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Assessment of real exchange rate through vector error correction model (VECM) in Nigeria

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Abstract

Despite the fact that exchange rate (REXR) is an integral part of macro economy and economic outlook of Africa, many Africans operate without an excise understanding of its operations. Hence, this study examined the assessment of real exchange rate (REXR) through Vector Error Correction Model (VECM) in Nigeria for the period of 1979-2014. Cointegration test, Vector Error Correction Model (VECM) technique and Granger causality test were employed in the analysis. The variables utilized in the study include real exchange rate (REXR), real gross domestic product (RGDP), and inflation rate (INFLR) and real interest rate (RINTR). Stationarity test was conducted and the results indicated that all the variables were stationary at level. The co-integration test result revealed that long run relationship exists among the variables understudy. More so, the long term co-integration vector suggests that real interest rate (RINTR) and real inflation rate (RINFLR) have a negative impact on the exchange rate, while ln(RGDP) have a positive on the exchange rate. Finally, the Granger causality results indicated multi-directional relationship between REXR to RGDP, REXR to RINFL and REXR to RINTR. Based on the findings above, it is recommended that government should ensure a stable interest rate, as an unstable interest rate will have an effect on real exchange rate, hence the exchange rate should reflect market realities to promote efficiency in resource allocation and productivity growth. Also, maintenance of a stable exchange rate regime should be prioritized through strong monetary policies by government so as to help in improving standard of living.

Keywords: Nigeria, exchange rate, standard of living, vector error correction model

1. Introduction

The debate over what determines the choice of exchange rate regimes has continued unabated in recent time, with the fall of Bretton-Woods system in 1970s and the subsequent introduction of floating exchange rates. These have in some cases become extremely unstable without any corresponding link to changes in the macroeconomic fundamentals and this led to higher interest in exchange rate modelling as the question of exchange rate determination reveals to be one of the most important problems on theoretical field of monetary macroeconomics (Ugoye, 2009) [26]. Traditionally, it has been argued that a country's optimal real exchange rate was determined by some key macroeconomic variables and that the long-run value of the optimal real exchange rate is determined by suitable (permanent) values of these macroeconomic variables (Williamson, 1994, Ugoye, 2009) [30, 26]. Friedman (1953) opined that exchange rates system is ultimately the choice of monetary regime and a floating rate will provide better insulation from foreign shocks by allowing relative prices to adjust faster in the presence of sticky prices. Floating exchange rate stipulated that in the long run the exchange rate system does not have significant real consequences, while the monetary policy does not matter for real quantities, but in the short run it does. But in contrast, Mundell (1963) [21], postulated that in a world of capital mobility optimal choice of exchange rate regime should depend on the type of shocks hitting an economy, real shocks would call for a floating exchange rate and monetary shocks would call for a fixed exchange rate. Therefore, "an exchange rate regime is the way an authority manages its currency in relation to other currencies and the foreign exchange market". It has a close relation to a country's monetary policy and the two are generally dependent on many of the same factors. There are different types of exchange rate regimes practiced all over the world; from the extreme case of fixed exchange rate system to a freely floating regime. Practically, countries tend to adopt a combination of different regimes such as scrawling peg, adjustable peg, target zone/crawling bands, and managed float, whichever that suits the peculiarity of their economic conditions. The importance of exchange rate regime on the performance of an economy is highly important even though controversial, since the flow of goods, services and capital is influenced by it. It exerts strong pressure on the balance of payments, inflation and other macroeconomic variables. This explains why the influence of exchange rate policy is critical to economic management in order to safeguard competitiveness, macroeconomic growth and stability.

