On the Causal Relationship Between The Gross Domestic Product, Inflation Rate, Exchange Rate and Interest Rate in Nigeria

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Abstract — **This study examines the causal interaction that exists among the gross domestic product (GDP), inflation, exchange rate and interest rate using Bound and Granger Causality tests. The Statistical Bulletin of Central Bank of Nigeria (CBN) datasets, ranging from 1981-2017 on Gross Domestic Product (GDP), Inflation, exchange rate, and the Interest rate was employed and analyzed using the E-views 10 software. The unit root result shows that the null hypotheses can be rejected since all three variables do not have a unit root. Granger Causality tests showed that there is a bidirectional relationship running from the exchange rate to GDP with values (4.E-06, 4.E-11). The uni-directional causality exists from the Exchange rate to inflation (0.3640). The Cusum test at 5% level of significance confirmed the stability of the Macroeconomic variables selected. ARDL (1, 1, 0, 0) was found to be the best fit model for forecasting showing a co-integrated, long-run and short-run relationship between Gross Domestic Product (GDP), Inflation, Exchange rate and Interest rate. The results of ARDL Bounds test discussed in this paper indicated that these macroeconomic variables have significant level relationships with GDP in Nigeria. GDP is directly related to the exchange rate movement in Nigeria, which is mainly associated with the efforts of the monetary authorities to stabilizing the local currency through its various exchange rate policies. The long-run speed of adjustment to equilibrium reveals that the exchange rate in Nigeria is slow to react to shocks on GDP and inflation rate.**

Keywords- *Gross Domestic Product, Exchange rate, Inflation, Interest rate***,** *Cusum test, ARDL Bound test.*

I. INTRODUCTION

According to Amalahu and Acha (2018) one variable is said to Granger cause the other if it helps to make a more accurate prediction of the other variable than had we only used the past of the latter as the predictor. The ***Granger causality test*** is a statistical hypothesis ***test*** for determining whether a one-time series is useful in forecasting another. Granger causality procedure is to study the causal interactions that exist among economic indicators in various countries of the world.

Moreover, several intelligent articles have surfaced in the literature on the use of Granger causality tests to analyze time-series data since its introduction by Granger (1969). Some of the articles include Granger (1969), Granger (1980), Granger (1988), Swanson and Granger(1997), Entner et al (2010), Mohammed et al (2010), Chu and Chymour (2008), Arnold et al (2007), Eichler and Didelez(2009), Clarke and Mirza (2006), Erdal et al (2008), Pearl (2012), Aryeetey (2005), Aryeetey, and Harrigan (2000), Aryeetey and Fosu (2005), Asiedu (2002), Choong, et al (2005), Ng, Perron, (2001), Frimpong, Oteng-Abayie (2006), Herzer, et al (2006), Karbasi, et al (2005), Kohpaiboon, (2004), Lipsey (2000), Lipsey (2001), Mansouri (2005), Pahlavani, et al (2005), Pesaran, et al (2001), Ouattara (2004), Shrestha and Chowdhury (2005), Wacziarg (2001).

The **bounds tests** or autoregression distributed lag model (ARDL) suggest that the variables of interest are **bound** together in the long-run when GDP is the dependent variable. The associated equilibrium correction was also significant confirming the existence of long-run relationships. It is used as the solution to determining the long-run relationship between series that are non-stationary and reconciling the short-run dynamics with long-run equilibrium. Musa and Yohanna (2017) investigated the close link between real effective exchange rate and economic growth for Turkey spanning the period 1970-2015 using time series data. The study used the autoregression distributed lag model (ARDL) and Toda–Yamamoto (TY) Granger non-causality tests to achieve the research

objective. All the variables were found stationary after first differencing with drift except GDP growth which is stationary at level. The empirical result demonstrated that the real effective exchange rate negatively affects economic growth in the short run; however, it exerts a significant positive impact on growth in the long-run. Sani et al., (2016) examined the dynamics of the inflationary process in Nigeria over the period 1981 – 2015, using the bounds testing approach to cointegration. Empirical results indicated that inflation in Nigeria proxied by CPI exhibited a strong degree of inertia. The econometric results showed that past inflation and average rainfall appeared to have been the main determinants of the inflationary process in Nigeria over the study period. Just to mention few more contributors: Arnold (2011), Shojaie and Michailidis (2010), Moneta et al (2011), Chen and Hsiao (2010), White et al(2011), Zou et al (2010), HavackovaSchindler et al (2007), Haufe et al (2010), Eichler and Didelez (2007), Cheng(1996), Cheng et al(1997), Toda et al (1994), Seth, A.K. (2005). With this background, this paper aims at assessing the causal interaction that exists among the gross domestic product (GDP), inflation, exchange rate and interest rate using Bound and Granger Causality tests. The objective would be achieved by analytically examining the theorized relationships to see if they hold in Nigeria.

