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FORECASTING OF EXCHANGE RATE BETWEEN NAIRA AND US DOLLAR USING TIME DOMAIN MODEL

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Abstract: *Most time series analysts have used different technical and fundamental approach in modeling and to forecast exchange rate in both develop and developing countries, whereas the forecast result varies base on the approach used or applied. In these view, a time domain model (fundamental approach) makes the use of Box Jenkins approach was applied to a developing country like Nigeria to forecast the naira/dollar exchange rate for the period January 1994 to December 2011 using ARIMA model. The result reveals that there is an upward trend and the 2^nd^ difference of the series was stationary, meaning that the series was I (2). Base on the selection criteria AIC and BIC, the best model that explains the series was found to be ARIMA (1, 2, 1). The diagnosis on such model was confirmed, the error was white noise, presence of no serial correlation and a forecast for period of 12 months terms was made which indicates that the naira will continue to depreciate with these forecasted time period.*

Keywords: Autocorrelation function, Partial autocorrelation function, Auto regressive integrated moving average, Exchange rate, AIC, BIC

1.0 **Introduction**

Most research have been made on forecasting of financial and economic variables through the help of researchers in the last decades using series of fundamental and technical approaches yielding different results. The theory of forecasting exchange rate has been in existence for many centuries where different models yield different forecasting results either in the sample or out of sample. Exchange rate which means the exchange one currency for another price for which the currency of a country (Nigeria) can be exchanged for another country's currency say (dollar). A correct exchange rate do have important factors for the economic growth for most developed countries whereas a high volatility has been a major problem to economic of series of African countries like Nigeria. There are some factors which definitely affect or influences exchange rate like interest rate, inflation rate, trade balance, general state of economy, money supply and other similar macro – economic giants' variables. Many researchers have used multi-variate regression approach to study and to predict the exchange rate base on some of these listed variables, but this has a limitation in the sense that macro- economic variables are available at most monthly period and precisely modeling of such explanatory variable on exchange rate do make explains that a change in unit of each macro- economic variables will definitely lead to a proportion change in the exchange rate. In this view why not exchange rate explains it self that is with the little information of its self can predict its current value and its future value through the use of robust time series or technical model or approaches.

This fundamental approach will generate equilibrium exchange rate. The equilibrium exchange rate will be used for projection and to generate trading signal. The trading signal can be generated every time when there is a significant difference between the model based expected or forecasted exchange rate and the exchange rate observed in the market. The question keeps on moving that what exactly type of approach fits the model for exchange rate? Madura (2006), Giddy (1994), Obrian (2006) Levich (2001), Eun and Resincle (2007) have an extensive coverage on these question, also Eiteman, Stonehill and Moffett (2004) also provided the answers but the later authors believe it is futile to forecast exchange rate in as efficient market. In recent years a number of related formal models for time varying variance have been developed so in this research, we are incorporating a univariate model to justify truly whether past values of Nigeria (naira) against the US (dollar) can predicts its current value and its future value using time modeling techniques ARIMA which is the fundamental approach which spins from the period January 1994 to December 2011. The fundamental approach encompasses both structural adjustment program and the foreign exchange market. The purpose of introducing this fundamental approach is to appreciate or to normalized in order to bring about improvement in trade to better Nigeria economy since the introduction of the structural adjustment program. The remainder of this research work is section as; section 2 focuses on the purpose introduction of structural adjustment program on Nigeria exchange rate, section 3 describes the literature review, section 4 focuses on the source of data and modeling cycle section 5 focuses on the empirical results and discussion.

2.0 **Effect of Structural Adjustment Program**

In 1986, Nigeria adopted the structural adjustment programme (SAP) of the IMF/World Bank. With the adoption of SAP in 1986, there was a radical shift from inward-oriented trade policies to out ward –oriented trade policies in Nigeria. These are policy measures that emphasize production and trade along the lines dictated by a country's comparative advantage such as export promotion and export diversification, reduction or elimination of import tariffs, and the adoption of market-determined exchange rates. Some of the aims of the structural adjustment programme adopted in 1986 were diversification of the structure of exports, diversification of the structure of production, reduction in the over-dependence on imports, and reduction in the over-dependence on petroleum exports. The major policy measures of the SAP were:

- Deregulation of the exchange rate
- Trade liberalization
- Deregulation of the financial sector
- Adoption of appropriate pricing policies especially for petroleum products.
- Rationalization and privatization of public sector enterprises and
- Abolition of commodity marketing boards.

