

# International Oil Prices and Exchange Rate in Nigeria: A Causality Analysis

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## Abstract

This study examined the effect of oil price movements on USD-Naira exchange rate pair using 420 observations from monthly time series data for the period January 2008 to December 2014. An ordinary least squares (OLS) model and a vector autoregression (VAR) model were estimated for analyzing respectively, the impact of oil price movements on exchange rate and the nature of causal link between them. Empirical results show that oil prices on a relative basis significantly affect exchange rate compared to imports. Also, there is evidence of unidirectional Granger causality from oil prices to exchange rate and from oil prices to foreign reserves. Based on the findings, policy recommendations were made in favour of a change in the current structure of our international trade to reduce and gradually eliminate import dependence in order to enhance the ability of the monetary authorities to manage both exchange rate and foreign reserves.

**Keywords:** Oil Prices, Exchange Rate, Foreign Reserves, Granger Causality, Vector

## Introduction

It is widely known among economists that international oil prices saw a sharp fall during the global economic crisis of 2008. This led to a fall in oil revenues and unfavorable exchange rate movements for major oil-exporting economies especially those that were not well-diversified. The situation was worse for some OPEC economies with low levels of accumulated foreign reserves. The motivation for this paper is drawn from the author's observation that the plunge in international crude prices experienced in late 2014 affected the USD/Naira exchange rate to the extent that according to media reports, the monetary authorities had to devalue the Naira twice between September 2014 and June 2015 after it was no longer sustainable to continue the defense of the local currency using the nation's foreign reserves. In addition, exchange rate volatility occasioned by unfavorable oil price movements not only contributes to increasing the foreign exchange risk of businesses but also leads to higher cost of living when an economy is import dependent. The complex chain of macroeconomic linkages creates a situation where cost-push inflation could lead to fall in real incomes and hence, standard of living. These economic realities show that a study of this nature is worthwhile. Our study examines the effect of oil price movements on exchange rate and attempts to highlight how import dependence exposes the Nigerian economy to huge exchange rate problems especially when oil prices fall and why addressing the problem

through the intervention of the monetary authorities in the foreign exchange market is only a short-term solution.

### **Theoretical Background**

We begin this section by shedding some light on what an exchange rate is and the forces that determine how much is paid for money and finally we consider the factors that also determine oil prices. So what is exchange rate? It is ideally the equilibrium price determined by the interplay of market forces of supply and demand in a free market. In the real world however, some form of intervention is done by the government through the monetary authorities. Thus, the foreign exchange market for the dollar-naira pair in Nigeria is not free from regulation. We can say that the exchange rate (price) in the Nigerian market is determined by three major factors: demand, supply and the activities of the monetary authorities.

The demand for the dollar is fuelled by the activities of traders who import goods such as capital equipment used for manufacturing, finished electronic hardware products such as computers and their associated software, other Information and Communication Technology (ICT) products as well as military equipment. Services which generate demand for foreign currency include expenses made to acquire academic education and professional training overseas and medical tourism to mention a few.

The supply of the dollar is sustained majorly by the periodic sale of the currency by multinational corporations especially oil majors to pay staff salaries and meet other operational expenses of their businesses in Nigeria and the sale of the foreign exchange earned by the Nigerian National Petroleum Corporation representing Nigeria's equity crude. It is important to note that what constitutes demand for the US dollar simultaneously constitutes supply of the Nigerian naira.

The third factor is the regular intervention of the CBN as it deems fit in the market to influence the direction of the exchange rate movement in line with its policy objectives. The intervention of the CBN is in fulfillment of one its statutory responsibilities and is truly a welcome development because the stability it brings to exchange rate is good for foreign investors who are assured that their exposure to exchange rate risk is within tolerable limits. In addition, it is good for the implementation of the federal budget which is predicated on an average exchange rate. We also note that the ability of the CBN to intervene in this market is affected by how much of foreign reserves it has at its disposal.

Additionally, oil prices like exchange rate are determined by the interaction of demand and supply forces. Generally, the demand for oil is affected by the state of the global economy while supply is affected by the combined productive capacity of OPEC and non-OPEC nations, economic sanctions on countries perceived to be sympathetic to terrorism as well as oil politics. Therefore, we find that when the global economy is booming, demand growth is strong and *ceteris paribus*, this tends to push up prices. On the other hand, when the global economy slows and the market becomes over supplied, prices begin to fall and the situation could be worse when competitors strategize to defend and retain market share.