II. RESEARCH METHODOLOGY

Here, sufficient detail on the procedure will be stated in logical order as follows:
The model of Interest rate, Exchange rate, Inflation and GDP are formulated as

(a) $$\Delta IR_t = \delta_1 + \sum_{i=1}^{p} \beta_{1i} \Delta IR_{t-i} + \sum_{i=1}^{p} \beta_{2i} \Delta ER_{t-i} + \sum_{i=1}^{p} \beta_{3i} \Delta GDP_{t-i} + \mu_{1t} \quad (1)$$

(b) $$\Delta ER_t = \delta_2 + \sum_{i=1}^{p} \alpha_{1i} \Delta IR_{t-i} + \sum_{i=1}^{p} \alpha_{2i} \Delta ER_{t-i} + \sum_{i=1}^{p} \alpha_{3i} \Delta GDP_{t-i} + \mu_{2t} \quad (2)$$

(c) $$\Delta ER_t = \delta_2 + \sum_{i=1}^{p} \alpha_{1i} \Delta IR_{t-i} + \sum_{i=1}^{p} \alpha_{2i} \Delta ER_{t-i} + \sum_{i=1}^{p} \alpha_{3i} \Delta GDP_{t-i} + \mu_{2t} \quad (3)$$

(d) $$\Delta GDP_t = \delta_3 + \sum_{i=1}^{p} \lambda_{1i} \Delta ER_{t-i} + \sum_{i=1}^{p} \lambda_{2i} \Delta GDP_{t-i} + \sum_{i=1}^{p} \lambda_{3i} \Delta IR_{t-i} + \mu_{3t} \quad (4)$$

where, δ, β, γ and λ are the short-run coefficients, IR represents Interest Rate, ER Exchange Rate, GDP Gross Domestic Product and μ are the stochastic error terms.

The Null Hypothesis: All three variables have a unit root.

Unit Root Test Results
Traditionally, most economic variables are non-stationary; hence we test for the presence of unit roots using the Augmented Dickey-Fuller tests. Dickey (1976) and Fuller (1976) noted that the least-squares estimator of the VAR model in the Granger causality analysis is biased in the presence of unit root and this bias can be expected to reduce the accuracy of forecasts.

i. Johansen test of cointegration
Johansen Cointegration test can be applied to examine the long-run relationship between the variables. Its test data or variable must be non- stationary and integrated of the same order. Cointegration indicates that causality exists between the three variables but it fails to show us the directions of the causal relationship.

ii. **Pairwise Granger Causality Test**
As Johansen cointegration test revealed that there is long-run equilibrium relationship exists between Interest rate, Exchange rate, Inflation and GDP, the study employed Granger causality test to see whether Interest rate does Granger cause Exchange rate and GDP, Exchange rate and Interest rate or GDP does Granger cause Interest rate and Inflation etc. Granger suggests that if cointegration exists between two variables in the long run, then, there must be unidirectional, bi-directional or non-directional.

iii. Bound test
It presents both the short and long forms of relationships in the variables. Finally will **bound** together in the long-run when GDP is the dependent variable. The presence of a long-run relationship amongst the variables leads to the selection of the optimal lag length in line with information criteria to get ARDL model.

I. Analysis and Results

Table 1 is the summary of the results of the Augmented Dickey-Fuller test for unit root. The unit root result shows that the values of computed ADF test-statistic of the three variables are smaller than the critical values at 1%, 5% and 10% levels of significance respectively. So, the null hypothesis can be rejected, since all the three variables do not have a unit root. Unit root result also shows that the three variables are stationary at first difference and that there is an absence of unit root according to the P-values of all the three variables as the P-values are significant

