommendations made.

2.0 Methodology

The method of analysis adopted in this study is the Box and Jenkins (1976) and Box *et al*. (1994) procedure for fitting autoregressive integrated moving average (ARIMA) model.

The Box, Jenkins and Reinsel multiplicative time series model is given by

$$\phi_p(B)\Phi_P(B^S)(1-B)^d(1-B^S)^D X_t = \theta_q(B)\theta_Q(B^S)e_t \qquad (1)$$

where for the time t,

X_t is the observed value of the series

$$\phi_p(B) = 1-\phi_1 B - \phi_2 B^2 - \ . \ . \ . - \phi_p B^p \qquad (2)$$

and

$$\theta_q(B) = 1-\theta_1 B - \theta_2 B^2 - . \ . \ . - \theta_q B^q \qquad (3)$$

are polynomials in B with no common roots which lie outside the unit circle

$$\Phi_P(B^S) = 1-\Phi_1 B^S - \Phi_2 B^{2S} - .... - \Phi_P B^{PS} \qquad (4)$$

and

$$\theta_Q(B^S) = 1 - \theta_1 B^S - \theta_2 B^{2S} - \cdots - \theta_Q B^{QS} \qquad (5)$$

are polynomials in B^S with no common roots which lie outside the unit circle e_t is the zero mean white noise process with constant variance $\sigma^2 < \infty$, $(1-B)^d$ is the regular differencing to remove the stochastic trend (if any) in the series $(1-B^S)^D$ is the seasonal differencing operator to remove seasonal effect.

Equation (1) contains both a seasonal component,

$$\phi_p(B^S)(1-B^S)^D X_t = \theta_Q(B^S)a_t \qquad (6)$$

and a non-seasonal component

$$\phi_p(B)(1-B)^d X_t = \theta_q(B)b_t \qquad (7)$$

In (6) and (7) $\{a_t\}$and $\{b_t\}$ are the residuals which may or may not be white noise. In a series that contains only the non – seasonal part, Equation (7) can be rewritten as

$$\phi_p(B)(1-B)^d(1-B^S)^D X_t = \theta_q(B)e_t \qquad (8)$$

where e_t is the white noise process. This is equivalent to the expression in (1) with

$$\phi_p(B^S) = \theta_Q(B^S) = 1 \qquad (9)$$

When there is no seasonal differencing this further reduces to

$$\phi_p(B)(1-B)^d X_t = \theta_q(B)e_t \qquad (10)$$

The value of d is determined by the number of regular differencing required to completely isolate the trend from the series. Complete isolation of the trend is indicated when the autocorrelation function (acf) shows spike(s) at the first few lags and cuts off thereafter. For a stationary autoregressive (AR) process, the pacf cuts-off after the first and/or second lags, while for a stationary moving average (MA) process there is a cut off in the acf after the first and/or second lags. When there is a cut off in both acf and pacf, we may consider the ARMA process. The value of D is determined by the number of seasonal differencing required to completely isolate the seasonal effect from the series. Complete isolation of the seasonal effect is indicated when the autocorrelation function (acf) shows spike(s) at the first few seasonal lags and cuts off thereafter.

For a stationary autoregressive (AR) process, the pacf cuts off after the first and / or second seasonal lags, while for a stationary moving average (MA) process there is a cut off in the acf after the first and / or second seasonal lags. When there is a cut off in both acf and pacf, we may consider the seasonal autoregressive-moving average process (SARMA). The advantage of the multiplicative model is that the seasonal and the non-seasonal parts can be identified and fitted separately. Details of ARIMA modelling procedure are contained in Box and Jenkins (1976), Pankratz (1983), Box *et al*. (1994). For the series under study, the estimates of the parameters which meet the stationarity and invertibility conditions were obtained using the MINI TAB Software.

ARIMA modeling procedure has been used to forecast the Gold Futures Prices by Hetamsaria (2007), Tse (1997) also applied ARIMA model to Real-Estate Prices in Hong Kong. ARIMA Modeling procedure was also used to analyse Crude oil exports in Nigeria by Nwogu and Iwu (2010), Badmus and Ariyo (2011) used ARIMA model in forecasting cultivated areas and production of maize in Nigeria and Etuk *et al*. (2012) used ARIMA procedure in modeling Nigeria Stock Prices data. ARIMA modeling procedure was also used to forecast the inflation rate in Nigeria by Olajide *et al*. (2012).