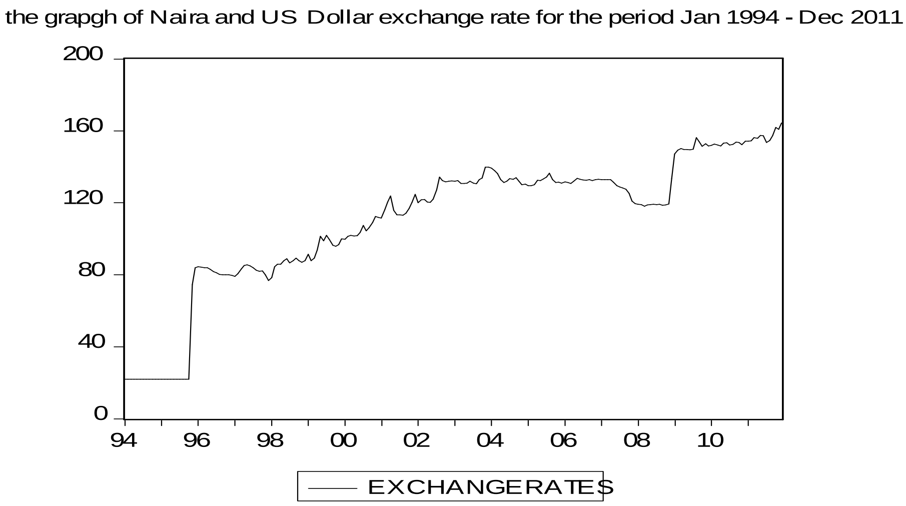
3.0 **Literature Review**

Most researchers have done a great research on forecasting of exchange rate for developed and developing countries using different approaches. The approach might vary in either fundamental or technical approach. Like the work of Ette Harrison (1998), used a technical approach to forecast Nigeria naira – US dollar using seasonal ARIMA model for the period of 2004 to 2011. He reveals that the series (exchange rate) has a negative trend between 2004 and 2007 and was stable in 2008. His good work expantiate on that seasonal difference once produced a series SDNDER with slightly positive trend but still within discernible Stationarity. M.K Newaz (2008) made a comparison on the performance of time series models for forecasting exchange rate for the period of 1985 – 2006. He compared ARIMA model, NAÏVE 1, NAÏVE 2 and exponential smoothing techniques to see which one fits the forecasts of exchange rate. He reveals that ARIMA model provides a better forecasting of exchange rate than either of the other techniques; selection was based on MAE (mean absolute error), MAPE (mean absolute percentage error), MSE (mean square error), and RMSE (root mean square error). Further work, Olanrewaju I. Shittu and Olaoluwa S.Y (2008) try to measure the forecast performance of ARMA and ARFIMA model on the application to US/UK pounds foreign exchange. They reveal that ARFIMA model was found to be better than ARMA model as indicates by the measurement criteria. Their persistent result reveals that ARFIMA model is more realistic and closely reflects the current economic reality in the two countries which was indicated by their forecasting evaluation tool. They found out that their result was in conferment with the work of Kwiatkowski et. al. (1992) and Boutahara. M. (2008). Shittu O. I (2008) used an intervention analysis to model Nigeria exchange rate in the presence of financial and political instability from the period (1970 - 2004). He explains that modeling of such series using the technique was misleading and forecast from such model will be unrealistic, he continued in his findings that the intervention are pulse function with gradual and linear but significant impact in the naira – dollar exchange rates. S.T Appiah and I.A Adetunde (2011) conducted a research on forecasting exchange rate between the Ghana cedi's and the US dollar using time series analysis for the period January 1994 to December 2010. Their findings reveal that predicted rates were consistent with the depreciating trend of the observed series and ARIMA (1, 1, 1) was found to be the best model to such series and a forecast for two years were made from January 2011 to December 2012 and reveals that a depreciation of Ghana cedi's against the US dollar was found.

