

## THE PRICE OF OIL AND EXCHANGE RATE DETERMINATION IN NIGERIA

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### Abstract

*This paper examine whether a link exists between oil price shocks and the Nigerian real effective exchange rate and other determinants of exchange rate. Unit root tests on the variables indicate that they could be characterised as  $I(1)$ . Johansen cointegration tests revealed at least three cointegration relationships using the trace and maximum eigen value rank test statistic. The evidence of cointegration enables us to estimate a cointegrating regression using real effective exchange rate as the dependent variable. The results show that the price of oil and openness of the economy significantly explain the level of exchange rate in Nigeria. The paper recommends expanded sources of foreign exchange for adequate funding of the market and import demand management as strategies in exchange rate management in Nigeria.*

**Key words:** Exchange rate, Oil price, Openness, Nigeria, Determinants, Cointegrating regression.

### Introduction

Getting the exchange rate right in a developing country has turned out to be one of the main challenges faced by macroeconomic policy design in recent times. This challenge is magnified by the adoption of World Bank/ IMF inspired Structural Adjustment Programme/ deregulation packages that were implemented in many of these countries. Edwards (1994) noted that real exchange rate behaviour occupies a central role in policy evaluation and design especially in the less developed countries. Since the real exchange rate is the price of foreign goods in terms of domestic goods, the real exchange rate plays a crucial role in guiding the broad allocation of resources in the domestic economy between foreign and domestic goods. It also signals inter-sectoral growth in the long-run and acts as a measure of international competitiveness. In the early 1980s the declining economic fortune of many sub-Saharan African Countries including Nigeria was attributed to over-valued exchange rates. Currency over-valuation often leads to a reduction in profits in the tradable goods sector, declining investment and adverse trade balance which may eventually lead to currency crisis (Xiaopu, 2002).

These potential weaknesses of currency over-valuation informed the adoption of the Structural Adjustment Programme (SAP) in 1986 in Nigeria. One of the main objectives of SAP was to put in place a realistic and stable exchange rate for the Naira. The new policy measure did not quite achieve the target of exchange rate stability. Rather, the naira exchange rate depreciated and also fluctuated throughout the post SAP era. The naira depreciated from N2.02 in 1986 to N8.03 in 1990. It depreciated further to N120.97, N129.36 and N133.50 to the US Dollar in 2002, 2003 and 2004 respectively (Central Bank of Nigeria(CBN),(2008). Although the Naira rate recorded some level of appreciation during the period 2005 to 2009, the exchange rate has since depreciated to N155 to the Dollar in 2011. Although several factors may be responsible for the instability in the Naira exchange market, the following are often mentioned: inadequate foreign capital inflow, unguided trade liberalization policy, weak export base, expansionary monetary and fiscal policies, import dependent production structures, fluctuations in crude oil earnings and demand- supply foreign exchange gaps (Obadan, 2006). In recent times the CBN has drawn attention to the fraudulent activities of some commercial banks that engage in "round-tripping", a situation in which banks buy foreign exchange from the CBN at official rates and sell to parallel market operators outside the stipulated official prices.

Although the effect of fluctuations in revenues from crude oil sales is tangentially implicated in explaining the instability in the naira exchange market, the relationships between the price of oil and the Naira exchange rate is less canvassed. It is the objective of this paper therefore to examine whether a link exists between oil prices and the Naira exchange rate. This study will contribute evidence to the suggestion that energy price changes can account for innovations in major Nigerian macroeconomic variables. Also, evidence of cointegrating relationship between oil prices and the exchange rate would offer a potential explanation for failure of real interest rate parity.

The paper is structured as follows. Following this introduction, section 2 reviews related literature. Section 3 describes the econometric methodology. Section 4 presents the results of the models while section 5 offers some concluding remarks.

## **2: Review of Related Literature**

In a seminal study, Edwards (1989) developed a model of exchange rate determination for a panel of 12 developing countries. The study found that in the short-run, real exchange rate variability was explained by both real and nominal variables while in the long-run only real variables were significant in explaining real exchange rate movements. The study also investigated the relationship between real exchange rate mis-alignment and economic performances and found that real exchange rate difference with regards to its equilibrium level has a negative impact. Richards (1997) used two approaches in investigating the empirical relationship between the real exchange rate and USA manufacturing profits. First it estimated a single-equation error correction model and second, a vector autoregressive (VAR) in log levels. The study found that after taking into account output, costs, relative prices and exports, shifts in the real exchange rate have, over the floating rate period had a significant influence on real USA manufacturing.

