

## **Oil Price-Exchange Rate Nexus in Nigeria: Further Evidence from an Oil Exporting Economy**

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### **Abstract**

*This study queries the oil price-exchange rate linkage in Nigeria deploying data at daily frequency spanning January 2, 2009 to September 28, 2010. Two volatility models – the generalised autoregressive conditional heteroscedasticity (GARCH) and exponential GARCH (EGARCH) – were deployed to estimate the influence of oil price on the nominal exchange rate. The study finds that an increase in the price of oil culminates in an appreciation of the Nigerian currency against the US dollar. We also establish the asymmetric effect, with regards magnitude, of positive and negative oil price shocks on exchange rate volatility.*

**Keywords:** Oil price; Exchange rate; Volatility; GARCH/EGARCH models; Nigeria

**JEL classification:** E44; G14; G15

### **1. Introduction**

There are numerous evidences, particularly over the post- Bretton Woods era, pointing to the crucial role of oil price fluctuations in the determination of the path of the exchange rate<sup>1</sup>. Theoretical contributions, by Golub (1983), Krugman (1983) and Corden (1984) among a few others, are suggestive of exchange rate appreciation<sup>2</sup> in response to soaring oil prices and attendant depreciation with falling oil prices in oil exporting countries, while the obverse is expected to be the case in oil-importing economies.

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<sup>1</sup> While the prominent role of the exchange rate as a key open macroeconomy variable is largely unarguable, a compendium of studies on both the theoretical and empirical fronts exists as contributions to the exchange rate determination debate. Financial shocks and supply-type shocks with respect to productivity are chief among the identified drivers of the exchange rate. Recent efforts, however, have been devoted to pinning down a role for real shocks (oil price shocks for instance) in explaining the observed pattern of movements in the exchange rate.

<sup>2</sup> It is noteworthy that adverse exchange rate fluctuations, particularly real appreciations, are emblematic of the classic Dutch Disease Phenomenon which has been used as rationale for the observed de-industrialisation in some oil-rich countries. Within this framework, real appreciation results in the loss of competitiveness of exports-based sectors and declines are usually evident in the manufacturing industry culminating in a non-tradables boom. This disease has been dubbed 'Dutch' in line with the experience of the Netherlands after the discovery of huge natural gas reserves in the 1960s.

On the empirical front, Amano and van Norden (1998a) adeptly query the linkage between oil price movements and exchange rate fluctuations in the United States (US) and find a unidirectional causal precedence (in the Granger-sense) running from the real price of oil to the exchange rate. In a companion paper, Amano and van Norden (1998b) extend their earlier analysis to also cover Germany and Japan. Adopting a two step procedure, which first rummages cointegration between oil prices and exchange rates and then establishes causality, they finish up with the submission that the price of oil causes variations in exchange rate for all three countries. With a similar testing procedure, albeit for sixteen Organisation for Economic Cooperation and Development (OECD) countries, Chaudhuri and Daniel (1998) come to the same conclusion. Akram (2004) elicits information on the oil price-exchange rate nexus in the case of – Norway – an oil exporter. Within an equilibrium corrections framework which allows for potential non-linearities, he finds that movements in oil prices have significant negative influence on the exchange rate. Bergvall (2004) combines a sample of Scandinavian oil importers and exporters using innovation accounting via variance decomposition. He finds, in consonance with theoretical expectations, that oil price increases result in exchange rate depreciation in the importers – Denmark, Finland and Sweden - , while Norway's exchange rate appreciates in response to the same shock.

What therefore appears at issue here is the disproportionate emphasis on explaining the subject matter in developed countries regardless of whether they are oil importers or exporters. Interestingly, there is ample reason to believe that oil prices significantly influence exchange rate movements, in particularly in small open developing oil exporters, an issue which has been relatively neglected in empirical investigations on oil exporting countries particularly Nigeria, so far. It is pertinent to note although, with a view to eschewing incredible generalisations, that there are few and far between evidences related to developing countries. For instance, Joyce and Kamas (2003) use cointegration as well as variance decomposition to arrive at the conclusion that oil prices are a significant determinant of the path of the exchange rate in Colombia and Mexico. They however failed to unearth any semblance of the same in the estimations for Argentina. In Narayan et al (2008), variants of the Generalized Autoregressive Conditional Heteroscedasticity (GARCH) model are employed. They wind up still in the precincts of an appreciation of the Fijian dollar following a rise in the price of oil. Ghosh (2011) forays into the crude oil price-exchange rate association using the same methodology with Narayan et al (2008) but with Indian data. In his case, a depreciation of the rupee consequent upon an oil price rise is reported. He further establishes the symmetry of the effects of positive and negative oil price shocks. Olomola and Adejumo (2006) also provide evidence on the appreciation of exchange rate due to oil price movements using annual data for Nigeria.