The exchange rate is the rate at which one currency is exchanged for another. It is the price of one currency in terms of another currency and is one of the most important prices in an open market (Jhingan, 2005, Obi *et al*., 2016) [16, 22]. Exchange rate is the price of one unit of the foreign currency in terms of the domestic currency. In Nigeria,

exchange rate managements have witness different significant changes over the past four decades. The country has maintained fixed exchange rates from 1960 till the breakdown of the Bretton Woods Monetary System in the early 1970s. Between1970 and mid 1980 Nigeria exchange rate policy shifted from fixed exchange rate to a pegged arrangement and finally, to the various types of the floating regime since 1986 following the adoption of the Structural Adjustment Programme (SAP) (Sanusi, 2004) [27]. The fixed exchange rate regime induced an overvaluation of the naira and was supported by exchange control regulations that engendered significant distortions in the economy. That gave channel to massive importation of finished goods with the adverse consequences on domestic production, balance of payments position and the nation's external reserves level (Ugoye, 2009) [26]. A regime of managed float exchange rate without any strong commitment to defend any particular parity has been the predominant characteristic of the floating exchange rate regime in Nigeria since 1986. The changes from the different regimes are not peculiar to the Naira as the US dollar was fixed in gold terms until 1971 when it was de-linked and has since been floated. Moreover, the period was bedevilled by sharp practices perpetrated by dealers and end-users of foreign exchange. These and many other problems informed the adoption of a more flexible exchange rate regime in the context of the SAP, adopted in 1986 (Sanusi, 1988) [27]. This therefore explains how exchange rate regimes have influence/impacted on the living conditions of the Nigerian populace.

Optimal exchange rate policy is designed to obtain real exchange rate (RER) that maintains both internal and external balance (Agu, 2002) [3]. The concept of real exchange rate comes from a realization that the observable nominal exchange rate movements, will result from both price changes and inflation rate changes in trading economies. When the real exchange rate is optimal, domestic producers of tradable goods can compete internationally. Exporters also are not disadvantaged by the exchange rate, when the real exchange rate is right (Maciejewski, 1983) [20]. What determines the exchange rate regime for an open economy is one of the oldest issues in international economics. The single most influential idea in this context has been the Mundellian prescription that if shocks facing the country are mostly monetary then fixed exchange rates are optimal whereas flexible rates are optimal if the shocks are mostly real (Amartya *et al.* 2004) [2]. Despite the fact that exchange rate (ER) is an integral part of macro economy and economic outlook of Africa, many Africans operate without an excise understanding of its operations.

Living standard or Standard of Living refers to the level of wealth, comfort, material goods, and necessities available to a certain socioeconomic class in a certain geographic area, usually a country. Most important thing to an average man is to have a good life which consists among other things: good food, good health conditions, good environment, good education for their wards etc, all of which summed up as a good living standard. Many factors and variables are acting contrary to the expected good living standard which is the expectation of an average man in Nigeria and Africa in general. The non-static of the exchange rate regimes and its oscillation between fixed and static is not encouraging, it was expected that the exchange should put Africa's economy on the path of macroeconomic growth but the reverse is observed (Bakare, 2011) [4]. This study is imperative because studying the dynamism of the variables of interest would help actors in the field to forecast the future and make relevance recommendations that will foster strong and sustain growth in the country (Dutt, 2018) [7]. Also, the recent efforts by monetary authorities in Nigeria to revive the economy through the financial sector reform which among other things sought to maintain stability in exchange rate. A good understanding of the exchange rate regime and its relationship with the living standard of the populace is imperative at this time when the Nigerian's Naira [1] is beaten hands down against the major currencies of the world (Essien *et al.*, 2017) [2]. Hence, this paper seeks to identify the determinants of exchange rate and examine if there is any long run relationship between the exchange rate and living standards based on these identified determinants in Nigeria.

2. Literature review

According to (Dornbusch, 2004) [9], exchange rate is the rate at which one country's currency is exchanged for the currency of another country. It can also be defined as the price of one country's currency relative to other countries' currency. While, Mankiw, (1997) [19] define it as the price at which exchange between two countries take place. How to determine the exchange rate is issue that has taken the centre stage of monetary and international economics.