Drine and Rault (2001) used panel data unit- root tests and panel data cointegration techniques to estimate the long-run determinants of real exchange rate in MENA countries. The study revealed that for the countries studied output per capita; government consumption, real interest differentials and the degree of openness of the economy affect the exchange rate. The Balassa – Samuelson hypothesis posited that there is a positive relationship between aggregate output per capita and real exchange rate. Balassa (1973) reported similar results. Hsieh (1992), in a study of Japan and Germany for the 1954-1974 period reported that productivity differential variables were significant in explaining exchange rate movements. Edison and Klovland (1987) also reported the positive correlation between output and exchange rate movements.

Drine and Rault (2001) contended that the degree of openness of an economy affects the exchange rate movement since openness leads to import price decrease. The paper argued that a decrease in the tradable goods sector induced a real exchange rate appreciation. Mungule (2004) analyzed the fundamental determinant of exchange rate movement in Zambia and found that the terms of trade, openness of the economy, capital flows and excess supply of domestic credit, all significantly explain movements in exchange rate. Mordi (2006) contended that exchange rate volatility in Nigeria is explained by fundamentals such output growth (GDP) rates, inflation, balance of payments position, external reserves, interest rates movements, external debt position, productivity and other macroeconomic shocks. Ogun (2004) in a study of the effects of real exchange rate misalignment and volatility on the growth of non-oil exports found that irrespective of the alternative measures of misalignment adopted both real exchange rate misalignment and volatility adversely affected growth of Nigeria's non-oil export.

Exchange rate management policies in Nigeria may be grouped under two broad periods - the period before SAP i.e. 1960 – 1985 and the post SAP period (1986 – 2011). The objectives of exchange rate policies during pre-SAP period include maintenance of stable exchange rate, stable value of external reserves and balance of payments equilibrium. It is often suggested that until 1986 when the SAP policy was implemented, exchange rate policies encouraged the over-valuation of the naira. During the SAP period, the exchange rate strategy was to float the naira and establish an institutional framework for its trading in a competitive market environment (Obadan, 2006). It should be noted that the institutional framework and the exchange rate management strategies in Nigeria have changed over time. The initial framework at the inception of SAP was the second- tier foreign exchange market (SFEM). It was later to become the foreign exchange market (FEM), the Dutch auction system and currently the wholesale Dutch auction system. These changes were necessitated by the desire to fine-tune the operations of the exchange market and to check sharp practices by market operators. In spite of all these refinements and changes in the exchange rate policies, the goal of a stable exchange rate for the naira is yet to be fully attained. The demand for foreign exchange has persistently risen above its supply leading to fluctuations in the value of the Naira.

### **2.1 Theoretical Framework**

The equilibrium real exchange rate depends on several factors. For the purpose of this study we adopt the approach developed by Drine and Rault (2001). Define real exchange rate in a country with tradable and non-tradable goods sector as

$$REER = \frac{E P^{TW}}{P^N}$$

Where  $P^{TW}$  is the world price of traded goods and  $P^N$  is the price of non-traded goods and  $E$  is the nominal exchange rate. Equilibrium exchange rate ensures both internal and external balance. Internal balance implies

$$Y_N(e) = (1 + \beta) e C + G_N \tag{1}$$

- Where  $Y_N$  = Production of non-traded goods
- $G_N$  = Government consumption of non-traded goods
- $\beta$  = the share of traded goods in total consumption
- $C$  = total private consumption

A rise in private consumption will increase the demand for both traded and non-traded goods and cause the relative prices of non-traded goods to rise. This will shift the supply curve of non-traded goods to the right and the exchange rate will appreciate as the demand for traded goods will also rise.