### **Literature Review**

The importance of oil in the Nigerian economy cannot be over emphasized. From an agrarian economy in the 1960's the Nigerian economy has come to be known and identified as being oil-powered, with oil receipts accounting for over 70 percent of federal revenue and over 90 percent of foreign earnings (Ani et al, 2014). This situation comes with its attendant consequences one of which is the exposure of key macroeconomic variables such as inflation

rate and exchange rate to oil price fluctuations. Indeed, oil prices have become so important to the Nigerian economy that principal economic policy makers at the CBN and the Federal Ministry of Finance factor them into economic policy decisions. This is due to the inevitable direct impact which oil prices have on the national budget which in turn is an instrument of fiscal policy (Ani et al, 2014).

There exists a sizeable volume of literature on the relationship between oil prices on the one hand and exchange rates or other macroeconomic variables on the other. We examine some of the on-going discussions below.

Umar and Abdulhakeem (2010) examined how oil price shocks affect the macro economy using a VAR approach and found that oil price shocks had strong impact on GDP and money supply. In a similar manner, Ayadi, (2005) studied how oil price movements affect the Nigerian economy using vector autoregressive model and found that changes in oil prices affect real exchange rates and industrial production.

In addition, Igberaese, (2013) did a study on the impact of oil prices on Nigeria's economic growth and found out that oil prices significantly impacted growth. Specifically, in the short run, high oil prices spurred growth but not in the long run. Also, Muritala et al. (2012) studied how oil and stock prices affect economic growth using Johansen method of cointegration and found that the variables have long-run relationship.

However, as far as oil prices and exchange rates are concerned, there seems to be a general consensus that oil price increases favour oil exporting nations. For example, Ogundipe et al. (2014) highlighted Krugman's (1983) claim that increases in oil prices led to favourable exchange rate movements for oil-dependent economies while at the same time, falling oil prices favored the exchange rates of non oil-dependent economies. Furthermore, Sascha et al.(2012) stated that positive oil price shocks triggered currency appreciation for oil exporters and ultimately increased accumulated foreign reserves.

In addition, several other studies report that oil prices strongly impact exchange rate (Englama et al, 2010). Nikbakht, (2009) studied the relationship between oil prices and exchange rate in OPEC countries using Johansen cointegration technique and found evidence in support of a long-run relationship between the variables. Englama et al. (2010) did a study on the impact of oil prices on exchange rate volatility in Nigeria and found that oil price shocks impacted strongly on exchange rate volatility. Oriavwote and Eriemo, (2012) did another study that examined the relationship between oil prices and real exchange rate in Nigeria. The results not only showed evidence for a long run relationship between oil prices and real exchange rates but also showed a unidirectional causality from oil prices to real exchange rate. In their study, Adeniyi et al (2012) observed that the Nigerian Naira appreciated against the US Dollar in response to increasing oil prices. In addition, they reported that Amano and Van Norden (1998) investigated the causal link between oil prices and exchange rates in the USA, Germany and Japan and found that oil prices caused exchange rates in all three countries to fluctuate. Yoshizaki and Hamori (2013) had reported the observation of Gregorio and Wolf (1994) that the currencies of countries trading commodities responded to movements in the prices of those commodities. They however argued that there could be exceptions to this rule as evidenced by the studies of Habib and Kalamova (2007). Another example of this exception is evidenced by the work of Ani et al. (2014) which examined the nature of causal relationship between four macroeconomic indicators including inflation rate , exchange rate, interest rate and real GDP in Nigeria using ordinary least squares and Granger causality approach. Interestingly, their results show that oil prices have no significant effect on real GDP and exchange rate. In another development, Ogundipe et al. (2014) examined how oil prices

affected exchange rate volatility in Nigeria and concluded that changes in oil prices led to more than proportionate changes in exchange rates. Finally, Yusuf, (2015) also conducted a study to investigate the relationship between oil prices, exchange rate and economic growth. The results show that the variables are cointegrated and that oil prices and exchange rate were significant in predicting the economic growth.

In theory, changes in oil prices affect exchange rate through a country's terms of trade or through what we call "the wealth effect" in which there is a transfer of wealth from oil-exporting nations to oil-importing nations when oil prices fall and vice versa (Sascha et al. 2015). Also, in practice, oil-exporting nations usually accumulate foreign reserves when oil prices rise and during periods of falling prices, they tend to reduce foreign reserves holdings while trying to manage the depreciation of local currency caused by unfavorable exchange rate movement (Sascha et al. 2015).