Table 1. ADF test for Unit Root

GDP	Augumented Dickey Fuller test statistic	t-Statistic	Prob.*
	Test critical values	3.624459	0.0000
		1% level	-3.724070
		5% level	-2.986225
		10% level	-2.632604
Inflation Rate	Augumented Dickey Fuller test statistic	t-Statistic	Prob.*
	Test critical values	5.947973	
		1% level	-3.679322
		5% level	-2.967767
		10% level	-2.622989
Exchange Rate	Augumented Dickey Fuller test statistic	t-Statistic	Prob.*
	Test critical values	-8.543043	
		1% level	-3.639407
		5% level	-2.951125
		10% level	-2.614300
Interest Rate	Augumented Dickey Fuller test statistic	t-Statistic	Prob.*
	Test critical values	-6.234537	
		1% level	-3.659194
		5% level	-2.971853
		10% level	-2.625121

*MacKnnon (1996) one-sided p-values

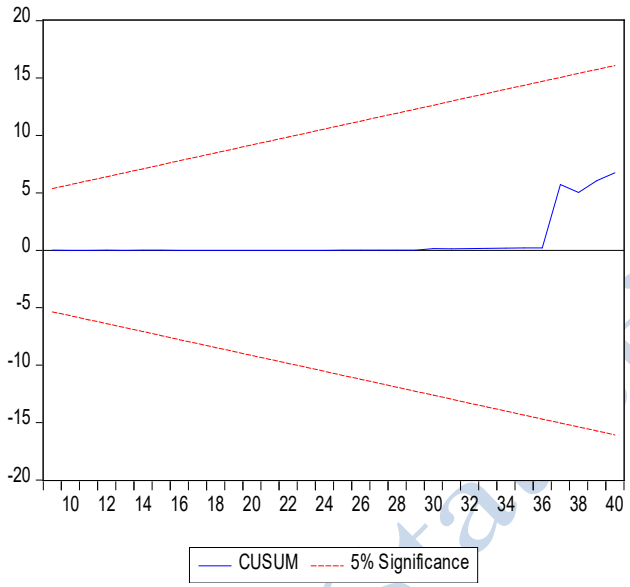

Figure 1: CUSUM TEST GRAPH

The Cusum test at 5% level of significance confirmed the stability of the Macroeconomic variables selected.

Table 2. Cointegration Test Analysis result (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.737405	131.5461	47.85613	0.0000
At most 1 *	0.687476	82.07183	29.79707	0.0000
At most 2 *	0.542559	39.03804	15.49471	0.0000
At most 3 *	0.238888	10.10007	3.841466	0.0015

Trace test indicates 4 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Table 3. Cointegration Test Analysis result (Maximum Eigenvalue)

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None *	0.737405	49.47424	27.58434	0.0000
At most 1 *	0.687476	43.03379	21.13162	0.0000
At most 2 *	0.542559	28.93797	14.26460	0.0001
At most 3 *	0.238888	10.10007	3.841466	0.0015

Max-eigenvalue test indicates 4 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

The Johansson cointegration test results in table 3 above shows that there is a long-run relationship between Interest rate, Exchange rate, and GDP as the trace statistic value of 131.5461 is more than the critical value of 47.85613 and is significant as the probability value of < 0.001 is less than 0.05, this is in line with Acha and Amalahu (2017). Hence the null hypothesis of no long-run relationship between Interest rate, Exchange rate, and GDP was rejected. In other words, they move together in the long run. Since the variables are found to be co-integrated, we can specify an ARDL model and estimate. Once there is a co-integrating vector, a long-run relationship is concluded Gujarati, (2004).

Table 4: Granger Causality Test

Null Hypothesis:	Obs	F-Statistic	Prob.
D(EXCHANGE__RATE) does not Granger Cause D(CGDP)	37	18.9405	4.E-06
D(CGDP) does not Granger Cause D(EXCHANGE__RATE)		55.0451	4.E-11
D(INFLATION) does not Granger Cause D(CGDP)	37	0.06051	0.9414
D(CGDP) does not Granger Cause D(INFLATION)		0.44340	0.6457
D(INTEREST__RATE) does not Granger Cause D(CGDP)	37	0.06515	0.9371
D(CGDP) does not Granger Cause D(INTEREST__RATE)		0.29890	0.7437
D(INFLATION) does not Granger Cause D(EXCHANGE__RATE)	37	0.36838	0.6947
D(EXCHANGE__RATE) does not Granger Cause D(INFLATION)		0.81135	0.4532
D(INTEREST__RATE) does not Granger Cause D(EXCHANGE__RATE)	37	0.23413	0.7926
D(EXCHANGE__RATE) does not Granger Cause D(INTEREST__RATE)		1.04326	0.3640
D(INTEREST__RATE) does not Granger Cause D(INFLATION)	37	0.07898	0.9242
D(INFLATION) does not Granger Cause D(INTEREST__RATE)		2.40095	0.1068

Granger Causality tests showed that there is a bidirectional relationship running from exchange rate to GDP with values (4.E-06, 4.E-11). The uni-directional causality exist from Exchange rate to inflation (0.3640), while there is non-directional causality from GDP to Inflation, Exchange rate to Interest rate, Interest rate and GDP to Interest rate, Exchange to Inflation.