In the external sector, equilibrium is defined as:

$$A = rA + Y_T(e) + G_T + \beta c \tag{2}$$

- Where  $A$  = net foreign assets
- $Y_T$  = the domestic supply
- $G_T$  = Government spending in traded goods
- $r$  = the world interest rate. If net foreign assets is equal to zero in equilibrium, then equation (2) becomes a relationship between private consumption and real exchange rate. A rise in private consumption leads to current account deficit and currency depreciation in order to maintain equilibrium. The depreciation of real exchange rate increases the demand for non-tradable and also increases the supply of tradable.

The real exchange rate at which both internal and external balance is achieved is thus:

$$E = f(G_N, G_T, A, r)$$

Assume tariffs are imposed on imported tradable then the real exchange rate will be defined as

$$Reer = E [\alpha (1 + t) P_m + (1 + \beta) P_x] \tag{4}$$

Where  $P_m$  and  $P_x$  are world prices of imported and exported goods and  $t$  is the tariff on imports (Drine and Rault, 2001).

### 3: Materials and Methods

#### 3.1: The data and Model Specification

In investigating the relationship between the naira exchange rate and the price of crude oil, we adopt a cointegration approach following the Engle-Granger (1987) theorem. In carry out this study, the following variables and their sources are described below.

- REER: This is the real effective exchange rate defined as the measure of the relative relation of non-tradable goods.
- TOT: This is the terms of trade, i.e. the number of the units of exports that must exchange for one unit of imports.
- OPEN: This the degree to which the country is “open” to the outside world. It is measured as the ratio of trade (imports and exports) to gross domestic product (GDP)
- NEER: This is nominal effective exchange rate. It measures the relative price of the naira to units of other currencies.
- POIL: Oil price volatility derived by means of a GARCH(1,1) equation of oil price.
- GEXPGDP: This is the ratio of government expenditures to GDP. This measures the fiscal stance of government.
- RGDP: Real gross domestic product
- INF: This is a measure of the rate of inflation.

The series for the variables listed above are obtained from the statistical Bulletin of the Central Bank of Nigeria except POIL, which we obtained from two sources: 1Petroleum and Energy Intelligence Weekly Inc. (1970-1977) and 2. USA Energy Information Administration, Weekly Petroleum Status Report 1978-2010)..

Deriving from the literature reviewed earlier as well as the theoretical framework, an expanded exchange rate model is specified as follows

$$REER = a_0 + a_1Poil + a_2 Open + a_3TOT + a_4 RGDP + a_5Neer + a_6 INF + U_1 \quad (5)$$

Where  $a_1, a_2, a_3 > 0$ ;  $a_4, a_5 > 0$   $a_6 < 0$

**3.1.1: Unit Root Test**

It is now common practice to check the time series properties of economic data to subsequent multivariate modeling and inference (Amano and Norden 1993). We therefore proceed by testing the null hypothesis of an autoregressive unit root tests. The augmented Dickey-Fuller (ADF) and the Phillips – Perron (PP) are most commonly used and based on the test regression:

$$Y_t = a_0 + a_1 Y_{t-1} + \sum_{i=1}^k \beta_i \Delta y_{t-i} + u_t \quad (6)$$

Where  $y$  is the variable being tested,  $a$ 's and  $\beta$ 's are parameters to be estimated and  $\Delta$  is the first- difference operator.  $u_t$  is the error term.

**3.1.2: Cointegration Test**

Testing for cointegration allows us to gauge the adequacy of specifying the long-run relationship among the variables. Evidence of cointegration implies that the price of oil (which is our main focus here) captures the main source of persistent innovations in the real effective exchange rate. It also shows the evidence of a long-run relationship among the variable. Gonzalo (1989) suggested that the Johansen and Juselius (1996) approach performs better than single equation and alternative multivariate methods; hence we adopt that approach in this study.