Engel (2000) [10] examines optimal exchange-rate policy in two-country, he used sticky-price general equilibrium models in which households and firms optimize over an infinite horizon in an environment of uncertainty. The models are in the vein of the "new open-economy macroeconomics" as exemplified by Obstfeld and Rogoff (1995) [24]. The conditions under which fixed or floating exchange rates yield higher welfare, or the optimal foreign exchange intervention rule, depend on the exact nature of price stickiness and on the degree of risk-sharing opportunities. The study provides some preliminary empirical evidence on the behaviour of consumer prices in Mexico that suggests failures of the law of one price are important. The evidence on price setting and risk-sharing opportunities is not refined enough to make definitive conclusions about the optimal exchange-rate regime for that country. Amartya *et al.* (2004) [2] revisits the issue of the optimal exchange rate regime in a flexible price environment. The key innovation is that he analyze the question in the context of environments where only a fraction of agents participates in asset market transactions (i.e., asset markets are segmented). He shows that flexible exchange rates are optimal under monetary shocks and fixed exchange rates are optimal under real shocks. These findings are the exact opposite of the standard Mundellian prescription derived under the sticky price paradigm wherein fixed exchange rates are optimal if monetary shocks dominate while flexible rates are optimal if shocks are mostly real. This result thus suggests that the optimal exchange rate regime should depend not only on the type of shock (Monetary versus real) but also on the type of friction

[1]Nigeria Naira is at ₦300 to a dollar ($1) (www.forexnews.com)

(Goods market friction versus financial market friction).
Bakare, (2011) [4] carried out on the consequences of the foreign exchange rate reforms on the performances of private domestic investment in Nigeria; using the ordinary least square multiple regression analytical method. The outcome of the regression analysis showed a significant but negative effect on floating foreign exchange rate and private domestic investment in Nigeria. The research concluded that there is the need for the government to dump the floating exchange regime and adopt purchasing power parity which has been considered by researchers to be more appropriate in determining realistic exchange rate for naira in order to contribute positively to macroeconomic performances in Nigeria. Fapetu, and Oloyede in 2014 [13], an examination of foreign exchange management against Nigeria economic growth was carried out focusing on the years 1070-2012. The least square estimation technique and Error correction model (ECM) was used and the study found out that managing the economy's foreign exchange rate does affect some economic variables, which will in-turn affects growth in the economy. Adelowokan, Adesoye and Balogun, (2015) [1] in a study conducted on the effect of exchange rate volatility on investment and growth in Nigeria, used the vector error correction method (VECM) and found out that exchange rate volatility has a negative effect on growth and investment, while it had a positive relationship with inflation and interest rate in Nigeria. Essien *et al*., (2017) [2] examined the dynamism of real exchange rate in relation to the Naira, with respect to the year period 200-2016, they also looked at the extent to which it deviates from its long run equilibrium path. In a bid to achieve this their research made use of the Behavioural Equilibrium Exchange Rate approach as against the Granger Causality approach used in this study. Their study was able to bring out an empirical evidence for the existence of a long run relationship between real exchange rate and its determinants subject to a structural break of 2011Q1.

3. Methodology

3.1 Data source

In order to empirically examine the relationship between exchange rate and economic growth in Nigeria, the study employed some statistical data from Word Bank's World Development Indicators (WDI), from the years 1979 to 2014 on real exchange rate, on real gross domestic product and inflation rate. Co-integration test, Vector Error Correction Model (VECM) technique and Granger causality test were employed in the analysis. The co-integration test was applied to examine the long run equilibrium relationship among the variables, while the VECM is employed to investigate the short run dynamics and long run relationship among the variables under study. The Granger causality on the other hand, examines the causality between exchange rate and economic growth in Nigeria.