4.0 **Data Source.**

In carrying out this research, a monthly time series data on Nigeria exchange rate (naira against the US dollar) for period from January 1994 to December 2011 was collected from the website www.oanda.com. This data has two components, the dependent variable and independent variable. The dependent variable is the exchange rate while the independent variable is the time and time component is in months. Table (1) shows the time plot of the series which aids to know the presence of outliers and the judge for Stationarity.

Graph (1)



4.1 ***Research methodology***

4.1.1***Modeling Approach***

To fulfill the objective of this research, we will be using simple time domain techniques (ARIMA model) to forecast the naira and dollar exchange rate for the period from Jan 1994 to Dec 2011. The simple ARIMA model description is covered on Box – Jenkins methodology. The ARIMA encompass three components, AR, MA, and integrated series. AR stands for the autoregressive model i.e. regressing the dependent variables with linear combination of its past values or lagged values, MA stands for moving average model i.e. regressing the dependent error with linear combination of its past error or lagged error or innovation and I stands for the differencing order, that is number of difference applied on the stochastic process before attaining to stationary. The model is

$$Z_t = \mu + \varphi_1 z_{t-1} + \varphi_2 z_{t-2} + ...\varphi_p z_{t-p} + \theta_1 e_{t-1} - \theta_2 e_{t-2} - ....\theta_q e_{t-q} + a_t$$

$$Z_t = \mu + \frac{\theta(B)}{\varphi(B)} a_t ,$$

Where t = index time, μ = mean term, B is the back shift operator

$\varphi(B)$ = AR operator represented as a polynomial in the back shift operator

$\theta(B)$ = MA operator represented as a polynomial in the back shift operator

a_t = independent disturbance term or random error

The general form of ARIMA is (p, d, q), where p stands for the number of periods in the past for AR, q stands for the number of periods in the past for MA, and d stands for integrating order.

There are three steps we will take to achieve our aims, and these are listed as (1) model identification (2) model estimation (3) model diagnostic and forecasting accuracy.

4.1.2 ***Model identification***

The first thing to do is to test for Stationarity of the series (naira and dollar exchange rate) using three different approach. The approach are (i) observing the graph of the data to see whether it moves systematically with time or the ACF and the PACF of the stochastic process (exchange rate) either to see it decays rapidly to zero, (ii) by fitting AR model to the raw data and test whether the coefficient "θ" is less than using the wald test or (iii) we fit the Argumented Dickey Fuller test on the series by considering different assumptions such as under constancy, along with no drift or along a trend and a drift term. If found out that the series is not stationary at level, then the first or second difference is likely to be stationary and this is also subject to the three different approach above.

4.1.3 ***Model Estimation***

Once stationary is attained, next thing is we fit different values of p and q, and then estimate the parameters of ARIMA model. Since we know that sample autocorrelation and partial autocorrelations are compared with the theoretical plots, but it's very hardly to get the patterns similar to the theoretical plots one, so we will use iterative methods and select the best model based on the following measurement criteria relatively AIC (Alkaike information criteria) and BIC (Bayesian information criteria), and relatively small SEE (standard error of estimate).

4.1.4 ***Model Diagnosis***

The conformity of white noise residual of the model fit will be judge by plotting the ACF and the PACF of the residual to see whether it does not have any pattern or we perform Ljung Box Test on the residuals. The null hypothesis is:

$$H_0 = \text{ there is no serial correlation}$$
$$\text{H}_1 = \text{ there is serial correlation}$$

The test statistics of the Ljung box is $LB = n(n+2)\sum_{k=1}^{m}\frac{\rho_k^2}{n-k}$........................ $\chi^2(m)$

where n is the sample size, m = lag lenth
and ρ is the sample autocorrelation coefficient

The decision: if the LB is less than the critical value of X^2, then we do not reject the null hypothesis. These means that a small value of Ljung Box statistics will be in support of no serial correlation or i.e. the error are normally distributed. This is concerned about the model accuracy.

When steps 1-3 is achieved, we go ahead and fit the model, and thereby we will now perform a meta-diagnosis on the model fit. The meta- diagnosis will aid us to know the forecasting, reliability, accuracy ability which will be judge under the coefficient of determination or through the use of the smallest mean square error or other smallest measurement tools like MAE (mean absolute error, MAPE (mean absolute percentage error), RMSE (root mean square error), MSE(mean square error).