**3.1.3: Cointegrating Regression**

Many economic time series are often difference stationary. Philips (1986) noted that a regression involving the levels of these 1(1) series will produce “spurious results”. Engle and Granger (1987) noted that a linear combination of two or more 1(1) series may be stationary, in which case we say the series are cointegrated. Such a linear combination defines a cointegrating equation with cointegrating vector of weights characterizing the long-run relationship between the variables. Consider the  $n + 1$  dimensional time series vector process  $(y, A_t)$ , with cointegrating equation.

$$Y = A_t \theta + \beta_1 t' \alpha + U_{1t} \quad (7)$$

Where  $\beta_t = (\beta_{1t}, \beta_{2t})'$  are deterministic trend regressors and the  $n$  stochastic regressors  $A_t$  are governed by the system of equations.

$$A_t = \begin{pmatrix} \delta_{21} & \beta_{1t} + \delta_{22} \end{pmatrix} \beta_{2t} + e_{2t} \quad (8)$$

$$\Delta e_{2t} = U_{2t}$$

The  $P_1$ - Vector of  $B_{1t}$  regressors enter into both the cointegrating equation and the regressors equations while the  $P_2$  vector of  $B_{2t}$  are deterministic trend regressors which are included in the regressors equations but excluded from the cointegrating equation.

Hansen (1992b) has shown that the innovations  $U_t = (U_{1t}, U_{2t})'$  are strictly stationary and ergodic with zero mean, contemporaneous covariance matrix  $\Sigma$ , one-sided long-run covariance matrix  $Z$ , and non-singular long-run covariance matrix  $\Delta$ , each of which could be represented as:

$$\Sigma = E(u_t, u_t') = \begin{pmatrix} a_{11} & a_{12} \\ a_{21} & \Sigma_{22} \end{pmatrix} \dots \dots \dots (9)$$

$$Z = \sum_{j=1}^{\infty} E(u_t u_{t-j}') = \begin{pmatrix} \lambda_{12} \\ \lambda_{21} \end{pmatrix} \begin{pmatrix} Z_{22} \end{pmatrix} \dots \dots \dots (10)$$

$$\text{And } \Delta = \sum_{j=0}^{\infty} E \begin{pmatrix} b_{12} \\ b_{21} \end{pmatrix} \begin{pmatrix} \Delta_{22} \end{pmatrix} \dots \dots \dots (11)$$

The assumption is that the elements of  $y$  and  $A_t$  are  $I(1)$  and cointegrated but exclude both cointegration among the elements of  $A_t$  and multicointegration. Hamilton (1994) found that if the series are cointegrated static ordinary least squares estimation of the cointegrating vector  $\theta$  in equation (7) is consistent, converging at a faster rate than is standard. One weakness of static ordinary Least Squares (OLS) is that the estimates have an asymptotic distribution that is generally non-Gaussian, exhibit asymptotic bias, asymmetry, and are a function of non-scalar nuisance parameters. Static OLS is therefore less recommended if one wishes to conduct inference on the cointegrating vectors. To overcome these weaknesses of the static OLS, Phillips and Hansen (1990) propose an estimator which employs a semi-parametric correction to eliminate the problems caused by the long-run correlation between the cointegrating equation and stochastic regressors innovations. The resulting Fully Modified Ordinary Least Squares (FMOLS) estimator is asymptotically unbiased and has fully efficient mixture normal asymptotics, allowing for standard Wald test using asymptotic Chi-square statistical inference. The FMOLS method was used to examine the relationship between real effective exchange and oil price volatility in Nigeria using a cointegrating regression methodology. This is followed by using the same procedure to examine the determinants of real effective exchange rate in Nigeria.

#### **4. Analysis of Results**

##### **4.1: Unit Root Test Results**

The results of the ADF and Philips Peron unit root tests are presented in table 1 below. From table 1 the unit-root tests are unable to find any significant evidence of stationarity at levels. We therefore conclude that the variable used in this study can be well characterized as  $I(1)$  process.

##### **4.1.1: Johansen Cointegration Test Results:**

Table 2 below shows the results of the Johansen cointegration test results. The table shows that using the Trace test indicates three cointegrating equations at the 0.05% level, and the max – eigen value Test also indicates three cointegrating equations. Evidence of cointegration shows that a long-run relationship exists among the variables.