From our discussion above, it is evident that there exists a substantial amount of literature on the relationship between oil prices and macroeconomic variables especially exchange rate. Some of these studies were done for countries that were already industrialized and are not oil exporters. The uniqueness of this study lies in the fact that it focuses on an oil-exporting economy striving to be industrialized and considers the period after the 2008 economic crisis. In addition, while most empirical studies have focused on modeling the volatility of exchange rate occasioned by oil price shocks, this study examines the causal link between oil prices and exchange rate and the impact of Nigeria's continued dependence on imports as well as its implications for exchange rate management by the monetary authorities.

### **Methodology**

Our study uses monthly time series data of all the variables downloaded from the CBN database and we employ a 5% level of significance for hypothesis testing. Our analysis will make use of ordinary least squares (OLS) for model estimation and vector auto regression (VAR) model for Granger causality test. Estimation of both models is premised on the assumption that the series or variables have stable means and variances that do not change with time. Series exhibiting this kind of property are said to be stationary. Stationarity implies that a series has a constant mean, constant variance and constant auto covariance structure at any given lag. One important characteristic of a stationary series is that the effect of shocks to the system at current time is always smaller compared to that in the previous time. In effect, shocks gradually die away with the passage of time and the system returns to equilibrium (Brooks, 2008).

Stationarity is highly desirable if inferences and forecasts from econometric models are to be reliable. The stationarity of a variable is determined by testing for unit root using the traditional methods like ADF, PP or KPSS tests. However, these methods especially ADF test have been criticized because when there is a structural break in the series, the chances of rejecting the null hypothesis when it is not true is diminished (Glynn et al, 2007). This means that there is an increased chance of committing a type two error when there is a structural break. They argued that in the presence of a structural break, the ADF test has a reduced chance of rejecting the null hypothesis when it is not true. To account for this deficiency, other methods have been advocated for doing the ADF test in the presence of a break. Some of these methods eg Perron (1989) require determining the break points exogenously while others eg Zivot and Andrews (1992) and Perron (1997) advocated for endogenous determination of break point from the data set. However, because the determination of break points is itself exposed to subjective bias, a generally accepted view on this issue is yet to

emerge (Glynn et al, 2007). Consequently, researchers' decision on what method to adopt is shaped by experience and feasibility among other factors. Our study will adopt the regular test for unit root using the Phillips-Perron test and we shall account for the structural breaks in our series on oil prices when we subject our econometric model to parameter stability test.

### Model Specification

Though we intend to model oil prices and exchange rate, we recall that Sascha et al.(2015) emphasized that international trade is an important channel through which the effect of oil price movements is transmitted to exchange rate. Therefore, we shall include imports as a control variable in our model and we shall also control for exports and foreign reserves when we do sensitivity analysis. Thus, the functional form of our model is stated as

Exchange rate =  $f(\text{Oil price and Imports})$

However, our regression model is specified below

$$\ln REER = \beta_0 + \beta_1 OILP + \beta_2 \ln IMP + \mu$$

Where the predictor variables are oil prices (OILP) and the natural logarithm of imports (lnIMP), the outcome variable is the natural logarithm of real effective exchange rate (lnREER),  $\beta_0$ ,  $\beta_1$ , and  $\beta_2$  are model parameters and  $\mu$  is the model residuals.

To investigate causality, it is necessary to estimate a VAR model. Causality implies that the present value of one variable correlates with the lagged values of another variable. It does not mean that movement in one variable is engineered or physically caused by movements in another (Brooks, 2008).

Causality can be unidirectional but it could also be bi-directional in which case it flows in opposite directions.

Testing for Granger causality involves estimating a VAR model of the form specified below:

$$Y_t = \alpha_1 + \delta_1 Y_{t-1} + \delta_2 Y_{t-2} + \dots + \delta_n Y_{t-n} + \gamma_1 X_{t-1} + \gamma_2 X_{t-2} + \dots + \gamma_n X_{t-n} + \mu_t \quad (1)$$

$$X_t = \alpha_2 + \lambda_1 X_{t-1} + \lambda_2 X_{t-2} + \dots + \lambda_n X_{t-n} + \varphi_1 Y_{t-1} + \varphi_2 Y_{t-2} + \dots + \varphi_n Y_{t-n} + v_t \quad (2)$$

Where  $Y_t$  and  $X_t$  are the variables under observation,  $\alpha_1$  and  $\alpha_2$  are intercepts,  $\delta_1$ ,  $\delta_2$ ,  $\delta_n$ ,  $\gamma_1$ ,  $\gamma_2$ ,  $\gamma_n$ ,  $\lambda_1$ ,  $\lambda_2$ ,  $\lambda_n$ ,  $\varphi_1$ ,  $\varphi_2$ , and  $\varphi_n$  are parameters of the system model while  $\mu_t$  and  $v_t$  are system residuals.