3.2. Model specification

The model expressing the relationship among real Gross Domestic Product (RGDP), exchange rate (REXR), inflation rate (INFLR) and real interest rate (RINTR) is represented as follows:

$$R(REXR) = f(RGDP, INFLR, RINTR) \quad \ldots, (1)$$

Where,
RGDP represents real Gross Domestic Product as a common measure for economic growth,
REXR= exchange rate
INFLR= Inflation rate
RINTR=Real interest Rate
The equation 1 above is further illustrated in linear form as:

$$REXR_t = \beta_0 + \beta RGDP_t + \beta_2 INFLR_t + \beta_3 RINTR_t + e_t \quad (2)$$

Where,
RGDP is the dependent variable; REXR, INFLR and RINTR are the explanatory variables; β_1, $\beta_2$and β_3 are the linearcoefficients of the equations, β_0 is the constant term and e_t is the stochastic variable.

Estimation Procedures

(i). Unit root test: Unit root test procedure is used to tests the stationarity of the variables employed in the study. It helps to determine the order of integration of the data series by applying the Augmented Dickey-Fuller (ADF) unit root test, postulated by Dickey & Fuller (1981) [8]. This test is adopted in order to find the long-term properties of the variables of interest in the study. If the time series are found to be stationary, it means that their variance, mean and covariance are constant overtime and that the result obtained from their analysis is reliable and can be used to predict future economic activities of the economy.
The ADF test is conducted through the following models.

$$\Delta y_{t=} \propto_0 + \propto_1 y_{t-1} + \sum n = 1 \ \Delta y_{t;+} e_t \quad \ldots, (3)$$

$$\Delta y_{t=} \propto_0 + \propto_1 y_{t-1} + \sum n = 1 \ \propto \Delta y_{t;+} \delta_{t+} e_t, \quad (4)$$

Where;
Y is a data series, t is linear time trend, Δ is first difference operator, $\propto_0$is constant, n is optimum number of lagsin the development variable and it is a stochastic variable. Meanwhile, if the ADF result fails to reject the test in levels but rejects the test in the first difference, it means that the series contains one unit root and is of integrated order one. More so, if the test fails to reject the test in levels and at first difference but rejects it in second differences, it therefore implies that the series contains two unit roots and is of integrated order two.

(ii). Co-integration test: The second estimation procedure involves the test of the level of co-integration among the data series of the same order through the application of the Johansen co-integration test. The implication is that, if in the long run, two or more series move closely together, whether the series itself is trended, the difference between them is constant. In theory, they can wander arbitrarily far away from each other. According to Johansen & Juselius (1990) [17], achieving empirical result amount to establishing maximum-likelihood test procedure.

The Johansen co-integration model is as shown below,

$$\gamma trace(r) = T\sum_{i=r+1}^{\Delta} ln(1-\gamma_t) \quad \ldots, (5)$$

Where;
T= number of usable observations, **λ** = estimated Eigen-value from the matrix; λ trace tests the null hypothesis, which states that the number of distinct co-integrating vector is less than or equal to q as against the general unrestricted alternatives. Therefore, rejecting the null hypothesis indicates the data series contain unit root and must be differenced at least once to achieve stationarity.

(iii). Vector error correction model (VECM): This step of estimation procedure is possible if the results of the co-integration test showed evidence of long-run relationship among the variables. The conventional vector error correction model (VECM) is employed to examine the short run dynamics and co-integrating equation among the series. The term 'error correction term' is estimated for the coefficients, such that when the series fails to co-integrate, it means that the short run model becomes the next estimation method. The concept of VECM is used to explain the relationship existing between short run dynamics and long run equilibrium relationship among the data series. The application of VECM was necessary as it is used to correct temporary short run deviation of series from the long run equilibrium relationship.
The model for VECM is presented as follows:

$$\Delta Y_i = a_0 + a_1 \Delta X_i + a_2 u_{t-1} + \varepsilon_t \quad \ldots, (6)$$