The Box, Jenkins and Reinsel Procedure outlined above assumes that (i) the underlying distribution of the series under study is normal, (ii) the variance is constant and (iii) that the relationship between the seasonal and non – seasonal components is multiplicative as indicated in Model (2.1). When one or all these conditions are violated the fitted model may be inadequate for the series under study. In order to determine the suitability of the study series for the ARIMA modeling procedure, the series was evaluated for these assumptions. The normality assumption was investigated by looking at the properties of the series (including the mean, median and measures of skewness and kurtosis). Furthermore, the Box – Cox transformation procedure which jointly investigates the need for and determines the appropriate transformation was also adopted to check the normality assumption and the stability of variances. For details of the Box – Cox transformation procedure, see Bartlett (1947). For time series data, Iwueze *et al.* (2011) noted that the appropriate Bartlett's transformation is determined by regressing the logarithm of group standard deviations on the logarithm of group averages. The various values of the regression coefficient β and the appropriate transformations are summarized in the Table 2.1.

Table 2.1: Bartlett's transformation for some values of β

S/№	1	2	3	4	5	6	7
β	0	1/2	1	3/2	2	3	-1
Transformation	No Transformation	$\sqrt{X_t}$	$\text{Log}_e X_t$	$1/\sqrt{X_t}$	$1/X_t$	$1/X_t^2$	X_t^2

Source: Iwueze *et al*. (2011).

3.0 Choice of appropriate transformation for the External Reserves data

The annual means $(\bar{Y}_t)$ and standard deviations $(\hat{\sigma}_t)$ of Nigeria external reserve from 1999 to 2008 are shown in Table 3.1 while the corresponding graphs are shown in Figure 1. As Table 3.1 and Figure 1 show, the means appear to be moving upwards in a curve-linear form while the standard deviations appear to be moving horizontally from 1999 to 2008 and slight jump from 2000 to 2008 for the entire period. The overall mean (21712.3), the median (10310.4), the measures of skewness (0.8994) and Kurtosis (-0.69) of the original data indicate that the series may not have come from a normal population. In summary there are indications that the underlying distribution may not be normal, the variance may not be stable and hence, that the data needs transformation.

In order to determine the appropriate transformation, the slope (β) of the regression equation of the logarithm of the annual standard deviations $(\log \hat{\sigma}_t)$ on the logarithm of the annual means $(\log \bar{y}_i)$ of the study series given in Table 3.1 was found to be equal to be $\hat{\beta} = 0.860$ with the standard error 0.2536 and coefficient of determination $R^2 = 0.539$. From the ANOVA table, this value of $\hat{\beta}$ is significantly different from zero at $\alpha = 0.01$ level of significance and at eight degrees of freedom. Furthermore, this value, $\hat{\beta} = 0.860$, lies

Table 3.1: Annual and overall means and standard deviations (and their natural logarithms) of Nigeria external reserve (in US $ Million).

Year	Mean $(\bar{Y}_i)$	$\hat{\sigma}(Y_i)$	Log $(\bar{Y}_i)$	Log $(\hat{\sigma}(Y_i))$
1999	5309	571	8.5772	6.34739
2000	7591	1186	8.9347	7.07834
2001	10282	284	9.2382	5.64897
2002	8592	885	9.0586	6.78559
2003	7642	399	8.9414	5.98896
2004	12063	2799	9.3979	7.93702
2005	24321	2986	10.0991	8.00169
2006	37456	3787	10.5309	8.23933
2007	45394	3264	10.7231	8.09071
2008	58473	2682	10.9763	7.89432
Overall Mean	21712.3		9.64774	
Overall STD		1341.17		0.961904