5.0 Empirical result

In other not to have a spurious result from the series, we subjected the series to stationary test using three different approaches. The approaches are plotting the time plot, fitting of auto-regression model (1) on the series and test on the coefficient whether less than one using the wald test, and ADF test on the series. Table (1) reports that there is an upward trend in the series and the series tends to be moving with time which indicates that the series is not stationary. To justify the time plot, table (2), table (3), table (4) reports the AR (1), the Wald test restriction on the coefficient of the AR (1) model and ADF test at different assumptions and table (5) presents the ACF and the PACF respectively at level form.

Table (2)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
AR(1)	1.003849	0.002551	393.5889	0.0000
R-squared	0.986358	Mean dependent var		110.9527
Adjusted R-squared	0.986358	S.D. dependent var		37.30067
S.E. of regression	4.356758	Akaike info criterion		5.785974
Sum squared resid	4062.007	Schwarz criterion		5.801651
Log likelihood	-620.9922	Durbin-Watson stat		1.601346
Inverted AR Roots	1.00			
	Estimated AR process is non-stationary			

Table (3)

Wald Test:
Equation: Untitled

Null Hypothesis:	C(1)=1		
F-statistic	2.276923	Probability	0.132787
Chi-square	2.276923	Probability	0.131312

Table (4)

ADF TEST							
		Test statistics			**Coefficient**		
	variable	Intercept	Intercept & Trend	None	Intercept	Intercept & Trend	None
At Level	**Exchange rate**	-1.919	-2.69	1.12	-0.0149	-0.0046	0.0028
1st Diff		-9.77	-9.8	-9.52	-0.8569	-0.864	-0.82
2nd Diff		-16.19	-16.15	-16.23	-1.77	-1.77	-1.77
Critical value		1% -3.46 5% -2.87 10% -2.57	1% -4.00 5% -3.43 10% -3.13	1% -2.57 5% -1.94 10% -1.6			

Table (5) At level form

	ACF	PACF	Q-Stat	Prob
1	0.976	0.976	208.50	0.000
2	0.949	-0.057	406.76	0.000
3	0.923	-0.016	594.91	0.000
4	0.897	0.009	773.59	0.000
5	0.872	-0.005	943.19	0.000
6	0.847	-0.005	1104.1	0.000

7	0.822	-0.018	1256.4	0.000
8	0.797	-0.017	1400.2	0.000
9	0.772	-0.016	1535.7	0.000
10	0.747	-0.013	1663.1	0.000

ACF = autocorrelation function, PACF = partial autocorrelation function

From the result in table (2), the coefficient is 1.003849, mere looking at it is not valid, since its value is greater than one. A further prove of rejection of 1.003849 was made in table (3) which reports that the probability of having a larger value of 2.2764 and 2.2769 for F stat and chi – square respectively is greater than the exact probability 5% which indicates that the series is not stationary. Further prove stills reveals at ADF test, where at level form, the series is not also stationary because at each assumptions; intercept, intercept and trend, none i.e. no drift, each ADF test statistics were less than the corresponding critical value of level of significance despite valid in each coefficients. But at 1st difference and 2nd difference, the ADF test statistics at each assumption respectively were greater than the critical value at each level of significance. Hence we indicate that or believe that the series is either I (1) or I (2). Further prove of nonstationary of the series was confirmed through the ACF and the PACF in table (5). This reports that from lag 1 to lag 10, there is a slow decay or decrease; this slow decay means the series is not stationary. In summary of Stationarity we conclude that base on the use ADF test the series is either integrated at order 1 or integrated at order 2. So we used both I value at order 1 and order 2 to compute various ARIMA model, and the best selected model is selected base on the smallest AIC and BIC. Table 6 reports the various ARIMA model.