Where;
$Y_{t=}\ Y_t - Y_{t-1}$, a_1 and a_2 represent the dynamic adjustment coefficients of the variables, while $u_{t-1}$is the residuallag; it represents the short run deviation from the equilibrium position, it is estimated to correct long-run equilibrium error, ε_t represents the random error term. The decision to apply VECM which based on ordinaryleast square (OLS) is borne out from the fact that the study employed more than one explanatory variable. There is therefore the need to apply the method in the investigation. The model is illustrated below.

$$\Delta LREXR_t = \beta_0 + \beta_1 \Delta LRGDP_{t-1} + \beta_2 \Delta LINFLR_{t-1} + \beta_3 \Delta LRINTR_{t-1} + ECM_{t-1} + U_t \quad (7)$$

Where,
ΔL is change in natural logarithm of the variable; for instance,
$\Delta LEXR_t$represent a change in naturallogarithm of the real exchange rate,β_0 is constant term, β_1,β_2, β_3, and β_4 are the parameters of the explanatory variables, ECM is error correction model andU_t is the error term of long run equilibrium error. The method of vector error correction model is estimated to investigate the dynamic behaviour of the relevant variables of the study, following the confirmation of long run equilibrium relationship.

(iv). The granger causality test: The third stage of the estimation procedure examines the causality between exchange rate and economic growth through the application of the Granger causality test propounded by Engle & Granger (1989) [11]. It focused on determining the nature of relationship between the two variables; that is, to determine whether the direction of the relationship is bi-directional, unidirectional, feedback or no causation between the two variables.
Thus, the model is specified as:

$$REXR_t = \beta_0 + RGDP_t + \beta_2 INFLR_t + \beta_3 RINTR_t + e_t \quad \ldots, (8)$$

$$REXR_t = \beta_0 + RGDP_t + \beta_2 INFLR_t + \beta_3 RINTR_t + e_t \quad \ldots, (9)$$

4. Data analysis and discussion of empirical results

4.1 Graphical trend movement in the variables

The graph in Figure 1, shows that the exchange rate in Nigeria was relatively stable from 1960 before a sudden rise around 2000, and since, it kept increasing. This may due to distortion in other variables that influences the exchange rate and may lead to increase in standard of living. The other variables depending on level of economic performance and management, has been fluctuating in the period under study; includes inflation rate, real interest rate and real Gross Domestic Product (RGDP).

Graphical trends in variables

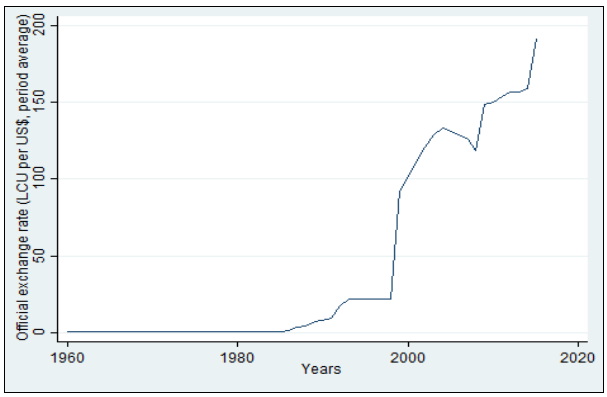

Fig 1: Trend in exchange rate in Nigeria (1979-2014).

Fig 2: Trend in real interest rate in Nigeria (1979-2014).

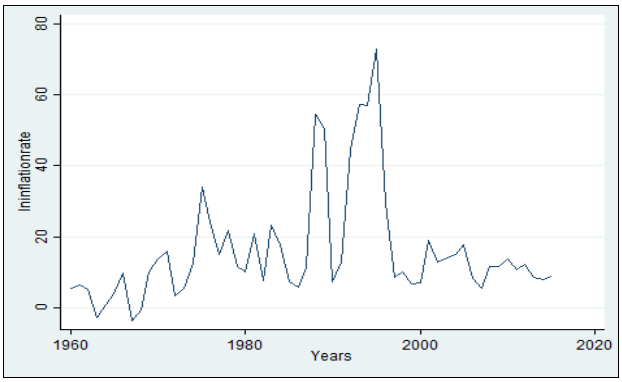

Fig 3: Trend in inflation rate in Nigeria (1979-2014)