Table 5: Autoregressive Distributed Lag Model

Variable	Coefficient	Std. Error	t-Statistic	Prob.*
D(CGDP(-1))	-1.032568	0.316560	-3.261840	0.0026
D(EXCHANGE__RATE)	1223.799	1137.054	1.076290	0.2898
D(EXCHANGE__RATE(-1))	4584.741	1519.249	3.017769	0.0050
D(INFLATION)	-122.1012	1635.725	-0.074647	0.9410
D(INTEREST__RATE)	744.6588	1093.295	0.681114	0.5007
C	-4166.719	23533.94	-0.177051	0.8606

R-squared	0.701635	Mean dependent var	794.2035
Adjusted R-squared	0.655016	S.D. dependent var	246388.5
S.E. of regression	144717.2	Akaike info criterion	26.74689
Sum squared resid	6.70E+11	Schwarz criterion	27.00546
Log likelihood	-502.1909	Hannan-Quinn criter.	26.83889
F-statistic	15.05026	Durbin-Watson stat	2.187988
Prob(F-statistic)	0.000000		

*Note: p-values and any subsequent tests do not account for model selection.

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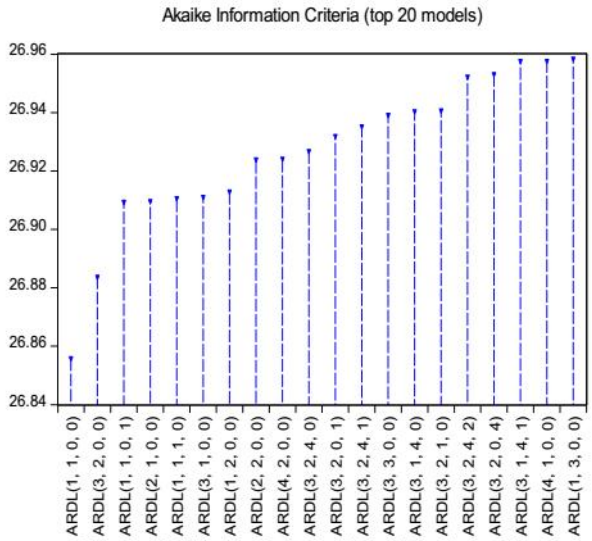
Table 6: ARDL Error Correction Model

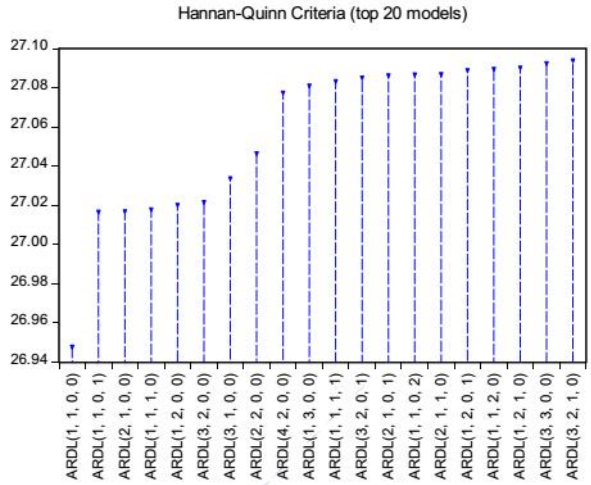
Error Correction:	D(Exchange_Rate,2)	D(Inflation_Rate,2)	D(Gdp,2)	D(Interest_Rate,2)
CointEq1	0.013652	0.012552	-14.62486	-0.029157
	(0.00422)	(0.00344)	(60.2417)	(0.00219)
	[2.22395]	[2.49395]	[-0.27119]	[-3.69427]

*Note: p-values and any subsequent tests do not account for model selection.