STD = Standard Deviation

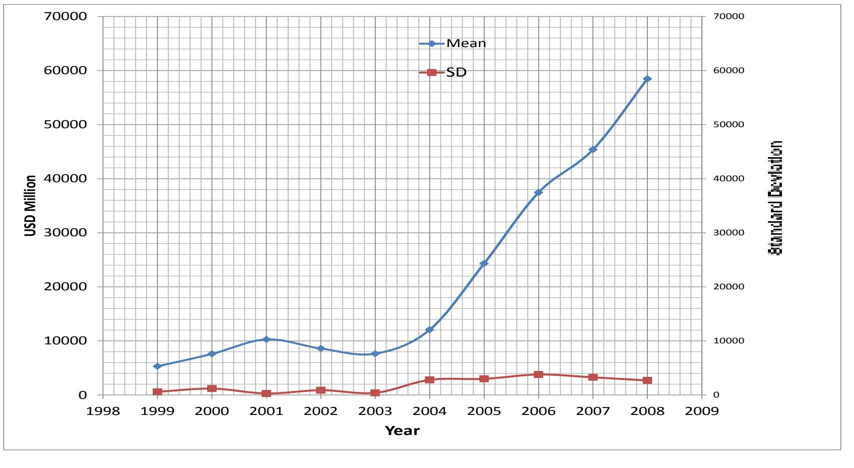

Fig. 1: Annual means and standard deviations of Nigeria external reserves

between 0.5 (when square root transformation is required) and 1 (when Logarithmic transformation is required). Since this value (0.86) appears closer to 1 than to 0.5, we examine the suitability of the logarithm transformation. Thus, the null hypothesis tested is $H_0: \beta = 1$ (and the appropriate transformation is the logarithm) against the alternative $H_1: \beta \neq 1$ (and the appropriate transformation is not logarithm). When the calculated t-value (0.5521) is compared with the tabulated value (2.26) at α = 0.05 level of significance and 8 degrees of freedom, the null hypothesis is not rejected, indicating that the logarithmic transformation may be the appropriate transformation.

The logarithm of the original data was taken to obtain the transformed series: $X_t = \log Y_t$ shown in Appendix B. The transformed series was also checked for the adequacy of this transformation, following the whole process of choice of appropriate transformation as outlined earlier. The annual means $(\overline{X}_i)$, standard deviations $(\hat{\sigma}_{X_i})$, and their corresponding logarithms are shown in Table 3.2 while the corresponding graphs are shown in Figure 2. As Figure 2 shows, the annual standard deviations appear to be moving horizontally, indicating that the variance has been stabilized while the mean appears to be moving upwards in a linear form.

Table 3.2: Annual and overall means and standard deviations (and their natural logarithms) of transformed Nigeria external reserve.

Year	Mean $(\overline{X}_i)$	$\hat{\sigma}(Y_i)$	Log $(\overline{X}_i)$	Log$(\hat{\sigma}(Y_i))$
1999	8.572	0.102	2.1485	-2.2828
2000	8.924	0.155	2.1887	-1.8643
2001	9.238	0.028	2.2233	-3.5756
2002	9.054	0.103	2.2032	-2.273
2003	8.94	0.052	2.1905	-2.9565
2004	9.374	0.228	2.2379	-1.4784
2005	10.092	0.124	2.3117	-2.0875
2006	10.526	0.102	2.3538	-2.2828
2007	10.721	0.07	2.3722	-2.6593
2008	10.975	0.047	2.3956	-3.0576
Overall Mean	9.642			
Overall STD		0.827		

STD = Standard Deviation

Furthermore, the slope $\left(\hat{\beta}_x\right)$ of the regression equation of logarithm of the annual standard deviation $\left[\log\left(\hat{\sigma}_x\right)\right]$ on the logarithm of the annual means $\left(\log_e \overline{X}\right)$ is -1.24 with standard error, 2.444 and coefficient of determination $R^2 = 3.1\%$. The p-value (0.625) associated with the slope $\left(\hat{\beta}_x\right)$ clearly indicates that it is not significantly different from zero and also indicates that the logarithmic transformation is adequate for the study data. Therefore, model building for Nigerian external reserve will be based on logarithm transformed series (X_t) shown in Appendix B.

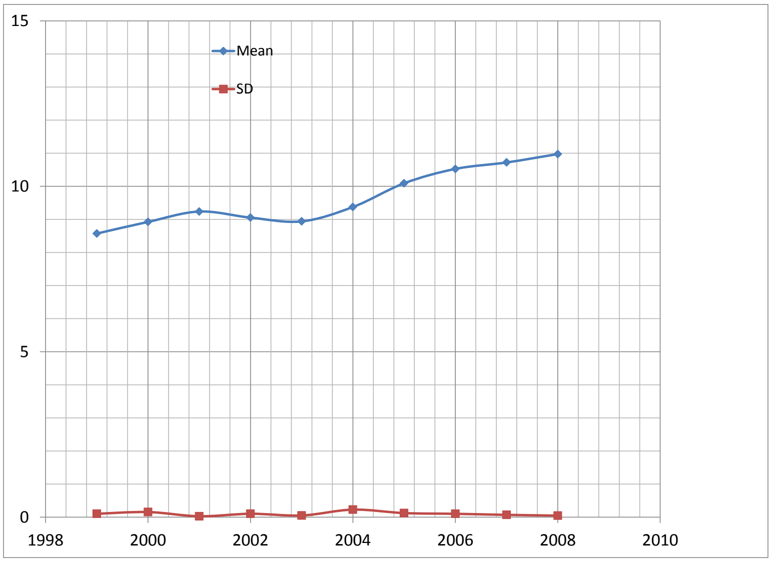

Fig. 2: Annual means and standard deviations of the transformed series

4.0 ARIMA Model for the logarithm transformed series

The logarithm-transformed monthly record of Nigeria external reserves (in US $ Million) from January 1999 to December 2008 is shown in Appendix B, while the corresponding time plot is shown in Figure 3. As Figure 3 shows, the plot of the series appears to be moving upwards in what appears like a linear trend. The plot of the annual means, shown in Figure 2 also indicates that the appropriate trend may be linear. Furthermore, the autocorrelation function (ACF) of the transformed series (X_t), shown in Figure 4 and Table 4.1 decayed slowly from a value of about 0.9838 at lag 1 to value of 0.2159 at lag 30, confirming the presence of trend in the series. This suggests that the transformed series requires differencing to remove the trend. The corresponding partial autocorrelation function (PACF) shown in Figure 5 and Table 4.1 has a spike at lag 1 only.