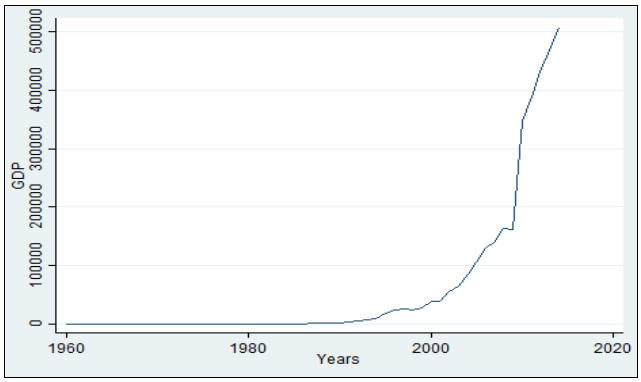

Fig 4: Real gross domestic product (RGDP) (1979-2014)

(i). Unit root test augmented dickey-fuller (ADF)

Table 1: Augmented Dickey-Fuller (ADF) Stationarity Test at both Levels and first difference

Variables	Statistic	1%CV	5%CV	Integration
LnEXR	-0.050	-3.376	-2.929 I(1)	0.9542
LnGDP	2.840	-3.376	-2.929 I(1)	1.000
LnINTR	-4.558	-3.376	-2.929 I(1)	0.010
LnINFLR	-3.376	-3.376	-2.929 I(1)	0.0118

Test: H_0: Exist a unit root; Critic values: 5 and 1 percent (p=0.05) to reject H_0, if p>0.05, we accept H_0.

For the variables to be stationary, it is expected that the t-ADF is greater than the chosen critical values. As it is shown in the table 1, all the variables were stationary at different level of differencing. However, the levels of the difference showed that real exchange rate, gross domestic product, real interest rate and inflation rate are all stationary after first differencing, i.e. they are all integrated of order 1.

From the unit root test in table 1, we noticed that real exchange rate which is the dependent variable in the specified equation have the same order of integration with Gross Domestic Product [2], inflation rate and real interest rate, which are endogenous variables, we then estimated their linear combination without the constant term and obtain their residual which was tested for unit root test of stationary using Augmented Dickey Fuller.

(ii) Co-integration Test

Table 2: Unrestricted co-integration rank Test (Trace)

Hypothesized No of CE(s)	Eigen Values	Trace Statistic	0.05 CV	0.01CV	Prob
None*		64.1970	47.21	54.46	0.0566
At most 1	0.6773	23.4813	29.68	35.65	0.000
At most 2	0.3247	9.3474	15.41	20.04	0.9987
At most 3	0.2284	0.0115	3.76	6.65	0.0059

Trace test indicates 1 co-integrating eqn(s) at the 0.05 level

Table 3: Unrestricted co-integration Rank Test (Maximum Eigen value)

Hypothesized No of CE(s)	Eigen Values	Trace Statistic	0.05 CV	0.01CV	Prob
None*		40.7157	27.07	32.24	0.0566
At most 1	0.6773	14.1339	20.97	25.52	0.000
At most 2	0.3247	9.3359	14.07	18.63	0.9987
At most 3	0.2284	0.0115	3.76	6.65	0.0059

Max-eigen value test indicates 1 co-integrating eqn(s) at the 0.05 level

Tables 2 and 3 represented the analysis of co-integration test through the application of Johansen Co-integration test. The results indicated three co-integrating equations in both the trace statistic and the max eigen statistic respectively. In Johansen co-integration method, the trace statistic and max-eigen statistic in any investigation determines level of co-integration among the data series employed in the study. In this sense, the results of the Johansen co-integration test in this study indicate long run relationship among the variables such as EXR, RGDP, INFLR and RINTR by indicating three co-integrating equations. Judging from the results, the study rejects the null hypothesis of no long run relationship and concludes that long run relationship exists among the variables under study. Definitely, the result showed that exchange rate has significant long run relationship with economic growth, real interest rate and inflation rate in Nigeria.

