Modeling of Determinants of Exchange Rate in Nigeria (1991-2017) ARDL/Long –Run form of Bound Test Methodology

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Abstract
The study modeled the determinants of exchange rate in Nigeria within the period 1991 to 2017. The data used were sourced from Central Bank of Nigeria (CBN) statistical database Website. The (Auto Regressive Distributed Lag) ARDL /Long Run Form and Bound Test Method were applied to build a suitable model for the variables selected. Results reveals that coefficient of lag values of exchange rate are significant with lags 2 and 3 being negative. Secondly the optimal lag of crude oil price is 2 and is significant though it is negative. We observe also that the coefficient of interest rate is negative but not significant. The study concludes that the major determinants of exchange rate are past year values of exchange rate and past year values of crude-oil price, while interest rate is not a major determinant of exchange rate. The coefficient associated with the Error Correction Model (ECM) is -0.5553 which is negative. This result shows that at least 55.5% of any movements into disequilibrium between exchange rate and its selected economic variables are corrected within one period. The study recommends that sound policies and management should be consolidated on the lag impact in order to improve Nigeria's economy, since the lag or past values of exchange rate influence the future value.

1.0 Introduction

Exchange rate is among the determinants used in evaluating economic growth of a nation. According to (Jhingan, 2005), exchange rate refers to the amount at which a country's currency exchanges for another. It is also referred to as the price of a country's currency with respect to another country's currency. Exchange rate depreciates when the amount of money required to purchase a foreign currency increases, on the other hand, it will appreciates if the amount of domestic currency required to purchase a foreign currency reduces. A very strong exchange rate is an indication of a viable and strong economy. While a very weak exchange rate is an indication of a very weak economy.

Since mid-1980s, the exchange rate between the naira and other currencies of the world especially the US dollar has been very volatile. It fluctuates on hourly, daily and even weekly basis; in fact there is no limit to its variability. This fluctuation has made the naira to be unstable and its value difficult to ascertain. Over the years the issue of exchange rate has been disturbing and has become a huge concern to policy maker, policy analysts, domestic and foreign investors etc.

Apparently the significance of exchange rate stability in the attainment of the macroeconomics policy objectives both in the developed and the developing economies cannot be over emphasized.

As a result of this problem, some economic variables with varying views on the explanation of exchange rate dynamics have been considered and listed as; crude-oil price, interest rate, among others. In view this, this study seeks to model and figure out the key determinants of exchange rate in Nigeria by means of ARDL/Long Run Form Bound Test Methodology.

2.0 Methodology

The data used in this research paperwas obtained from the Central Bank of Nigeria (CBN) statistical database Website. Variables used are monthly data on Nigeria Exchange Rate (US Dollar/Naira), Crude-Oil Prices (US Dollar/Barrel) and Interest Rate (Naira) within the period 1991-2017.

2.1 Model Specification

The ARDL is used to model the data (economic variables) in a single equation time series set-up. The basic ARDL Model specification for the Bound Test methodology order (p q r) takes the form;

$$Y_t = \beta_0 + \sum_{i=1}^{\rho} \beta_i Y_{t-1} + \sum_{i=1}^{q} \alpha_i X_{t-1} + \sum_{i=1}^{r} \eta_i W_{t-1} + \mu_t \quad (3.1)$$

Where;

Y_t = Exchange rate (dependent variable)
X_t = Crude Oil Price (independent variable)
W_t = Interest rate (independent variable)
U_t = Error term

2.2 Unit Root Test

Before estimating the model in equation (3.1), we examine the time series properties of the data using Augmented Dickey Fuller (ADF). The reason is to ensure the variables (series) to be used are integrated of order I(d) with d<2. That is I (d) is either I(0) or I(1)

2.3 Co-integration Test

For a co-integrated data set, a standard ECM takes the form;

$$\Delta \mathbf{Y_t} = \beta_0 + \sum_{i=1}^{\rho} \beta_i \Delta Y_{t-1} + \sum_{i=1}^{q} \alpha_i \Delta X_{t-1} + \sum_{i=1}^{r} \eta_i \Delta W_{t-1} + \varphi \mathbb{Z}_{t-1} + \varepsilon_t \quad (3.2)$$

Here ƶ,which is the error-correction term also known as the OLS residual obtained from the long-run co-integration regressionis specified as;

$Y_t = a_0 + a_1 W_t + a_2 W_t + e_t$ (3.3)

The equation (3.3) above shows that $ƶ_{t-i}$ is of the form;