The time plot of the first order differenced series (W_t) shown in Figure 6 fluctuated about a horizontal line through zero, indicating that the trend may have been removed. The ACF and PACF of the detrended series (W_t), also shown in Figure 7 and 8 respectively and Table 4.1, indicate that the ACF dropped from values of about 0.24 and 0.25 at lags 1 and 2 respectively to about 0.20 at lag 6. This confirms that the series (W_t) is stationary, suggesting that first order difference was sufficient to achieve stationarity in mean.

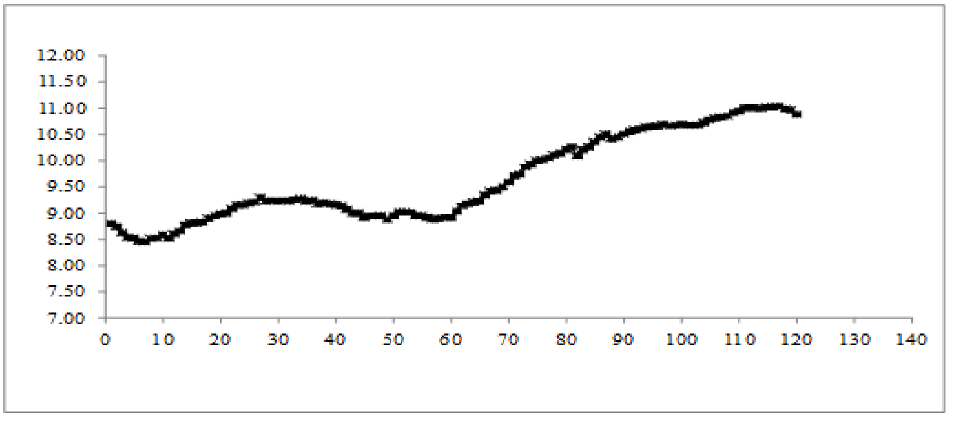

Fig. 3: Time plot of the transformed series (X_t)

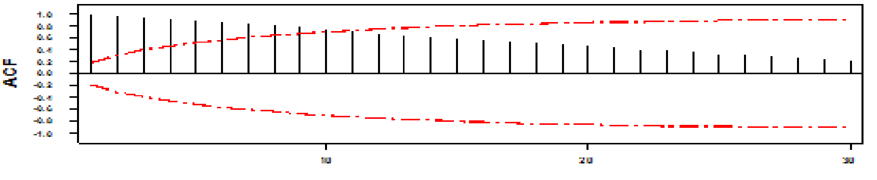

Fig. 4: Autocorrelation Function for the transformed data (X_t)

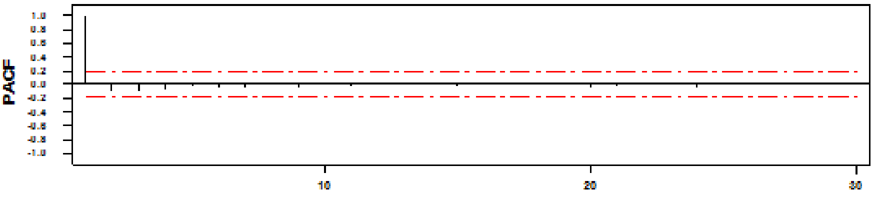

Fig. 5: Partial Autocorrelation Function for the transformed data (X_t)