(iii) Error correction model (ECM)

Having established the existence of long run equilibrium relationship among the variables employed in the study through the application of Johansen co-integration test, the

study proceeds to carry out the estimation of the vector error correction model (VECM) in order to examine the short run dynamics and long run relationship among the variables of the study. The estimation result of the test is presented below.

Table 3: Error Correction Model (ECM)

Cointegrating Eqn:	EXR (-1)	RGDP (-1)	RINTR (-1)	RINFL (-1)
Coint Eq1(Vector of cointegration L-R)	1.000	0.0003 (0.0013)	-10.7924 (1.3346)	-2.5017 (0.9145)
Error correction	D(EXR)	D(RGDP)	D(RINTR)	D(RINFL)
Coint Eqn (Speed of adjustment)	[-0.0641] 0.007 (0.2375)	[0.4107] 0.050 (0.2099)	[0.1429] 0.000 (0.2948)	[0.0065] 0.973 (0.1903)
Constant	[-21.6332] 0.030 (9.9655)	[0.8844] 1.000 (2426)	[59.3364] 0.000 (12.3713)	[-5.4697] 0.689 (13.6772)
R-Squared	0.2900	0.3769	0.6427	0.0136
Adj. R-Squared	0.9688	0.9720	0.2895	0.4497
No of Obs.= 36, t=(1979-2014), AIC=47.97575, SBIC=49.55927, HQIC=48.52845				

Source: Author's Computation Stata

Table 3: The long-term variables that explain real exchange rate (REXR) are GDP, RINTR RINFLR and they are the coefficients which measure the extent of changes in exchange rate in the long term, derived from changes in these explanatory variables, are calculated as product of the coefficient. The elasticity of changes in GDP is 0.05. This means that an increase of 1 % of GDP, which represents the increase in exchange rate cause an increase with 0.05% of the people purchasing power. Elasticity to RINTR was – 10.7924, which means that an increase of 1 % in RINTR causes reduction on exchange rate by less than 1 %, concretely with 10.79 % and the elasticity to INFLR was -2.3017, indicating that an increase of 1% in INFLR causes an increase in the exchange rate by less than 2.3017%. In general, based on the methodology used, an increase of REXR increases the purchasing power, increases the inflation rate of the country and this will have a great effect on the standard of living of the country through the GDP.

The estimation of long term relationship of purchasing power for real interest rate is shown in equations below:

$$Ln(REXR) = C - \propto \beta . Ln(RGDP_t) - \propto \beta . Ln(RINTR_t) + \propto \beta . Ln(RINFLR_t) + \mu_t \quad (10)$$

$$Ln(REXR) = C + 0.003(0.0013)Ln(RGDP_t) - 10.7924(1.3346)Ln(RINTR_t) - 2.5017(0.9145)Ln(RINFLR_t) + \mu_t \quad (11)$$

The long term co-integration vector suggests that ln (RINTR) and ln(RINFLR) have a negative impact on the exchange rate, while ln(RGDP) has a positive on the exchange rate. A robust and growing economy with a growing Gross Domestic Product (GDP) will definitely have stable and healthy exchange rates to other currency. Inflation rate and real interest rate are expected to be negatives as usual.