The model above is only for illustration purposes and our ideal model will comprise a system of three equations to account for the three variables we are investigating. The causality test also involves computing an F-statistic for the joint null hypothesis  $H_0: \gamma_1 = \gamma_2 = \gamma_n = 0$ . This a test that the lagged values of  $X_t$  do not Granger cause  $Y_t$  and rejection of this null hypothesis is an indication that  $X_t$  Granger causes  $Y_t$  (Giles, 2011). It is important to emphasize that the F-statistic will deviate from its supposed asymptotic chi-square distribution under the null if all or some of the causal variables are not stationary (Brooks, 2008 & Giles, 2011). Therefore, to avoid misleading inferences, it is necessary to ensure that variables are all stationary.

## Empirical Results

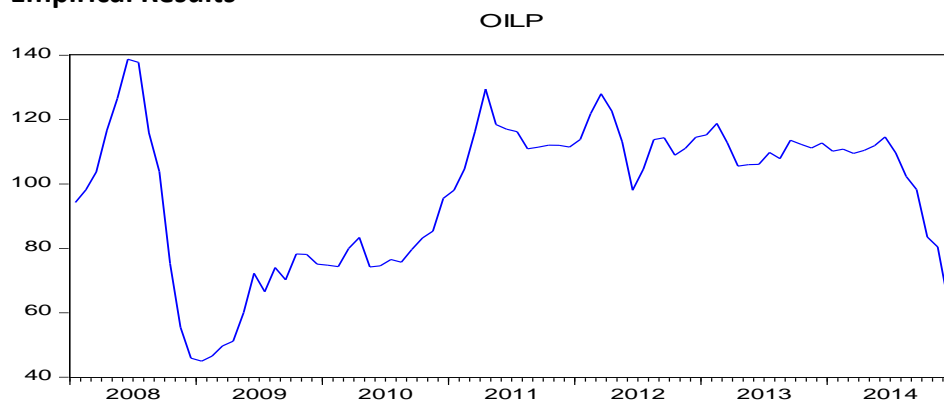


Figure 1 oil price series

### Data source and reference crude: Central Bank of Nigeria, London Brent.

The line graph above clearly highlights the sharp fall in oil prices in the second half of 2008 and 2014.

We begin our empirical analysis by testing for unit root in our data series. Results are presented below.

#### Philips Perron Unit root test

H<sub>0</sub>: Series has a unit root

| Variable | Level   | First diff. | 5% Crit. Value | Stationarity status         |
|----------|---------|-------------|----------------|-----------------------------|
| LREER    | -0.1059 | -7.6479     | -2.8967        | I(0) after first difference |
| OILP     | -2.0261 | -5.1801     | -2.8967        | I(0) after first difference |
| LIMP     | -3.3779 | -16.5840    | -2.8967        | I(0) at level               |
| LRES     | -1.3995 | -6.5284     | -2.8967        | I(0) after first difference |
| LEPT     | -2.5254 | -11.0594    | -2.8967        | I(0) after first difference |

Panel (A): Unit root test with constant only.

| Variable | Level   | First diff. | 5% Crit. Value | Stationarity status         |
|----------|---------|-------------|----------------|-----------------------------|
| LREER    | -1.6883 | -7.6561     | -3.4648        | I(0) after first difference |
| OILP     | -1.9329 | -5.1993     | -3.4648        | I(0) after first difference |
| LIMP     | -4.7230 | -16.4172    | -3.4648        | I(0) at level               |
| LRES     | -1.4072 | -6.5107     | -3.4648        | I(0) after first difference |
| LEPT     | -2.4787 | -11.0100    | -3.4648        | I(0) after first difference |

Panel (B): unit root test with constant and linear trend.

The results of our unit root test shows that with the exception of the series on imports (LIMP) which is stationary in its level form, other variables are stationary after first differences. We therefore proceed with model estimation.

The results of model estimation are presented below.

