A Co-Integration Approach on Real Exchange Rate Determinants in Nigeria

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Abstract — **The study examines the elements of real exchange rate for the fiscal years from January, 1960 to January, 2020 taking into account 60 yearly observations in Nigeria. The ADF stationarity test was employed to examine the stationary process of each series and the tests showed that the macroeconomic variables under study have no stochastic trends, hence, are stationary in levels. The result from Johansen cointegration showed a long-run relationship between real exchange rate and the five explanatory variables. R^2 of the estimated FMOLS model shows that about 73.39% of the total variability in real exchange rate has been explained by the independent variables and the model further revealed that inflation rate and government expenditure contribute more to exchange rate volatility. Our model adjust its prior periods dis-equilibrium at a speed of 56.98% annually with the $ec(-1)$ coefficient value -0.5698; also to achieve long term equilibrium stable state, the VECM is well specified and its parameter coefficients are not biased because the ARCH test indicates that it is free from heteroscedasticity. Finally, the macroeconomic variables strong forces that influence real exchange rate fluctuations in Nigeria as revealed by the Granger causality test are: money supply growth rate, government expenditure, inflation rate and real interest rate.**

Keywords: *Real Exchange Rate Determinants, Granger causality test, Vector Error Correction Model,* ***macroeconomic*** *variables, Johansen cointegration, volatility.*

I. Introduction

In any economy, real exchange rate is an essential component that drives export and private investment as well as ensuring stability in the growth of an economy. According to Hamdu (2013) most developing countries ensure that exchange rate policies are used to reduce persistence in misalignment. Hence, to curtail misalignment, it is relevant to ascertain what determines the real exchange rate. As Edwards (1989) puts “it is not an overstatement to say that real exchange rate behavior now occupies a central role in policy evaluation and design”.

For cross border trade, exchange rates plays key role in determining any country’s growth, that is, it measures the global competiveness of a country (Bah and Amusa, 2003). When relevant determinants of a country’s real exchange rate are not known, it will definitely lose its rate (Kia, 2013). Consequently, understanding the drivers of real exchange rate is absolutely the key for both public and private monetary institutions (Detken *et al*., 2002).

In developing economy such as Nigeria, exchange rate is really a perplexing problem such that, getting currency rates right continue to pose a threat to the economy except monetary institutions will reflects its policies on macroeconomic variables that determines the nation’s currency value (Williamson, 2008; Abdelbeky, 2005). Based on this fact, monetary experts have focused their attention in analyzing factors that influences real exchange rates and how government can sustain growth through internal systems, thereby focusing on local or indigenous economy mechanisms (Eichengreen, 2007).

It is important to note that the Nigeria government has always ensured and continually promote trade through exchange rate and macroeconomic policies as well as engaging in foreign trade (Ademola et al., 2009). But, despite all these efforts by different administration to stabilize and mitigate the constant value dropped by the nation's currency to the US dollar which is a tool for improving the country's export rate and gain popularity in terms of international trade not much has been achieved.

As highlighted by Detken *et al.* (2002) exchange rate when overrated can definitely reduce profit in the export sector. Bhattarai and Armah (2013) point out that the real exchange rate has been used as a tool for regulating flows of trade and capital by many developing economies, which tend to have persistent deficits in the balance of payment because of a structural gap between the volumes of exports and imports.

This paper employed the Johansen cointegration, Vector Error Correctional Model (VECM) as well as Granger causality (or "G-causality") test in evaluating Nigeria's real exchange rate in that way seeking to determine the long-run stable association between the variables and evaluate the selected determinants. This study will also measure the speed of adjustment for attaining steady state position and finally, examine the direction of causality amongst the study variables.

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II. Materials And Methods

2.1 Data

This study employed yearly observations on real exchange rate, money supply growth rate, real GDP growth rate, inflation rate, real interest rate and Government expenditure (annual percentage) in Nigeria covering the fiscal years from January, 1960 to January, 2020. It takes into account a sample size of 60 years (i.e. 60 numbers of yearly observations) from the period of 1960-2020 obtained from Central Bank of Nigeria (CBN) statistical bulletin (2015). The study seeks to evaluate real exchange rate in Nigeria taking into consideration some selected determinants; these include money supply growth rate, real GDP growth rate, inflation rate, real interest rate and government expenditure using EVIEWS statistical software.