##### **4.1.2: Cointegrating Equations**

To overcome some of the weaknesses of the static ordinary Least Squares we investigate the relationship between the real effective exchange rate and the price of oil as well as the other variables in the model by using the cointegration regression method (Startz, 2009). First, we regress real exchange rate using first differenced data on oil price volatility. Table 3 presents the results of the regression. Table 3 reveals a negative relationship between the price of oil and real effective exchange rate in Nigeria. The coefficient of oil price volatility is significant at the 1% level. We note here that while the measures of fit and the Durbin-Watson statistic may be of casual interest, we exercise caution in using these measures. Table 3 also reveals “Long-run variance value which is the estimate of the long-run variance of  $U_{1t}$  conditional on  $U_{2t}$ . In table 3 the value of 4.000 is the ‘ $b_{12}$ ’ in equation (11) employed in forming the coefficient covariance and is obtained from  $Z$  and  $\Delta$  (equation 10 and 11) used in estimation.

The negative relationship between real effective exchange rate and the price of oil indicates that when there is a rise in the price of oil, Nigeria will earn more foreign exchange from the sale of oil to fund the foreign exchange market. The enhanced foreign exchange supply depresses its price and vice versa. Next, we explore further the dynamic relationship between the real effective exchange rates and its other determinants. The result of the cointegrating regression in first differences is reported in table 4. From table 4, the price of oil, openness of the economy, nominal exchange rate and government spending significantly explain innovations in the real effective exchange rate in Nigeria. Although the terms of trade variable bear the expected sign, it is not significant. The nominal exchange rate variable and government spending/GDP ratio bears the unexpected negative sign and are significant. In summary, exchange rate determination in Nigeria is substantially explained by the volatility in the international price of oil and the openness of the economy.

#### **5: Conclusion**

This study set out to explore whether a link exists between the price of crude petroleum oil and the Nigerian real effective exchange. It also examined the other determinants of exchange rate as documented in the literature. The time series properties of the variables were investigated and found that the series were  $I(1)$  processes.

The study also revealed that oil prices are cointegrated with real exchange rate which suggests that oil prices may have been the dominant source of persistent real exchange rate shocks especially since the structural adjustment programme (SAP) of 1986. Using the FMOLS estimation technique a single equation model of real exchange rate and oil price was estimated by means of a cointegrating regression in first differences. The regression was done in two parts: first, the real effective exchange rate was regressed on the price of oil. The result showed that oil prices significantly explain variations in real exchange rate. The negative relationship observed is in line with ‘a priori’ expectations. Revenues, from the sale of oil are the main source of funding the Naira exchange rate market. A rise in oil prices would translate to increased foreign exchange with which government fund the exchange market. Second a real exchange rate multivariate model was estimated by means of FMOLS. The result shows that as in the first regression, the price of oil is negatively related to the real effective exchange rate and is significant in explaining innovations in Naira exchange rate. The regression also reveals that the openness of the economy has a negative relationship with real effective exchange rate. This indicates that openness permits unrestricted demand for imports. A rise in import demand would trigger a rise in demand for foreign exchange. Given the limitations in foreign exchange supply, openness has the potential to create a gap between demand and supply in the foreign exchange market. The coefficient of openness in the regression is statistically significant at 10% level.

The nominal exchange rate (NEXR) and government spending/ GDP ratio (GSPGDP) variables turned out to be significant in explaining real effective exchange rates in Nigeria but bear the unexpected negative sign. From the results of our cointegration regressions, the price of oil has been found to be significant in explaining real effective exchange rates in Nigeria. Oil price is exogenously determined and prone to frequent fluctuations. Since the level of real exchange rate in Nigeria is significantly accounted for by innovations in the oil prices, exchange rate management is unable to affect all the variables that determine the rate. Two recommendations follow from these findings. First, government should boost the level of foreign exchange from other sources so that the funding of the exchange rate market would not rely heavily on revenues from the sale of oil as the case in today. Government should also put in place an import demand management framework with a view to putting a check on the demand for foreign exchange.