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Dependent Variable: D(LREER)

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Included observations: 83 after adjustments

| Variable           | Coeff.  | Std. Error         | t-Statistic | Prob.  |
|--------------------|---------|--------------------|-------------|--------|
| D(OILP)            | 0.0008  | 0.000428           | 1.924300    | 0.0579 |
| LIMP               | -0.0208 | 0.013016           | -1.599484   | 0.1137 |
| C                  | 0.1683  | 0.109004           | 1.544454    | 0.1264 |
| R-squared          | 0.0754  | Adjusted R-squared |             | 0.0523 |
| Log likelihood     | 174.25  | F-statistic        |             | 3.2663 |
| Durbin-Watson stat | 1.7270  | Prob(F-statistic)  |             | 0.0432 |

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Regression results from Eviews 8

Having estimated our regression model, we proceed with serial correlation and parameter stability tests as well as test for model misspecification. Results are presented below.

Diagnostic test of serial correlation

We subject our model to serial correlation test to ensure that inferences made from it would not be unreliable. Results presented below show that the null hypothesis of no serial correlation cannot be rejected.

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Breusch-Godfrey Serial Correlation LM Test:

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|               |        |             |        |
|---------------|--------|-------------|--------|
| F-statistic   | 0.8226 | Probability | 0.4430 |
| Obs*R-squared | 1.7146 | Probability | 0.4242 |

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Test for model misspecification

The Ramsey's RESET test is generally used for testing misspecification of functional form (Brooks, 2008) and the null hypothesis for this test is that the model is not misspecified.

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Ramsey RESET Test

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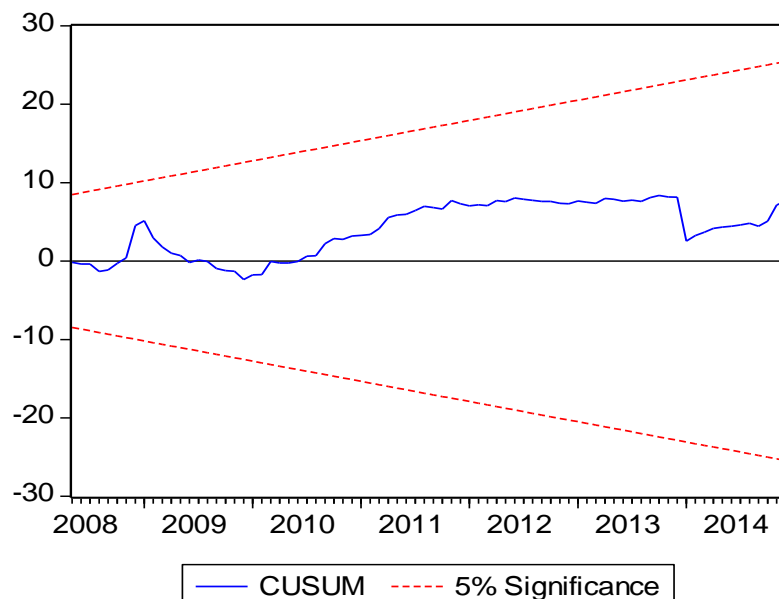
|                      |        |             |        |
|----------------------|--------|-------------|--------|
| F-statistic          | 0.1305 | Probability | 0.7188 |
| Log likelihood ratio | 0.1370 | Probability | 0.7112 |

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The F and  $\chi^2$  statistic above with their p- values show that we cannot reject the null hypothesis. Thus, our model is not misspecified.

Test for parameter stability

Brooks (2008; P187) reports that an appropriate technique to test for parameter stability in an OLS model when a structural break with an unclear date exists in the series is the stability test based on recursive estimation. We employ the cumulative sum (CUSUM) test which is derived from the recursive estimation for our stability test. The null hypothesis here is that the model's parameters are stable. Results of the CUSUM test are presented below:



The results show that we cannot reject the null hypothesis because the line lies within the five percent confidence bands. This therefore, suggests that our parameters are stable.

Discussion of results

Our model estimate is stated as

$$\ln REER = 0.1683 + 0.0008 OILP - 0.0208 \ln IMP$$

Though the estimated model has a low R<sup>2</sup> value, the F-statistic which is highly significant at 5%, shows that the predictor variables jointly explain the dependent variable. In addition, the model is not misspecified, its parameters are stable and it is free from serial correlation. Hence, it could be used for making inferences.

In analyzing our model, we see that holding other factors constant, a 1% increase in imports decreases or depreciates exchange rate by approximately 0.02% and vice versa. Similarly, a unit change in oil prices affects exchange rate by 100\*(0.0008) = 0.08%. This shows that oil prices exert a relatively stronger effect on exchange rate than imports. Also, the negative sign of import coefficient in our model is in proper alignment with economic theory.