Table 4.1 : ACF and PACF transformed (X_t) and differenced (W_t) series

Lag k	X_t Series		W_t Series		e_t Series	
	ACF	PACF	ACF	PACF	ACF	PACF
1	0.9838	0.9838	0.2372	0.2372	-0.0618	-0.0618
2	0.9644	-0.1066	0.2471	0.2022	-0.1365	-0.1408
3	0.9418	-0.1012	0.12	0.0279	-0.0529	-0.073
4	0.9165	-0.0807	0.231	0.1699	0.1014	0.0748
5	0.8898	-0.0338	0.1565	0.0638	0.0507	0.0483
6	0.8615	-0.0509	0.2037	0.0994	0.1216	0.1551
7	0.8318	-0.0384	0.0981	-0.0086	0.0278	0.0785
8	0.8018	-0.0132	0.0662	-0.0459	-0.0095	0.0371
9	0.7706	-0.0407	-0.0107	-0.0817	-0.0773	-0.0607
10	0.7398	0.006	0.0538	0.0073	0.0355	-0.0012
11	0.7083	-0.0347	0.0395	0.0107	0.0254	-0.0195
12	0.6776	0.0148	0.0506	0.0133	0.0161	-0.0142
13	0.6477	0.0052	0.0445	0.0414	0.03	0.0358
14	0.6188	0.0079	0.0453	0.0291	0.0817	0.098
15	0.5897	-0.0335	-0.0415	-0.0676	-0.0394	0.0051
16	0.5607	-0.0216	-0.137	-0.1697	-0.1395	-0.1245
17	0.533	0.0169	-0.0137	0.03	0.0401	0.0045
18	0.5061	0.0019	-0.1158	-0.1125	-0.0871	-0.1707
19	0.4801	-0.0035	-0.0032	0.0485	0.0736	0.0315
20	0.4539	-0.0384	-0.0594	0.0225	0.0274	0.0139
21	0.4275	-0.0268	-0.1127	-0.0812	-0.0736	-0.0505
22	0.4024	0.015	-0.1016	0.0191	-0.0581	0.0146
23	0.3781	0.0036	-0.1201	-0.0691	-0.0757	-0.0862
24	0.3535	-0.0405	-0.0427	0.028	0.0433	0.0303
25	0.3294	-0.0062	-0.0244	0.0223	0.0969	0.0656
26	0.3053	-0.0217	-0.0998	-0.0728	-0.0547	-0.0316
27	0.2824	0.0141	-0.1972	-0.1542	-0.1504	-0.1293
28	0.2596	-0.0201	-0.0705	0.063	0.0585	0.0681
29	0.2374	-0.0053	-0.1947	-0.1313	-0.1009	-0.1338
30	0.2159	-0.001				

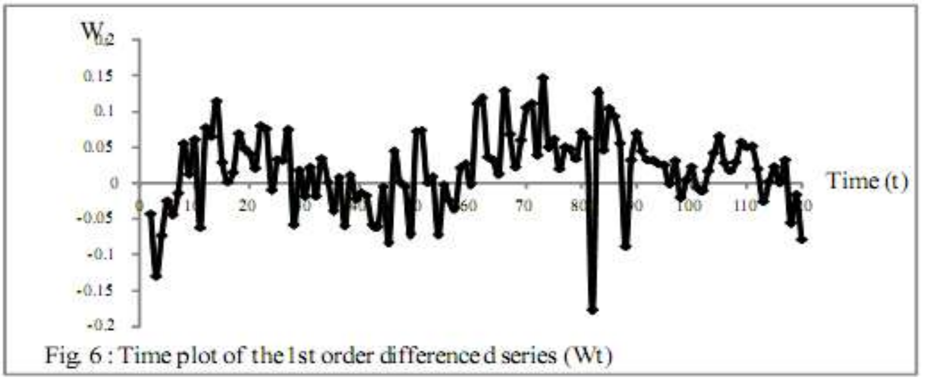

Fig. 6 : Time plot of the 1st order differenced series (Wt)

When compared with the 95% confidence limits $\left(\pm\frac{2}{\sqrt{n}}=\pm 0.1833\right)$ the PACF, on the other hand, appears to have cut-off after lag 2. These suggest that the model to be tentatively entertained is the ARIMA (p, d, q) with p = 2, d = 1 and q = 0.

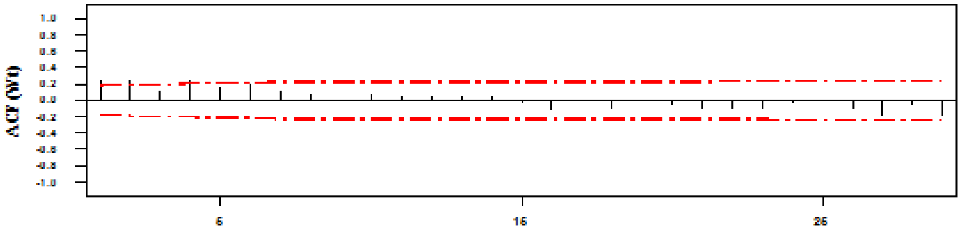

Fig. 7: ACF for first order difference of (W_t)