2.2 Model Specification

In this study, the empirical description will closely follow the theoretical framework as shown in section 2.2. Thus, the theoretical model signifies a long-run relationship amongst the study variables as highlighted in this paper. We employ cointegrating regression model using fully modified ordinary least squares (FMOLS) to investigate the impact of macroeconomic variables on real exchange rate in Nigeria. The model characterising the association among macroeconomic variables presented and specified as follows:

$$RER = f(RGDP, M2, IFR, RIR, GEX) \quad (1)$$

The functional model is specified as follows:

$$RER_t = \beta_0 + \beta_1 RGDP_t + \beta_2 M2_t + \beta_3 IFR_t + \beta_4 RIR_t + \beta_5 GEX_t + \varepsilon_t \quad (2)$$

where: $RER_t =$ Real exchange rate at time t; $RGDP_t =$ Real GDP growth rate at time t; $M2_t =$ Money supply at time t; $IFR_t =$ Inflation rate at time t; $RIR_t =$ Real interest rate at time t; $GEX_t =$ Government expenditure annual growth rate at time t; $\beta_0 =$ Intercept of the regression equation; $\varepsilon_t \sim N(0,1)$ is the random error term, and $\beta_1, \beta_2, \ldots, \beta_5$ are the slope coefficients of the independent variables in the model which expresses the linear component of the model.

The study expects the slope coefficients ($\beta_1, \beta_2, \ldots, \beta_5 > 0$) to be positive for the independent variables to have positive impacts on the response variable.

III. Results And Discussion

In analyzing time series data, we first plot the original series in level against time which help us in understanding the trend as well as pattern of movement of the original series. The plots of the original series are reported in Figure 1.

From the time plots of the study variables reported in Figure 1, it shows clearly that the trend movements in all the plots are very smooth. This indicates that their means and variances do not change with time (homoscedastic) and the series seems to be covariance stationary. We further investigate the stationarity of the study variables using unit root and stationarity test.

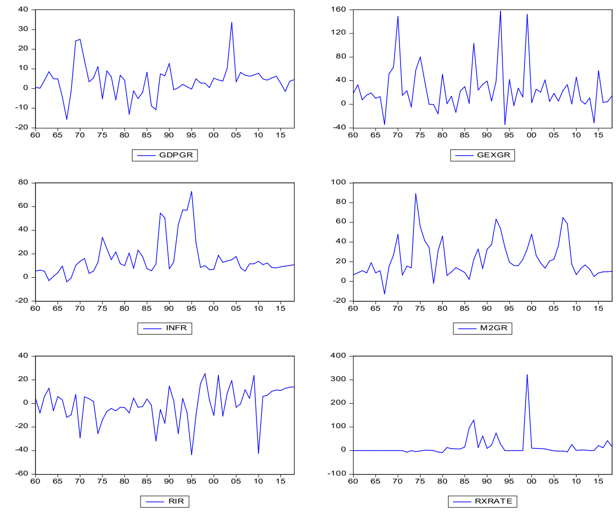

Figure 1: Time Plots of GDP Growth Rate, Government Expenditure Growth Rate, Inflation Rate, Money Supply Growth Rate, Real Interest Rate and Real Exchange Rate in Levels.

3.1 Stationarity Test

The ADF stationarity test result is presented in Table 1.

Table 1: ADF Unit Root Test Results

Variable	*Option*	*Test Statistic*	*P–Value*
rer	Intercept only	−9.1070	0.0000 *
	Intercept and trend	−9.0467	0.0000 *
gdp	Intercept only	−15.7796	0.0000 *
	Intercept and trend	−14.3485	0.0000 *
rir	Intercept only	−8.8792	0.0000 *
	Intercept and trend	−8.9038	0.0000 *
$infr$	Intercept only	−10.5560	0.0000 *
	Intercept and trend	−10.0054	0.0000 *
$m2r$	Intercept only	−9.7882	0.0000 *
	Intercept and trend	−9.9878	0.0000 *
gex	Intercept only	−8.7030	0.0000 *
	Intercept and trend	−8.6051	0.0000 *

** denotes the significant of ADF test statistic at* 1%, 5% *and* 10% *significance levels.*

From the results of ADF unit root presented in Table 1, the result suggests that the macroeconomic variables under study are stationary. This means that the variables do not contain unit roots and hence are stationary in levels.