**Table 1. Results of ADF and PP Unit Root Test**

ADF			PHILIP PERRON (PP)	
Variables	At levels	Order of integration	At levels	Order if integration
REER	-2.0767	1(1)	-3.4477	1(1)
NEXR	0.1724	1(1)	0.01672	1(1)
OPEN	0.5654	1(1)	-3.8953	1(1)
POIL	1.7207	1(1)	1.3305	1(1)
RGDP	1.2507	1(1)	1.5527	1(1)
INF	-3.1371	1(1)	-3.0354	1(1)

Source: Author’s computations

**Table 2. Results of Johansen Cointegration Test**

Date: 10/16/11 Time: 20:57				
Sample (adjusted): 1972 2008				
Included Observations: 37 after adjustments				
Trend assumption: Linear deterministic trend				
Series: REER NEXR POIL TOT INF RGDP GSPGDP OPEN				
Lags interval (in first differences): 1 to 1				
Unrestricted Cointegration Rank Test (Trace)				
Hypothesized	Eigenvalue	Trace Statistic	0.05	Prob.**
No. of CE(s)			Critical Value	
None*	0.926759	265.5369	159.5297	0.0000
At most 1*	0.836511	168.8189	125.6154	0.0000
At most 2*	0.685463	101.8116	95.75366	0.0179
At most 3	0.568992	59.01539	69.81889	0.2669
At most 4	0.358474	27.87515	47.85613	0.8191
At most 5	0.161084	11.45064	29.79707	0.9493
At most 6	0.122987	4.951795	15.49471	0.8139
At most 7	0.002596	0.096175	3.841466	0.7565

Trace test indicates 3 cointegrating eqn(s) at the 0.05 level  
 \* denotes rejection of the hypothesis at the 0.05 level  
 \*\* Mackinnon-Haug-Michelis (1999) p-values

Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Value	Critical Value	Prob.**
None*	0.926759	96.71807	52.36261		0.0000
At most 1*	0.836511	67.00732	46.23142		0.0001
At most 2*	0.685463	42.79617	40.07757		0.0241
At most 3	0.568992	31.14024	33.87687		0.1025
At most 4	0.358474	16.42450	27.58434		0.6295
At most 5	0.161084	6.498849	21.13162		0.9709
At most 6	0.122987	4.855620	14.26460		0.7600
At most 7	0.002596	0.096175	3.841466		0.7565

Source: Author's computations.

**Table 3: Cointegration regression results.**

Dependent Variable: LREER  
 Method: Fully Modified Least Squares (FMOLS)  
 Date: 10/25/11 Time: 18:49  
 Sample (adjusted): 1971 2008  
 Included observations: 38 after adjustments  
 Cointegrating equation deterministics: C  
 Long-run covariance estimate (Bartlett Kernel, Newey-West Fixed bandwidth = 4.0000)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LPOIL	-0.711617	0.336640	-2.113880	0.0415
C	7.303749	1.032243	7.075608	0.0000
R-Squared	0.779988	Mean dependent var		5.312798
Adjusted R-Square	0.757210	S.D. dependent var		0.966980
S.E. of regression	0.887723	Sum squared resid		28.36985
Durbin-Watson stat	0.233395	Long-run variance		2.366961

Source: Author's computations

**Table 4: Cointegration regression results**

Dependent Variable: LREER  
 Method: Fully Modified Least Squares (FMOLS)  
 Date: 10/26/11 Time: 07:47  
 Sample (adjusted): 1972 2008  
 Included observations: 37 after adjustments  
 Cointegrating equation deterministic: C @ TREND @ TREND^2  
 Regressor equations estimated using differences  
 Long-run covariance estimate (Bartlett kernel, Integer Newey-West Fixed bandwidth = 4.0000)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LPOIL	-0.494289	0.181108	-2.729252	0.0108
LOPEN	-0.172367	0.092732	-1.858766	0.0736
LNEXR	-0.818993	0.201724	-4.059976	0.0004
LRGDP(-1)	-0.156990	0.126751	-1.238568	0.2258
LGSPGDP	0.152480	0.081039	1.881574	0.0703
LTOT	-0.006335	0.022477	-0.281857	0.7801
C	8.988315	1.133475	7.929874	0.0000
@ TREND	-0.023640	0.060526	-0.390576	0.6991
@TREND^2	0.003806	0.000725	5.251079	0.0000
R-squared	0.930218	Mean dependent var		5.270261
Adjusted R-squared	0.910281	S.D. dependent var		0.943588
S.E. of regression	0.282635	Sum squared resid		2.236704
Durbin-Watson stat	0.938557	Long-run variance		0.109127

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