Table (6) above, presents both the short and long-form of the ARDL error correction model. Our parameter estimates generally demonstrate strong significance at 0.05 level of significance. Exchange rate and Interest rate measured by GDP deflators in the short run influence economic growth positively. The error correction mechanism of (0.014) is positive and statistically significant. This means that disequilibrium in the short run is corrected, adjusted and tied to the long run equilibrium position with a speed of 1.36 annually



Figures 2: Akaike Information Criteria graph



Figures 3: Hannan-Quinn Criteria graph

Table 7: Bounds test for cointegration

Null Hypothesis: No long-run relationships exist

Test Statistic	Value	K
F-statistic	11.23463	3
Critical Value Bounds		
Significance	I(0) Bound	I(1) Bound
10%	2.37	3.2
5%	2.79	3.67
2.5%	3.15	4.08
1%	3.65	4.66

Figures 2 and 3 depict the two information criteria employed: Akaike information criteria and Hannan-Quinn Criteria graphs that help in selecting the best model among the best twenty (20) models. ARDL (1, 1, 0, 0) was found to be the best fit model for forecasting showing a co-integrated, long-run and short-run relationship between Gross Domestic Product (GDP), Inflation, Exchange rate and Interest rate.

The bound long-run relationship amongst the variables in the model was assessed by conducting the ARDL bounds test and compare the critical values for the bounds test as documented in Pesaran et al. (2001), considering whether the variables in the model are I(0) or I(1). The results of the ARDL bounds test are presented in Table 5. The results indicated no cointegration, as it was inconclusive at the 1 percent level, with the calculated F-statistics falling between the lower and upper critical values. The F-statistic was 5.92, which was higher than the upper bound of the critical values at the 1 percent level (4.66) and implies the presence of a long-run relationship amongst the variables. A maximum lag of 4 was chosen in the ARDL cointegration test since the study utilized a yearly series. The optimal lag length was chosen in line with the Akaike information criteria and Hannan-Quinn Criteria and the selected ARDL representation for the model was ARDL (1, 1, 0, 0).

i. CONCLUSION

This study assesses the relationship between the gross domestic product (GDP), inflation, exchange rate and interest rate using Auto-Regressive Distributed Lag Model (ARDL) Bound Test. The Statistical Bulletin of Central Bank of Nigeria (CBN) datasets, ranging from 1981-2017 on Gross Domestic Product (GDP), Inflation, exchange rate, and the Interest rate was employed and analyzed using the E-views 10 software. Unit root result shows that the values of computed ADF test-statistic of the three variables are smaller than the critical values at 1%, 5% and 10% levels of significance respectively. So, the null hypothesis can be rejected, since all the three variables do not have a unit root. The unit root result also shows that the three variables are stationary at first difference and that there is an absence of unit root according to the P-values of all the three variables as the P-values are significant. Granger Causality tests showed that there is a bidirectional relationship running from the exchange rate to GDP with values (4.E-06, 4.E-11). The uni-directional causality exists from the Exchange rate to inflation (0.3640), and from inflation to interest rate (0.1068), while there is non-directional causality from Inflation to GDP, GDP to Inflation; interest rate to GDP and GDP to interest rate. Also, inflation does not Granger cause Exchange rate with the value 0.6947. The interest rate does not Granger cause Exchange rate with value 0.7926, Interest rate does not Granger cause Inflation with value 0.9242. The Cusum test at 5% level of significance confirmed the stability of the Macroeconomic variables selected. F-statistic of 11.23463 was found to be higher than the critical value of (2.37, 2.79, 3.15, 3.65) in the Lower Bound I(0) and 3.20, 3.67, 4.08, 4.66 in the Upper bound I(1) at the 10%, 5%, 2.5%, and 1% levels respectively. ARDL (1, 1, 0, 0) was found to be the best fit model for forecasting showing co-integrated, long-run and short-run relationship between Gross Domestic Product (GDP), Inflation, Exchange rate and Interest rate. The results of ARDL Bounds test discussed in this paper indicated that these macroeconomic variables have significant level relationships with GDP in Nigeria. GDP is directly related to the exchange rate movement in Nigeria, which is mainly associated with the efforts of the monetary authorities to stabilizing the local currency through its various exchange rate policies. The inflation rate and interest rate remain ineffective in the stabilization of GDP and the exchange rate in the short-run. The long-run speed of adjustment to equilibrium reveals that the exchange rate in Nigeria is slow to react to shocks on GDP and inflation rate.

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