3.2 VAR Lag Order Selection Criteria

Table 2: VAR Lag Order Selection Criteria

Lag	LR	FPE	AIC	SIC	HQC
0	*NA*	< 0.001	−8.440	−8.078	−8.2931
1	798.824	< 0.001	−13.069	−12.418 *	−12.8051 *
2	37.744 *	< 0.001 *	−13.119 *	−12.179	−12.7379
3	19.690	< 0.001	−13.061	−11.831	−12.5622

*Note: * indicates lag order selected by the criterion.*

Table 2 result selected the lag order by each of the criteria considered as follows: LR ($p = 2$); FPE ($p = 2$); AIC ($p = 2$); SIC ($p = 1$); and HQC ($p = 1$). Henceforth, the lag length for $P = 2$ will be used in this study.

Table 3: VAR Residual Serial Correlation LM Test

Lags	LM-Stat	P-value
1	17.7833	0.3367
2	25.4822	0.0618
3	16.1053	0.4456
4	17.5334	0.3519
5	13.5929	0.6290
6	21.6761	0.1540
7	15.5517	0.4847
8	17.2649	0.3687
9	27.4158	0.3371
10	23.3820	0.1039
11	20.0774	0.2168
12	22.5420	0.1265

Table 3 showed that the estimated VAR for lag order selection criteria is dynamically stable since all the p-values of the LM-test statistics are not statistically significant ($p > 0.05$).

3.3 Johansen Cointegration Test

Having confirmed that the variables under investigation are all integrated of the same order (i.e., I (0)), we are now in a better position to explore their long-run stable relationships using Johansen cointegration testing procedure. The results of both Trace and maximum eigenvalue tests are reported in Table 4.

Table 4: Summary of Johansen Cointegration Test Results

Hypothesized No. of CE(s)	H_0	H_1	Trace Test Trace statistic	Critical Value	P-value**
None *	$r = 0$	$r \geq 1$	173.1688	117.7082	0.0000
At most 1 *	$r \leq 1$	$r \geq 2$	120.8260	88.8038	0.0000
At most 2 *	$r \leq 2$	$r \geq 3$	76.0319	63.8761	0.0034
At most 3 *	$r \leq 3$	$r \geq 4$	46.0467	42.9153	0.0235
At most 4	$r \leq 4$	$r \geq 5$	23.1637	25.8721	0.1048
At most 5	$r \leq 5$	$r = 6$	9.3605	12.5180	0.1593
			Maximum Eigenvalue Test		
Hypothesized No. of CE(s)	H_0	H_1	λ_{max} statistic	**Critical Value**	**P-value****
None *	$r = 0$	$r = 1$	52.3427	44.4972	0.0058
At most 1 *	$r \leq 1$	$r = 2$	44.7942	38.3310	0.0079
At most 2	$r \leq 2$	$r = 3$	29.9852	32.1183	0.0891
At most 3	$r \leq 3$	$r = 4$	22.8830	25.8232	0.1166
At most 4	$r \leq 4$	$r = 5$	13.8032	19.3870	0.2676
At most 5	$r \leq 5$	$r = 6$	9.3605	12.5180	0.1593

Trace test shows 4 cointegrating equations and Max-eigenvalue test shows 2 cointegrating equations at the 0.05 *level.*

The results from Table 4 for both trace and maximum eigenvalue cointegration established the presence of a long run equilibrium relationship amongst the variables. This means that all the macroeconomic variables cointegrated and hence shared a common stochastic trend.

3.4 Parameter Estimates of Cointegrating Model Coefficients

In evaluating the influence of explanatory variables on real exchange rate, we apply the cointegrating regression equation using FMOLS method. The residuals obtained from this model is saved and use in estimating the VECM. The parameter estimates of the cointegrating multiple regression equation is presented in Table 5.

Table 5: FMOLS Parameter Estimates of the Study Variables

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	11.1175	9.5735	1.1613	0.2507
gdp	−1.8054	0.7175	−2.5163	0.0149
gex	0.7328	0.1556	4.7084	0.0000
$infr$	0.4744	0.0815	5.8177	0.0000
$m2r$	0.3442	0.1330	2.5884	0.0134
rir	0.3845	0.3216	2.6265	0.0176
R-squared	0.7339			
Adjusted R-squared	0.6711			
F-statistic	5.3141			
Prob(F-statistic)	0.0005			
Durbin-Watson stat	2.0486			