$ƶ_{t-i} = Y_{t-1} - a_0 - a_1 X_{t-1} - a_2 W_{t-1}$ (3.4)

The next step is to formulate the conditional ECM (Pesaram *et al*, 2001), otherwise called unrestricted ECM or unconstrained ECM. It is of the form;

$$\Delta Y_t = \beta_0 + \sum_{i=1}^{\rho} \beta_i \Delta Y_{t-1} + \sum_{i=1}^{q} \alpha_i \Delta X_{t-1} + \sum_{i=1}^{r} \eta_i \Delta W_{t-1} + \theta_0 Y_{t-1} + \theta_1 X_{t-1} + \theta_2 W_{t-1} + Y_t \quad (3.5)$$

2.4 Bound Test

To perform the bound test we recall equation (3.5) as follows;

$$\Delta Y_t = \beta_0 + \sum_{i=1}^{\rho} \beta_i \Delta Y_{t-1} + \sum_{i=1}^{q} \alpha_i \Delta X_{t-1} + \sum_{i=1}^{r} \eta_i \Delta W_{t-1} + \theta_0 Y_{t-1} + \theta_1 X_{t-1} + \theta_2 W_{t-1} + v_t \quad (3.5)$$

We proceed to conduct an F-test of the Null hypothesis H_0; $\theta_0=\theta_1=\theta_2=0$ versus the alternative that H_0 is not true. H_0 is equivalent to absence of long-run equilibrium between variables. This non-existence implies that coefficient of y_{t-1},x_{t-1} and w_{t-1} are equal to zero. If H_0 is rejected, then it means is a long run relationship exists.Often time problem encountered at this stage is that the distribution of the test statistics (F) is totally not-standard. The precise critical values for the F-statistics are unavailable for an arbitrary basket of I(0) and I(1) variables. Therefore we resort to Pesaram *et al.* (2001) provision of bounds on the critical values for the asymptotic distribution of the F-statistics. The table of critical values has lower bound and upper bound. The lower bound is of the assumption that all the variables are I(0) while the upper bound is of the assumption that all the variables are I(1).

2.5 Result Evaluation

If the calculated F-statistics falls beneath the lower bound, it is an indication that the variables are I(0), and implies no co-integration, on the other hand if it is higher than the upper bound, it is an indication of co-integration. The test is declared inconclusive if the F-statistics lies between the upper and lower bounds.

However, a situation where the bound test indicates existence of co-integration, weproceed to compute the long-run relationship between the variables.

$Y_t= a_0 + a_1 X_t+ a_2W_t + e_t$ (3.6)

and the usual ECM

$$\Delta Y_t = \beta_0 + \sum_{i=1}^{\rho}\beta_i \Delta Y_{t-1} + \sum_{i=1}^{q}\alpha_i \Delta X_{t-1} + \sum_{i=1}^{r}\eta_i \Delta W_{t-1} + \varphi \mathcal{Z}_{t-1} + \varepsilon_t \quad (3.7)$$

Where;

$z_{t-1}= Y_{t-1}-a_0 - a_1 x_{t-1} -a_2w_{t-1}$and α,η and $\beta$are the OLS coefficient estimates in equation (3.7). We can obtain the long-run effect from the unrestricted ECM captured in equation (3.5) and noting that at lung-run equilibrium, $\Delta y_t=\Delta x_t=\Delta w_t=0$ and the lung-run coefficient for x_t and w_t are $-(\theta_1/\theta_0)$ and (θ_2/θ_0) respectively.

2.6 Model Diagnostic

To validate if the model is a good fit to the data, the residuals are tested for the presence of serial correlation, heteroskedasticity and dynamic Stability.

3.0 Results

The result of the unit root test for the series EXCR, COILP and INTR are shown in Table 3.1 below.

Table 3.1: Result of Unit Root Test for EXCR, COILP, and INTR

S/N0	Variables	Probability	Lag	Observation
1	EXCR	0.9978	16	307
2	COILP	0.3585	0	322
3	INTR	0.3386	0	323

Source: Researcher's Computation using Eview software version ten

The result of the unit root test for the first difference series DEXCR, DCOILP and DINTR are shown in Table 3.2 below.

Table 3.2: Result of Unit Root Test for DEXCR, DCOILP and DINT

S/N0	Variables	Probability	Lag	Observation
1	DEXCR	0.0005	16	306
2	DCOILP	0.0000	0	322
3	DINTR	0.0000	0	322

Source: Researcher's Computation using Eview software version ten

The result of the ARDL Regression for the series DEXCR, DCOILP and DINTR are shown in Table 3.3 below.