Table (6)

S/n	**p d q**			**AIC**	**BIC**	**S.E**	**LOGL**
1	1	1	1	1238.299	1245.04	4.2891	-617.149
2	1	1	2	1240.252	1250.36	4.2987	-617.126
3	1	1	3	1242.201	1255.68	4.308	-617.1008
4	1	1	4	1244.201	1261.05	4.3186	-617.1008
5	1	1	5	1246.160	1266.38	4.3285	-617.0802
6	2	1	1	1240.2248	1250.336	4.298	-617.1124
7	2	1	2	1242.1938	1255.676	4.308	-617.0969
8	2	1	3	1242.856	1259.709	4.288	-616.428
9	2	1	4	1244.1768	1264.400	4.274	-616.088
10	2	1	5	1246.720	1270.314	4.300	-616.360
11	1	2	1	1235.920***	1242.65***	4.2744***	-615.9602
12	1	2	2	1237.197	1247.295	4.2765	-615.598
13	1	2	3	1239.121	1252.585	4.285	-615.560
14	1	2	4	1241.088	1257.918	4.295	-615.544
15	1	2	5	1243.406	1263.602	4.309	-615.7033
16	2	2	1	1237.128	1247.226	4.275	-615.564
17	2	2	2	1239.382	1252.846	4.288	-615.6911
18	2	2	3	1240.951	1257.780	4.293	-615.475

19	2	2	4	1242.999	1263.194	4.3048	-615.499
20	2	2	5	1244.947	1268.509	4.315	-615.473
21	3	1	1	1242.213	1256.695	4.30854	-617.1066
22	4	1	1	1244.209	1261.063	4.318	-617.1049
23	5	1	1	1246.092	1266.316	4.327	-617.046
24	3	2	1	1239.7710	1253.234	4.2933	-615.885
25	4	2	1	1241.392	1258.222	4.299	-615.696
26	5	2	1	1243.069	1263.265	4.3058	-615.534

AIC = Alkaike information criteria, BIC = Bayesian information criteria, S.E = standard error of estimate LOGL = log likelihood

Base on the selection criteria AIC, BIC and S.E of estimate, the above table shows that ARIMA (1, 2, 1) was selected to be the best model. Hence table (7) presents the model estimates.

Table (7) ARIMA (1,2,1)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
AR(1)	0.200568	0.068157	2.942749	0.0036
MA(1)	-0.995690	0.007840	-127.0043	0.0000
R-squared	0.396452	Mean dependent var		0.017116
Adjusted R-squared	0.393592	S.D. dependent var		5.528514
S.E. of regression	4.305177			
Sum squared resid	3910.789			
Log likelihood	-612.1705	F-statistic		138.5994
Durbin-Watson stat	1.976058	Prob(F-statistic)		0.000000

The model equation is ex rate = $0.200568exrate_{t-1}$ $-0.99569e_{t-1}$ $+\varepsilon_t$

Table (8) Residual test.

	AC	PAC	Q-Stat	Prob
1	0.005	0.005	0.0056	
2	-0.051	-0.051	0.5756	
3	-0.034	-0.033	0.8251	0.364
4	-0.006	-0.009	0.8337	0.659
5	-0.025	-0.028	0.9667	0.809
6	-0.048	-0.050	1.4711	0.832
7	-0.001	-0.004	1.4711	0.916
8	0.022	0.015	1.5760	0.954
9	-0.027	-0.031	1.7371	0.973
10	-0.012	-0.012	1.7687	0.987

Table (9) Portmanteau and ljung Box test for serial correlation test

Test type	Test Stat	p - value
portmanteau	1.4369	0.6969
Ljung Box	1.4659	0.6902

From table (7), the coefficient of ARIMA(1,2,1) model were valid and stationary condition was met and satisfied since the coefficients are both less than one (0.200568 and-0.9956) and both are also significant since their p – value are less than 0.05 and at 0.01. This is also justified by the p – value of F value (0.000) was less than the exact probability (0.05), these means that the overall significance of the coefficients of ARIMA (1, 2, 1) was rejected and hence both AR (1) and MA (1) thus explain the series. The accuracy of the model is also reported by comparing the R^2 (0.36) and the Durbin statistics (1.97), R^2 tends to be lower than the DB statistics which is in accordance of a good model. Further model accuracy was reported in table (8), where the ACF and the PACF of the error were presented. These reports indicate that the errors are normal distributed (white noise), independent of time in essence they are random. From both ACF and the PACF, their values at lag 1 up to lag 10 hovers around the zero line, this makes the model valid and adequate. Also concentrating on its p –value from lag 3 up to lag 10, each p –value were greater than the exact p – value (0.05) which indicates that from lag 3 to lag 10 the hypothesis of (no serial correlation) was not rejected. The above statement is also confirmed in table (9) where it reports the ljung Box and portmanteau test; each p –value (0.6969 and 0.6902) were greater than the observed p – value (0.05) which confirms the presence of no serial correlation. With these result is in accordance with the result of Eiteman, Stonehill and Moffett (2004) incurring that past values and present values of dependent variable do predict its future values base on fundamental approach.