Having estimated our regression model, we proceed with testing for causality within the VAR-Granger framework. Results are presented below.

Granger causality test

VAR Granger Causality/Block Exogeneity Wald Tests

Included observations: 81

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Dependent variable: D(LREER)

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| Excluded | Chi-sq   | df | Prob.  |
|----------|----------|----|--------|
| D(OILP)  | 5.993244 | 2  | 0.0500 |
| LIMP     | 1.241468 | 2  | 0.5375 |
| All      | 7.546637 | 4  | 0.1097 |

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Dependent variable: D(OILP)



| Excluded | Chi-sq   | df | Prob.  |
|----------|----------|----|--------|
| D(LREER) | 0.452351 | 2  | 0.7976 |
| LIMP     | 1.762940 | 2  | 0.4142 |
| All      | 3.019804 | 4  | 0.5545 |

Dependent variable: LIMP

| Excluded | Chi-sq   | df | Prob.  |
|----------|----------|----|--------|
| D(LREER) | 2.948414 | 2  | 0.2290 |
| D(OILP)  | 2.821133 | 2  | 0.2440 |
| All      | 5.437266 | 4  | 0.2453 |

Interpreting the results above entails rejecting the null hypothesis that no causality exists from the excluded variables to the dependent variables at 5% level of significance. An observation of the results above shows that we cannot reject the null for all of the variables, meaning that no causality exists. However, at a p-value of exactly 5%, the Granger causality test from oil prices to exchange rate is inconclusive. To resolve this, we repeat the causality test using the Pairwise approach. Results are presented below

#### Pairwise Granger Causality Tests

Sample: 2008M01 2014M12

| Null Hypothesis:                  | Obs | F-Statistic | Probability |
|-----------------------------------|-----|-------------|-------------|
| LREER does not Granger Cause OILP | 82  | 0.38588     | 0.68116     |
| OILP does not Granger Cause LREER |     | 6.69400     | 0.00209     |

Results show that we can reject the null hypothesis that OILP does not Granger cause LREER. This suggests that a unidirectional causality runs from oil prices to exchange rate. This finding is in consonance with both economic theory and our expectations.

#### Sensitivity Analysis

We attempt an analysis of model behavior under varying scenarios. When we controlled for exports in our model, we found that 1% change in oil prices results in 0.09% change in exchange rate, though the model was not statistically significant. We also controlled for the effect of foreign reserves on our model and results show that exchange rate changed by 0.1% for every 1% change in oil prices, keeping other factors constant. This seems to suggest that exchange rate is particularly sensitive to oil prices even as other macroeconomic variables change. In addition, when we controlled for the effect of foreign reserves in our Granger causality test, we found that oil prices Granger-caused foreign reserves. The implication of

this is that historical oil prices and past levels of foreign reserves when used together, could give an idea where future levels of foreign reserves are headed.

### **Conclusion and Policy Recommendation**

This study examined the impact of oil price movements on exchange rates while also controlling for the effect of imports. It also looked at the nature of causal link between oil prices and exchange rate. Our study found results that are similar with those of Oriavwote and Eriemo (2012).

Empirical results show that oil prices exert a significant effect on exchange rate. In addition, there is a unidirectional causality running in each case from oil prices to exchange rate and from oil prices to foreign reserves. Economic analysis of the international oil market shows that the factors which influence the movement of oil prices are beyond the control of the Nigerian economic policy makers. These factors affecting oil prices invariably move exchange rate in undesired direction through international trade channels. The continued exportation of crude- a primary product and importation of finished goods will only ensure that the demand for the dollar will continue to outperform its supply in the Nigerian market, leading to a sustained and undesired pressure on exchange rate and foreign reserves.

The conclusion of this paper is that since those factors affecting oil prices are determined exogenously outside of the control of the CBN, it will only be able to take temporary short-term remedial measures by defending the local currency using the nation's foreign reserves. This clearly, is not sustainable in the long run. The question then is what can be done to fix the problem in the long run? The solution is to implement measures aimed at reshaping the structure of our trade. Specifically, there is an urgent need to encourage the manufacturing of high-end, value added goods and services in Nigeria which if implemented, will reduce the demand for dollar for importation purposes. This in turn will limit the necessity for intervention of the CBN in the foreign exchange market and the depletion of the nation's foreign reserves will be curtailed.

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