(iv) Granger causality test

Table 4: Granger Causality Test

Null Hypothesis	Observations	F-Statistic	Prob.
EXR does not Granger Cause INFLR	36	7.5839	0.023*
EXR does not Granger Cause RGP	36	1.0577	0.589
EXR does not Granger Cause RINTR	36	0.8318	0.660
EXR does not Granger Cause ALL	36	10.207	0.116
INFLR does not Granger Cause EXR	36	0.3485	0.840
INFLR does not Granger Cause RGDP	36	0.1732	0.917
INFLR does not Granger Cause RINTR	36	0.1276	0.938
INFLR does not Granger Cause ALL	36	2.3998	0.880
RGPD does not Granger Cause EXR	36	7.3152	0.026*
RGDP does not Granger Cause INFLR	36	1.2506	0.535
RGDP does not Granger Cause RINTR	36	0.7901	0.674
RGDP does not Granger Cause ALL	36	10.937	0.090*
RINTR does not Granger Cause EXR	36	4.4788	0.107
RINTR does not Granger Cause RINFLR	36	6.3513	0.042*
RINTR does not Granger Cause RGDP	36	0.4570	0.796
RINTR does not Granger Cause ALL	36	13.974	0.030*

Source: Researcher's Compilation from Stata

From table 5 above, the results of the Granger causality test revealed multi-directional relationship between exchange rate (REXR), real Gross Domestic Product (RGDP), real interest rate (RINTR) and inflation rate (INFLR) with causality running from REXR to RGDP, RINFLR and RINTR in the economy. The results also showed that RGDP, RINTR and INFLR have causal relationship with real exchange rate (REXR) in Nigeria. This is evidenced by

the P-values of the variables as shown in the estimation results of the Granger causality test. From the results, it is indicated that the Prob values are all greater than 0.005 (critical value), hence the null hypothesis is rejected, the alternate hypothesis is accepted that there is causal relationship between real exchange rate (REXR), real Gross Domestic Product (RGDP), real interest rate (RINTR) and inflation rate (INFLR).

Sensitivity tests

1. Autocorrelation

Table 5: Lagrange-multiplier test

Lag	Chi2	df	Prob
1	8.6028	16	0.9289
2	22.0138	16	0.1428
3	19.1029	16	0.2634

Source: Author's computation from Stata 14

Since the value of Prob is higher than the 5% critical values. i.e. Prob>0.005 critical values, hence there is no serial autocorrelation.

H_o**:** No autocorrelation at lag order

2. Test for heteroscedasticity

Breusch-Pagan / Cook-Weisberg test for heteroskedasticity
Ho: Constant variance
chi2 (1) = 0.30
Prob > chi2 = 0.5816
The *Prob>0.005* critical value, hence there is no heteroskedasticity.

5. Summary and Conclusions

Explicitly, this study focused on the assessment of real exchange rate through Vector error Correction Model in Nigeria for the period 1979-2015. Co-integration test and its associated vector error correction model (VECM) and Granger causality test were used in the analysis. Stationarity test was conducted through the application of the Augmented Dickey - Fuller (ADF) test, with the results indicating that all the variables were stationary at level 1 and first difference. Furthermore, the result of the Johansen co-integration test revealed that significant long run relationship exists among REXR, RGDP, RINTR and INFLR. The long term co-integration vector (VECM) suggests that (RINTR) and (RINFLR) have a negative impact on the exchange rate, while (RGDP) have a positive on the exchange rate. Finally, the result of the Granger causality test indicated multi-directional relationship between REXR, RGDP, INFLR and RINTR with causality running from REXR to RGDP, INFLR and RINTR. The findings above have some implication for dynamic monetary policy formulations in Nigeria mostly in determine the real exchange rate in Nigeria.

Hence, it is recommended that there is need for the monetary authority to pursue interest rate stability as hike in interest rate will post a serious threat to maintaining stability in real exchange rate. The fulfilment of a stable exchange rate regime that results in a balance of payments position that is viable and sustainable is one of the ultimate goals of monetary policy. The exchange rate should be prevented from too much appreciation; this may reduce the foreign reserve of the country. Also, government should try to encourage stable and sustained monetary policies so as to maintain the strength of the naira and should pursue strategies that are designed to neutralize the effects of some practices such as round tripping, over-invoicing and under-invoicing which have characterized the activities of the banking sectors in the recent years.

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