From the parameter estimates of cointegrating multiple regression coefficients reported in Table 5, it is observed that the intercept of the regression model is positively related to real exchange rate, although not statistically significant. This means that real exchange rate is predicted to be 11.12% holding the explanatory variables constant. The slope coefficient of real GDP growth rate (gdp) is negative and statistically significant at 5% significance level. This means that an increase in real GDP growth rate by 1% will leads to a corresponding decrease of real exchange rate by 1.81% implying that real GDP growth rate has negative and significant impact on real exchange rate in Nigeria. The slope coefficients of real interest rate (rir), inflation rate ($infr$), money supply growth rate ($m2r$) and government expenditure growth rate (gex) all have positive impacts on real exchange rate and are statistically significant at 5% significance level. This means that by increasing real interest rate (rir), inflation rate ($infr$), money supply growth rate ($m2r$) and government expenditure growth rate (gex) by 1%, real exchange rate is predicted to increase by 0.38%, 0.47%, 0.34%, and 0.73% respectively in the long-run. The implication is that real interest rate, inflation rate, money supply growth rate and government expenditure growth rate having a direct and significant impacts on real exchange rate in Nigeria.

The coefficient of determination (R^2) of the estimated model shows that about 73.39% of the total variability in real exchange rate (rer) has been explained by the independent variables in the model and the overall fitness of the cointegrating regression model is good and adequate. The Durbin Watson statistic value of 2.05 which is greater than R^2 and R^2 adjusted indicates that our model has no positive serial correlation.

3.5 Parameter Estimates of Vector Error Correction Model

One of the basic conditions for estimating a VECM is that the study variables must be cointegrated. When the study variables are cointegrated, they shared a common stochastic drift and are in a state of equilibrium. To break this equilibrium, the residuals from the cointegrating regression equation in Table 5 will be used to evaluate the VECM. The result of the VECM is presented in Table 6.

Table 6: Parameter Estimates of VECM Model

Variable	Coefficient	Std Error	t-statistic	P-value
c	4.6673	10.4948	0.4447	0.6586
$\nabla rer(-1)$	−0.0674	0.1416	0.4756	0.6366
∇gdp	−2.0674	0.8064	−2.7635	0.0082
$\nabla gdp(-1)$	−0.6992	0.7787	−0.8979	0.3739
∇gex	0.8498	0.1576	5.3926	0.0000
$\nabla gex(-1)$	0.3718	0.1991	1.8678	0.0682
$\nabla infr$	0.1195	0.5404	0.2211	0.8260
$\nabla infr(-1)$	0.4178	0.4549	0.9185	0.3631
∇m2r	−0.9666	0.3719	−2.5989	0.0085
$\nabla m2r(-1)$	−0.5413	0.4404	−1.2291	0.2253
∇rir	0.9548	0.4274	2.1677	0.0324
$\nabla rir(-1)$	1.1962	0.4159	2.8770	0.0061
$ec(-1)$	−0.5698	0.0975	−5.8427	0.0000

R-squared	0.6667
Adjusted R-squared	0.5392
F-statistic	6.6602
Prob(F-statistic)	0.0009
Durbin-Watson stat	2.2804

From the result of the VECM reported in Table 6, the slope coefficients are called short-run equilibrium coefficients while $ec(-1)$ is the long-run equilibrium coefficient known as the error correction coefficient.

The short-run equilibrium coefficients show the proportions at which the preceding period's disequilibrium is been corrected. In our VECM, the system corrects its previous period's disequilibrium at the speed of 6.74% between real exchange rate and real exchange rate lag one year, 206.74% between real exchange rate and real GDP growth rate, 69.92% between real exchange rate and real GDP growth rate lag one year, 84.98% between real exchange rate and government expenditure growth rate, 37.18% between real exchange rate and government expenditure growth rate lag one year, 11.95% between real exchange rate and inflation rate, 41.78% between real exchange rate and inflation rate lag one year, 96.66% between real exchange rate and money supply growth rate, 54.13% between real exchange rate and money supply growth rate lag one, 95.48% between real exchange rate and real interest rate and 119.62% between real exchange rate and real interest rate lag one year. The slope coefficients of ∇gdp, ∇gex, $\nabla m2r$ and ∇rir are statistically significant in the current year indicating that the impacts of real GDP growth rate, government expenditure growth rate, money supply growth rate and real interest rate on real exchange rate are time-based.

In our model the $ec(-1)$ coefficient is -0.5698. This value is negative as expected signifying that the scheme corrects its preceding period's disequilibrium at a speed of 56.98% annually. This implies that the VECM model identifies a sizeable speed of adjustment of 56.98% for correcting disequilibrium annually for attaining long term equilibrium balanced state point.