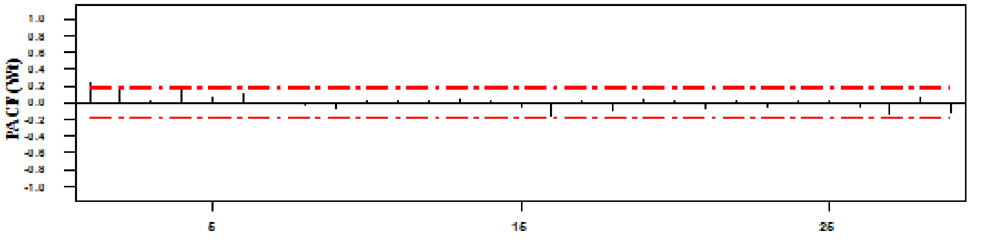

Fig. 8: PACF for first order difference of (W_t)

After model identification and estimation parameters, diagnostic checks were applied to the model to ascertain its adequacy. The suggested model (ARIMA (2,1,0)) was fitted to the differenced transformed series $\left(W_t\right)$and the resultant residuals $\left(e_t\right)$ were evaluated to assess the adequacy of the fitted model. All the ACF and PACF of the residuals$\left(e_t\right)$, also shown in Table 4.1 and Figures 9 and 10, lie within the 95% confidence limits $\left(\pm\frac{2}{\sqrt{n}}=\pm 0.1833\right)$. This indicates that the fitted model is adequate (in terms of residual ACF and PACF) to describe the pattern in the transformed series. The estimates of the parameters of the selected model given by MINITAB software are $\hat{\phi}_1 = 0.1985$ with a standard error of 0.0913, $\hat{\phi}_2 = 0.2329$ with a standard error of 0.0914 and constant $\hat{\phi}_0 = 0.009072$, with a standard error of 0.004716.

The t-value (1.92) associated with the constant indicates that the constant is not significant. Hence, the model is fitted without the constant.

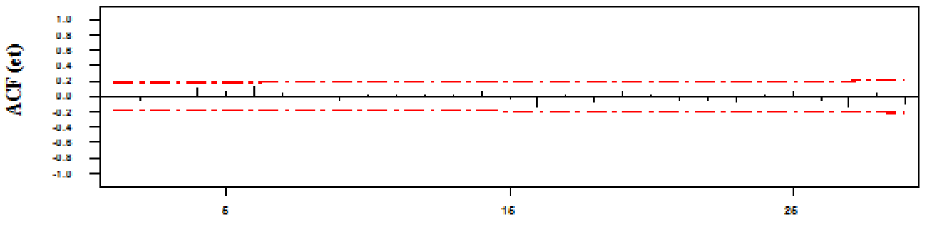

Fig. 9: ACF for residual $(e_t)$from the fitted model

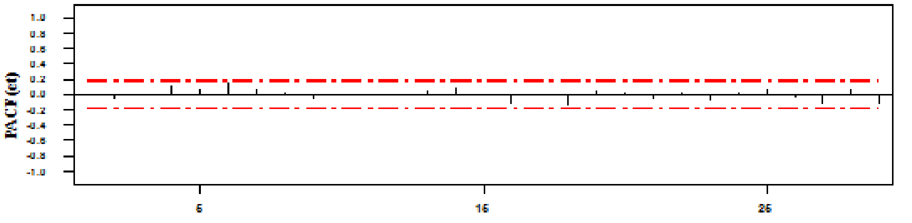

Fig. 10: PACF for residual (e_t) from the fitted model

The estimates of the parameters of the selected model without the constant are $\hat{\phi}_1 = 0.2385$, with a standard error of 0.0893 and $\hat{\phi}_2 = 0.2817$ with a standard error of 0.0893. The t-values, 2.67 associated with $\hat{\phi}_1$ and 3.15 associated with $\hat{\phi}_2$, are both significant even at 1% level of significance. Both parameters also satisfy the stationarity conditions. Hence, the fitted model is

$$\hat{W}_t = 0.2385 W_{t-1} + 0.2817 W_{t-2} \quad (11)$$

where

$$W_t = (1-B)X_t = X_t - X_{t-1} \quad (12)$$

In terms of the transformed series(X_t), the fitted model is

$$\hat{X} = 1.2385 X_{t-1} + 0.0432 X_{t-2} - 0.2817 X_{t-3} \quad (13)$$

This indicates that the current value of the transformed series depends on the three immediate past values of the series.