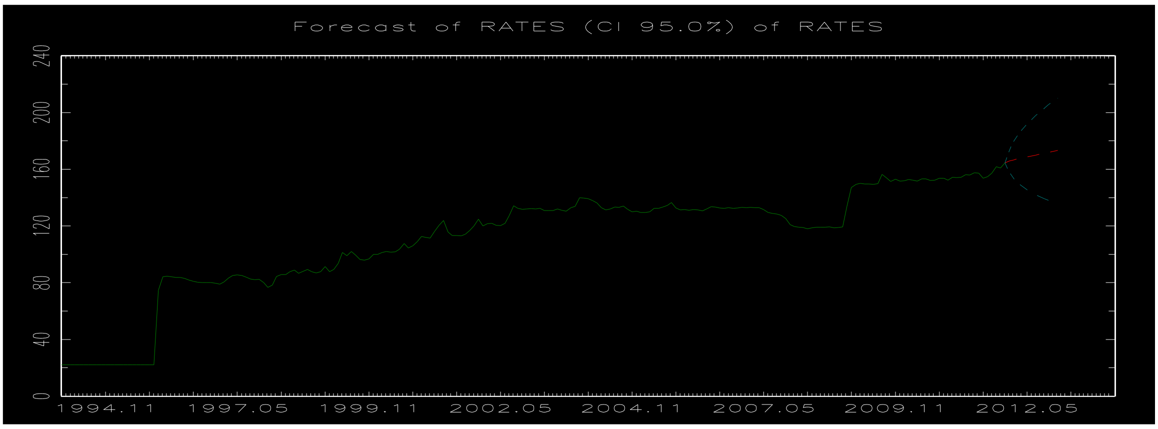
After we had subjected the model (1, 2, 1) to diagnosis testing and confirmed that the model is adequate, we proceed ahead and did an out sample forecast for period of 12 months terms. Table (10) presents the model to have a minimum mean square error 2.29 and mean absolute percentage error of 91.707 and graph 2 displays that the Nigeria (naira) will continue to depreciate for the period forecasted.

Table (10)

Forecast sample: 1994:01 2011:12
Adjusted sample: 1994:04 2011:12
Included observations: 213

Root Mean Squared Error	5.515497
Mean Absolute Error	2.290046
Mean Absolute Percentage Error	91.07981

Graph (2): Forecast of Naira – Dollar exchange rate for period 1994:1 – 2012:12



6.0 Conclusion

This research aims to identify a time domain model forecast for Nigeria (naira) and dollar exchange rate for the period of January 1994 to December 2011 through the use of Box Jenkins fundamental approach. The modeling cycle was in three stages, the first stage was model identification stage, where the series was not non- stationary at level form base on the result provided by ADF test, wald test restriction on the coefficient of AR(1) model and time plot. It was found out that the series was stationary at the 2^{nd} difference. Base on the selection criteria AIC and BIC, reports show that ARIMA (1, 2, 1) was selected and to be the best model to fit the data. The second stage was the model estimation, where the parameters conforms to the stationary conditions (less than one) and finally the third stage was model diagnosis where the errors derived from the model (1,2,1) was normally distributed, random (no time dependence) and no presence of error serial correlation. An out sample forecast for period of 12 months term was made, and this shows that the naira will continue to depreciate on US dollar for the period forecasted.

The policy implication of this research for policy decision makers which makes use of forecasting as a control for economic and financial variables is meant for them to incorporate fiscal policies, monetary and devaluation method to stabilize naira exchange rate and thereby eliminating over dependence on imports.

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