3.5.1 Diagnostic Test for Vector Error Correction Model

The ARCH tests is employed to investigate the presence of heteroscedasticity in the estimated VECM is presented in Tables 7.

Table 7: ARCH Heteroscedasticity Test for Vector Error Correction Model

Variables	F-Statistic	Prob.	Chi-Square Statistic	Prob.
VECM	0.818917	0.9845	52.84117	0.8993

* *Significant at the* 0.05 *level*

Table 7 shows that the p-values for both F-statistic and Chi-square statistic are not statistically significant indicating that the VECM is free from heteroscedasticity; hence, the variance across the residuals of the VECM is homogenous. By implication, the parameter coefficients of estimated VECM are not biased and the model is well specified.

3.6 Causality Test Results (Using Wald Modified Test)

Before estimating the Granger causality test, we firstly estimated VAR model which enables us to establish the number of lags to be included in the Granger causality test as presented in Table 2. Table 8 presents the Granger causality test result.

Table 8: Granger Causality Test Results based on Modified Wald Test

Dependent variable	Excluded	Chi-Square	Degree of freedom	P-value
rer	gdp	3.1727	2	0.2047
	gex	10.9812	2	0.0031*
	$infr$	9.1572	2	0.0113*
	$m2r$	12.6598	2	0.0026*
	rir	8.1005	2	0.0174*
gdp	gex	11.6696	2	0.0027*
	$infr$	1.5188	2	0.4679
	$m2r$	13.2531	2	0.0013*
	rir	0.6893	2	0.7085
	rer	0.0481	2	0.9763
gex	gdp	11.4316	2	0.0031*
	$infr$	3.7934	2	0.1501
	$m2r$	8.9726	2	0.0173*
	rir	0.3691	2	0.8315
	rer	4.5731	2	0.1016
$infr$	gdp	5.4001	2	0.0672
	gex	8.7529	2	0.0153*
	$m2r$	13.9049	2	0.0010*
	rir	1.0062	2	0.6047
	rer	0.0056	2	0.9972
$m2r$	gdp	0.1741	2	0.9166
	gex	12.0599	2	0.0035*
	$infr$	0.1087	2	0.9471
	rir	0.5948	2	0.7428
	rer	4.3876	2	0.1115
rir	gdp	0.9143	2	0.6331
	gex	4.4659	2	0.1072
	$infr$	2.6736	2	0.2627
	$m2r$	0.5069	2	0.7761
	rer	7.9502	2	0.0185*

**denotes significant at 5% level of significance*

From the results of the Granger causality test presented in Table 8, money supply growth rate, inflation rate and government expenditure growth rate Granger cause real exchange rate in Nigeria since there is a one-way causality running amongst them. There is also a two-way causality between real exchange rate and real exchange rate in turn Granger causes real interest rate. Government expenditure influences real GDP growth rate and money supply; and real GDP growth rate and money supply in turn promotes government expenditure in Nigeria. The economic growth and inflation in Nigeria is Granger caused by too much money in circulation. Also inflation is Granger caused by government expenditure in Nigeria which shows a unidirectional causality running.

In summary, the Granger causality test revealed that money supply, government expenditure, inflation rate and real interest rate are the main determinants of real exchange rate in Nigeria. According to this result, these macroeconomic variables are the strong forces that influence real exchange rate fluctuations in Nigeria.

IV. Conclusion

The macroeconomic variables under study do not contain unit roots and hence are stationary in levels as contained in the result of the ADF unit root test which then implies that the variables are all integrated of the same order, $I(0)$.

This has placed us in a better position of using Johansen cointegration testing procedure to explore the long-run stable relationships of the variables under investigation; which show that all the variables are all cointegrated and hence shared a common stochastic trend. It was observed from the study that real interest rate, inflation rate, money supply growth rate and government expenditure growth rate have direct and significant impacts on real exchange rate but real GDP growth rate has an indirect and significant impact on real exchange rate in Nigeria. The VECM model identifies a sizeable speed of adjustment of 56.98% for correcting disequilibrium yearly for attaining long term equilibrium balanced state.

To sum it up, the Granger causality test revealed that money supply, government expenditure, inflation rate and real interest rate are the main determinants of real exchange rate in Nigeria.

Author's contributions

CLA and LOM conceived and designed the study. CLA and LOM analyzed the data. CLA, LOM, JO and AYE contributed to the writing of the manuscript.

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