4.4 Forecasting

One of the objectives of model building is to provide forecasts of future values. In producing the forecasts using the fitted model, it is assumed that the condition(s) under which the model was constructed would persist in the periods for which forecasts are made. If we denote the forecast made at time t_0 for the lead time k by $\hat{X}_{t_0}(k)$, then the estimate of the forecast function $\hat{X}_{t_0}(k)$ is given by

$$\hat{X}_{t_0}(k) = 0.2385\ X_{t_0+k-1} + 0.0432 X_{t_0+k-2} - 0.2317\ X_{t_0+k-3} \quad (14)$$

The corresponding forecast error $\hat{e}_{t_0}(k)$ at lead time k is given by

$$\hat{e}_{t_0}(k) = X_{t_0+k} - X_{t_0}(k) \quad (15)$$

Where X_{t_0+k} is the actual value at $t_0 + k$.

Table 4.2: Actual and forecast of monthly records of Nigeria external reserve 2009 ($x10^6$)

Lead k	t_{0+k}	Months	Actual X_{t_0}	Forecast $\hat{X}_{t_0}(k)$	Error $\hat{e}_{t_0}(k)$	Error $[\hat{e}_{t_0}(1)]^2$	95% confidence limits Lower	Upper
1	121	January	10.8219	10.8536	-0.0317	0.001	10.6323	11.0116
2	122	February	10.7813	10.8249	-0.0436	0.0019	10.5916	10.971
3	123	March	10.7596	10.8112	-0.0516	0.0027	10.5699	10.9493
4	124	April	10.7345	10.7998	-0.0653	0.0043	10.5449	10.9242
5	125	May	10.7108	10.7932	-0.0824	0.0068	10.5211	10.9005
6	126	June	10.6797	10.7884	-0.1087	0.0118	10.49	10.8693
7	127	July	10.6771	10.7854	-0.1083	0.0117	10.4874	10.8668
8	128	August	10.6396	10.7834	-0.1438	0.0207	10.4499	10.8292
9	129	September	10.6769	10.7821	-0.1052	0.0111	10.4872	10.8666
10	130	October	10.6702	10.7812	-0.111	0.0123	10.4806	10.8599
11	131	November	10.6695	10.7806	-0.1111	0.0123	10.4799	10.8592
12	132	December	10.6545	10.7802	-0.1257	0.0158	10.4648	10.8442
MSE						**0.0094**		

Using the model in (4.4) with t_0 = 120, the MINITAB software gave the forecasts $\hat{X}_{t_0}(k), k = 1,2,\ldots,12$ for the 12 months of 2009. The values of the forecast and the actual values are shown in Table 4.2, while the plot of the actual and forecasts are shown in Figure 4. As Figure 4 shows, between 1999 and up to July 2009, the actual and fitted values of the transformed Nigeria external reserve agreed strongly. Table 4.2 also shows that the forecast values lie within two standard deviations from the actual values. However, for the last six months of 2009, the plot of the forecast and actual values given in Figure 5 shows a great disparity between the actual and forecast (with the forecast values being increasingly higher than the actual). This suggests that circumstances under which the model was constructed may have started changing. This is understandable considering the dwindling proceeds from petroleum products from which greater part of the Nigeria external reserve is derived.

5.0 Summary, Recommendation and Conclusion

This work discusses fitting of ARIMA Model to Monthly record of Nigeria external reserve for the period January 1999 to December 2008 obtained from the CBN Statistical Bulletin, Golden Jubilee Edition December 2008, while the 2009 figures were used to assess the forecasting performance of the fitted model. The ultimate objective is to construct a statistical model which may be used to obtain forecasts of future values of Nigeria external reserve necessary for policy formulation, implementation and monitoring. The result of data evaluation (for the assumptions of ARIMA models) shows that the data requires logarithmic transformation to make the distribution normal and stabilize the variance. The logarithmic transformed series was then subjected to Box, Jenkins and Reinsels iterative procedure for model building. The result of the analysis shows that appropriate model for the transformed series is the Auto-regressive Process of order two [AR (2)] after the first order non-seasonal differencing (i.e. Auto-regressive integrated Moving average Process of order (2,1,0) [ARIMA (2,1,0)]. The forecast for the twelve months of 2009 using the fitted model agreed strongly with the actual values at 95 percent level of confidence. This model has therefore been recommended for use in the study of Nigeria external reserve until further studies prove otherwise.

Acknowledgement

Our sincere gratitude is due to CBN for providing the data for this study and the authority of the Federal University of Technology, Owerri for providing the support for this study.

References

AfDB, OECD, UNDP, UNECA (2011). *African Economic Outlook*. Available online at http://www.africaneconomicoutlook.org/fileadmin/uploads/ aeo/Country_Notes/2011/ Full/Nigeria.pdf

Ajakaiye, O. and Fakiyesi, T. (2009). *Global Financial Crisis Discussion Series; Paper 8: Nigeria*. Overseas Development Institute. London.

Archer, D. and Halliday, J. (1998). "The Rationale for Holding Foreign Currency Reserves", *Reserve Bank of New Zealand Bulletin*, 61(4):346 ‑354.