Table 3.3: Result of ARDL Regression

Variables	Coefficient	Std. Error	t-statistics	Probability
DEXCR(-1)	0.311093	0.055071	5.648999	0.0000
DEXCR(-2)	-0.089156	0.057642	-1.564729	0.1230
DEXCR(-3)	-0.066837	0.058051	-1.151351	0.2505
DEXCR(-4)	0.289507	0.055422	5.223646	0.0000
DCOILP	0.126954	0.098247	1.291839	0.1974
DCOILP(-1)	-0222694	0.101788	-2.187810	0.0294
DCOILP(-2)	-0.191156	0.097665	-1.957269	0.0512
DINTR	-0.053028	0.561430	-0.094451	0.9248
EXCR(-1)	-0.008774	0.006823	-1.285985	0.1994
COILP(-1)	-0.012386	0.016445	-0.753171	0.4519
NTR(-1)	-0.217219	0.151252	-1.436137	0.1527
C	4.1568220	2.329506	-1.784164	0.0754
F-statistics = 6.615014				
Probability of (F-statistics) = 0.000000				

Source: Researcher's Computation using Eview software version ten

The result of the Serial Correlation Test for the series EXCR, COILP and INTR are shown in Table 3.4 below.

Table 3.4: Result of Serial Correlation Test

F-statistic	1.989752	Prob. F(2,305)	0.1385
Obs*R-squared	4.108562	Prob. Chi-Squared(2)	0.1282

Source: Researcher's Computation using Eview software version ten

The result of the Heteroskadasticity Test for the series DEXCR, DCOILP and DINTR are shown in Table 3.5 below.

Table 3.5: Result of Heteroskadasticity Test

F-statistic	35.13038	Prob. F(11, 307)	0.0000
Obs*R-squared	177.7710	Prob. Chi-square(11)	0.0000
Scaled explained SS	1669.428	Prob. Chi-square(11)	0.0000

Source: Researcher's Computation using Eview software version ten

The result of the Corrected ARDL Regressionfor the series DEXCR, DCOILP and DINTR are shown in Table 3.6 below.

Table 3.6: Result of Corrected ARDL Regression

Variables	**Coefficient**	**Std. Error**	**t-statistics**	**Probability**
DEXCR(-1)	0.311093	0.027650	11.25117	0.0000
DEXCR(-2)	-0.089156	0.027034	-3.297836	0.0011
DEXCR(-3)	-0.066837	0.026805	-2.493415	0.0132
DEXCR(-4)	0.289507	0.044368	6.525132	0.0000
DCOILP	0.126954	0.092485	1.372704	0.1708
DCOILP(-1)	-0.222694	0.116999	-1.903375	0.0579
DCOILP(-2)	-0.191156	0.043660	-4.378335	0.0000
DINTR	-0.053028	0.248988	-0.212972	0.8315
EXCR(-1)	-0.008774	0.002389	-3.672015	0.0003
COILP(-1)	-0.012386	0.010690	-1.158622	0.2475
INTR(-1)	-0.217219	0.132362	-1.641100	0.1018
C	4.156220	1.918713	2.166150	0.0311

F-statistics = 6.6155015
Probability of (F-statistics) = 0.000000

Source: Researcher's Computation using Eview software version ten

The result of the ARDL Long Run Form and Bound Test for the series DEXCR, DCOILP and DINTR are shown in Table 3.7 below.

Table 3.7: Result of ARDL Long Run Form and Bound Test

Variable	Coefficient	Std. Error	t-Statistic	Prob.
DCOILP	-0.516565	0.159395	-3.240788	0.0013
DINTR	-0.095478	0.448542	-0.212862	0.8316
EC=DEXCR – (-0.5166*DCOILP -0.0955*DINTR)				
F-Bound Test				
Test Statistic	Value	Significance	I(0)	I(1)
F-statistic	13.89112	10%	3.17	4.14
K	2	5%	3.79	4.85
		2.5%	4.41	5.52
		1%	5.15	6.36
t-Bound Test				
Test Statistic	Value	Significance	I(0)	I(1)
t-statistic	-6.042801	10%	-2.57	-3.21
		5%	-2.86	-3.53
		2.5%	-3.13	-3.8
		1%	-3.43	-4.1

Source: Researcher's Computation using Eview software version ten

The result of the ECM for the series DEXCR, DCOILP and DINTR are shown in Table 3.8 below.

Table 3.8: Result of ECM

Variable	Coefficient	Std. Error	t-Statistic	Probability
C	4.156220	2.313020	1.796880	0.0733
D(DEXCR(-1))	-0.133514	0.075658	-1.764715	0.0786
D(DEXCR(-2))	-0.222670	0.064119	-3.472735	0.0006
D(DEXCR(-3))	-0.289507	0.053645	0.053645	0.0000
D(COILP	0.126954	0.088347	1.436995	0.1517
D(DCOILP(-1))	-0.191156	0.088021	2.171719	0.0306
EXCR(-1)	-0.086774	0.006772	-1.295629	0.1961
COILP(-1)	-0.012386	0.016328	-0.758567	0.4487
INTR(-1)	-0.217219	0.149735	-1.450690	0.1479
CointEq(-1)*	-0.555393	0.085755	-6.476484	0.0000

Source: Researcher's Computation using Eview software version ten

The result of Wald Test for the series DEXCR, DCOILP and DINTR are shown in Table 3.9 below.

Table 3.9: Result of Wald Test

Test Statistic	Value	df	Probability
F-statistic	4.731374	(3, 307)	0.0030
Chi-square	14.19412	3	0.0027

Source: Researcher's Computation using Eview software version ten

4.0 Discussion

Unit Root test was conducted to ensure stationarity. The result in Table 3.1indicates that the series EXCR, COILP and INTRhave unit roots with p-values > 0.05, while the unit root result in Table 3.2 with first difference confirms that the series DEXCR, DCOILP and DINTR do not have unit root as the p-values < 0.05.

The ARDL Regression is shown in Table 3.3 with the outcome being (4, 2, 0) for the series DEXCR, DCOILP and DINTR.

The ARDL Regression residual in Table 3.4 is tested for serial correlation. Theresultshows that there is no serial correlation since F-statistic p-value is = 0.1385 and > 0.05.

In table 3.5, theARDL Regression residuals are tested for heterosckeasticity. The output shows presence of heterosckeasticity with the p-value of F-statistic = 0, to solve this problem; we use the HAC covariance matrix adjustment and re-compute the regression. The corrected ARDL

Regression output in table 3.6 has better result with respect to the coefficients compared to output in table 3.3.

The ARDL Long Run and Bound Test result in table 3.7, shows that the F-statistic is = 13.89112, and>I(1) critical value, this indicates there is equilibrating relationship between the variables. More so, the absolute value of the t-statistic is /-6.042801/ = 6.042801, is > the absolute value of either the I(0) or I(1) t-Bound, again this suggests that a Long Run or Co-integrating relationship exist among the time series variables.
This paper considers crude-oil price as one of exchange rate determinants rather than Gross Domestic Product (GDP) because Nigerian economy is oil driven. And according to Elizabeth Soriola (2017) crude oil provides 90 percent Nigeria's export revenue. Hence this paper is in support of Ojo et al, (2018) findings that GDP has positive sign and significant effect on exchange rate in Nigeria.

5.0 Conclusion

Empirical results obtained from the tests above shows that both lag values of exchange rate and crude-oil price have negative signs and have significant relationship with exchange rate, this suggests that one year past value of exchange rate and crude-oil price are major determinant of exchange rate. Whereas, regardless of the negative sign interest rate has, it does not have a significant relationship with exchange rate, meaning it is not a major determinant of exchange rate.

The ECM term in Table 3.8 given as CointEq (-1)* is negative with a connected coefficient estimate of -0.555393, this implies that about 55.5% of any movements into disequilibrium between exchange rate and crude oil price or interest rate are corrected within one period, additionally, with a t-statistic as high as (-6.042801) we can firmly conclude that the coefficient is highly significant.
The Wald Test result in Table 3.9, reveals that F-statistic = 4.731374, here is H0: C(9) = C(10) = (11) = 0 (meaning no co-integration), H1: A negation of H0 (meaning continual lung run relationship). Decision Rule: Reject H0 if P(F) < 0.05. Since P(F) =0.003<0.05 we will reject H0 and conclude there is co-integration between the variables thus confirms that crude-oil price and interest rate are some of the determinants of exchange rate in Nigeria.

5.1 Recommendations

1. The lag of exchange rate have a crucial effect on future exchange rate changes, this will aid the forecasts of future economic conditions. Therefore, sound policies and management should consolidate on this lag impact so as to better the economy.
2. The study shows that exchange rate responds positively to real interest rates. As such monetary policy is crucial here; hence a need for the Nigerian monetary authority to pursue interest rate stability as swings in interest rate will post a serious threat to maintaining stability in real exchange rate.
3. For further studies on Autoregressive Distributed lag Model is recommended for Modeling Crude-oil price determinants of Nigeria

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