Badmus, M.A. and Ariyo, O.S. (2011). Forecasting Cultivated Areas and Production of Maize in Nigerian using ARIMA Model, Asian Journal of Agricultural Sciences 3(3):171-176

Bartlett, M.S (1947). The use of transformation, Biometric Biometric Bulletin, 3, 36-52.

Box, G.E.P. and Jenkins, G.M. (1976) *Time Series Analysis: Forecasting and Control*, Revised Edition, San Francisco: Holden Day

Box, G.E.P., Jenkins G.M. and Reinsel, G.C. (1994). Time series Analysis; forecasting and control, Prentice-Hall, New Jersey

Central Bank of Nigeria. (2007). The Bullion: Building and Management External Reserves for Economic Development. 31(2).

Central bank of Nigeria. (2005), *Statistical Bulletin*, Vol.16, December.

Dooley, M.P., Folkerts‑Landau, D. and Garber, P. (2004), "The Revived Bretons Woods System", *International Journal of Finance and Economics*, 9(4):307–313.

Etuk, H.E, Uchendu, B., Udo, E.O. (2012). Box-Jenkins Modeling of Nigerian Stock Prices Data, Greener Journal of Science Engineering and Technological Research 2(2):032-038.

Hetamsaria, N. (2007). Application of ARIMA and GARCH Models to forecast the Gold Futures Prices*NICR Workshop.*

Humphries, N. (1990). "External reserves and Management of Risk" *Reserve Bank of New Zealand Bulletin*, 53(3):277‐287.

International Monetary Fund. (2004). Guidelines for foreign Exchange Management, IMF, Washington D.C.

International Monetary Fund. (2003). "Are foreign exchange reserves in Asia too high?" *World Economic Outlook*, Washington, D.C, September.

International Monetary Fund. (2003). Guidelines for Foreign Exchange Reserve Management. IMF, June.

Iwueze I.S., Nwogu E.C., Ohakwe J. and Ajaraogu J.C. (2011), Uses of Buys-Ballot Table in Times Series Analysis,*Applied Mathematics*, 2011, 2, 633-645, (http://www.SciRP.org/journal/am)

Olajide J.T., Ayansola, O.A., Odusina, M.T., Oyenuga, I.F. (2012). Forecasting the Inflation Rate in Nigeria: Box Jenkins Approach, *IOSR Journal of Mathematics (IOSR-JM), ISSN: 2278-5728.* 3(5):5-19, *www.iosrjournals.org*

Mendoza, R.U. (2004). "International Reserve‐Holding in the Developing World: Self Insurance in a Crisis‐Prone Era?" *Emerging Markets Review*, 5(1):61–82.

Nda, A.M. (2006). "Effective Reserves Management in Nigeria: Issues, Challenges, and Prospect", *Central Bank of Nigeria Bullion*, Vol.30, No.3, July –September.

Nwogu, E.C. and Iwu, H.C. (2010). Arima Model of Crude Oil Exports in Nigeria, Journal of Nigerian Association of Mathematical Physics, Volume 17, Pages 285 – 292.

Nugee, J. (2000). *Foreign Exchange Reserves Management Handbooks in Central Banking*, Centre for Central Banking Studies, Bank of England, London.

Pankratz, A., (1983). Forecasting with Univariate Box-Jenkins Model, (New York: John Wiley and Sons).

Soludo, C.C. (2005). “The Challenges of foreign exchange Reserve Management in Nigeria”, *A key Note Address delivered at the UBS Eleventh AnnualReserve Management Seminar*.

Tse, R.Y.C. (1997). An application of the ARIMA model to real-estate prices in Hong Kong, Journal of Property Finance 8(2):152-163.

Turner P. (2007). “Are Banking Systems in East Asia Stronger?” *Asian Economic Policy Review* 2(1):75–95.

UNCTAD (2007). *Activities Undertaken By UNCTAD In Favour Of Africa*, Trade and Development Board, 42nd Executive Session, Geneva, June 27.

UNECA (2009). *The global financial crisis: impact, responses and way forward*. Twenty-eight meeting of the committee of experts. 2-5 June 2009. Cairo, Egypt.

Williams, D. (2003). “The need for Reserves”, in Pringle R. and N. Carver (Eds.), *How Countries Manage Reserve Assets*, Central Banking Publications, London, pp.33‑44.

World Bank (1999). *Global Development Finance 1999*. Washington D.C.: World Bank.

Yuguda, L. (2003). *Management of External Reserves: 13th Annual Internal Auditors Conference*, Central Bank of Nigeria, Kaduna, 27‑30th November.