On the basis of the foregoing, it is easily seen that the oil price-exchange rate relationship remains a relatively uncluttered area of research particularly in developing oil exporting countries. While a number of the aforementioned studies dealt with some aspects of the issue, a number of questions still spring to mind namely: Is there a role for oil prices in exchange rate determination in Nigeria? Do positive and negative shocks to oil prices volatility have symmetric effect on exchange rate volatility?<sup>3</sup> What are the plausible implications for exchange rate policy in Nigeria? In pursuance of these, the prime aim of this paper is to examine the relationship between oil price shocks and exchange rate in an oil-exporting country, precisely Nigeria. With a view to accomplishing these objectives, the present study charts an inventive course in at least a number of ways. One, the preponderance of extant empirical literature appears to be predicated on cross-sectional and panel approaches with country-specific time-series evidences few and far between<sup>4</sup>. It is now, of course, trivial that estimates of cross-country regressions are not well suited to making any policy prescription on specific countries in the sample. Two, the few studies specific to Nigeria have typically considered the oil price- macroeconomy relationship using the exchange rate as one of the macroeconomic variables included in their models.<sup>5</sup>

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<sup>3</sup> Suffice to say, at this point, that theoretically a number of reasons could be pointers to the likelihood of shock asymmetry. These include, but are of course unlimited to, stickiness of nominal prices especially downwards, heterogeneity in terms of market participants expectations about exchange rate risk, high transactions cost which drag the adjustment process as well as economic, social and institutional factors.

<sup>4</sup> Apart from the studies by Koranchelian (2005) for Algeria, Zalduendo (2006) for Venezuela, Kalcheva and Oomes (2007) for Russia and Issa et.al (2008) for Canada in that order, this study could almost conveniently, to the best of our knowledge, proceed *carte blanche*.

<sup>5</sup> Ayadi et al (2000), Ayadi (2005) as well as Olomola and Adejumo (2006) are some of the few that have examined the role of oil price in Nigeria's macroeconomy. They, however, did not explicitly consider in a strict sense the influence of oil prices

Here we chart a different course by testing a particular theory of exchange rate determination. In other words, we attempt to provide empirical evidence on the claim that real shocks, such as those to oil prices, could explain a substantial part of observed variations in exchange rate particularly after the first oil shock episode of the early 1970s. Three, since every conceivable metric categorises Nigeria as highly oil dependent, we offer an instructive assessment of the role of oil prices in both exchange rate determination and consequent external sector competitiveness. This should be of prime interest to policymakers as the country strives towards joining the league of the biggest global economic players by the year 2020. The rest of the paper is mapped out as follows. Section 2 presents and subsequently discusses the data, model and methodology while section 3 displays and interprets the empirical results. The fourth section summarizes the principal findings and sketches out some reliable policy suggestions.

## 2. Data description, measurement and methodologies

Data, at a daily frequency<sup>6</sup>, on crude oil price and the naira-dollar exchange rates are obtained from the databases of the Organisation of Petroleum Exporting Countries (OPEC) and the Central Bank of Nigeria (CBN) respectively. For the exchange rate we use the official exchange rate of the naira vis-à-vis the US dollar, while the daily prices of Nigeria's Bonny Light crude benchmark was adopted as the oil price variable. In this study, nominal data is used as the inaccessible daily consumer price index precludes the option of working with real values. One therefore takes solace on the premise that tracking the daily<sup>7</sup> movements in oil prices and exchange rate does not require information about their real values (Narayan et.al, 2008). We also tried to avoid the nonsynchronous trading problem by using only trading dates which match for both the oil and foreign exchange markets. This study considers the returns on daily oil prices and exchange rate obtained via the ensuing computation:

$$r_t = \log \left( \frac{x_t}{x_{t-1}} \right) \quad (1)$$

where  $x_t$  and  $x_{t-1}$  are nominal exchange rate and oil price for period  $t$  and  $t-1$  in that order. The daily returns on oil prices and exchange rate are henceforth denoted by  $roilp_t$  and  $rer_t$  respectively. Table 1 below displays the descriptive statistics of the variables of interest to our analysis. As the table makes clear, the statistics associated with Skewness, Kurtosis and Jarque- Bera are suggestive of non-normality of the variables. For the kurtosis statistic, both of the return series appear to have fat tails (leptokurtic) suggesting that the mean equation should be subjected to autoregressive conditional heteroscedasticity (ARCH) test. The finding of ARCH-type effect further underscores the appropriateness of our GARCH estimation. Also, a profound look at both panels of Figure 1 is indicative of both volatility as well as volatility clustering particularly for the oil return series. This is equally supported by the standard deviation figures which seem to point to about five times more volatility of oil returns<sup>8</sup>.

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on the exchange rate. Another point of departure is that low frequency data (annual and quarterly) were used, while the present study tests a theory-driven model on daily observations.

<sup>6</sup> A few other studies have also used daily data. For example, Akram (2004) used data from January 1, 1986 to August 12, 1998 for Norway. In the case of India, daily data spanning July 2, 2007 to November 28, 2008 was employed by Ghosh (2011). Narayan et. al (2008) engage the analysis of the oil price-exchange rate nexus for the Fiji Islands deploying daily data straddling the 2000 to 2006 period. Here, in consonance with earlier literature, we use daily Nigerian data from January 2, 2009 to September 28, 2010.

<sup>7</sup> Our choice of a daily frequency nonetheless constrains the analysis to nominal value movements. The implication of this is that any consideration of long-run association between the variables becomes inappropriate since any such long term assessment of the linkage should naturally be carried out with real values. Also, oil and exchange rate trading decisions are made on the trading day while consumer price index, if at all available, can only be retrieved at the end of the trading day.

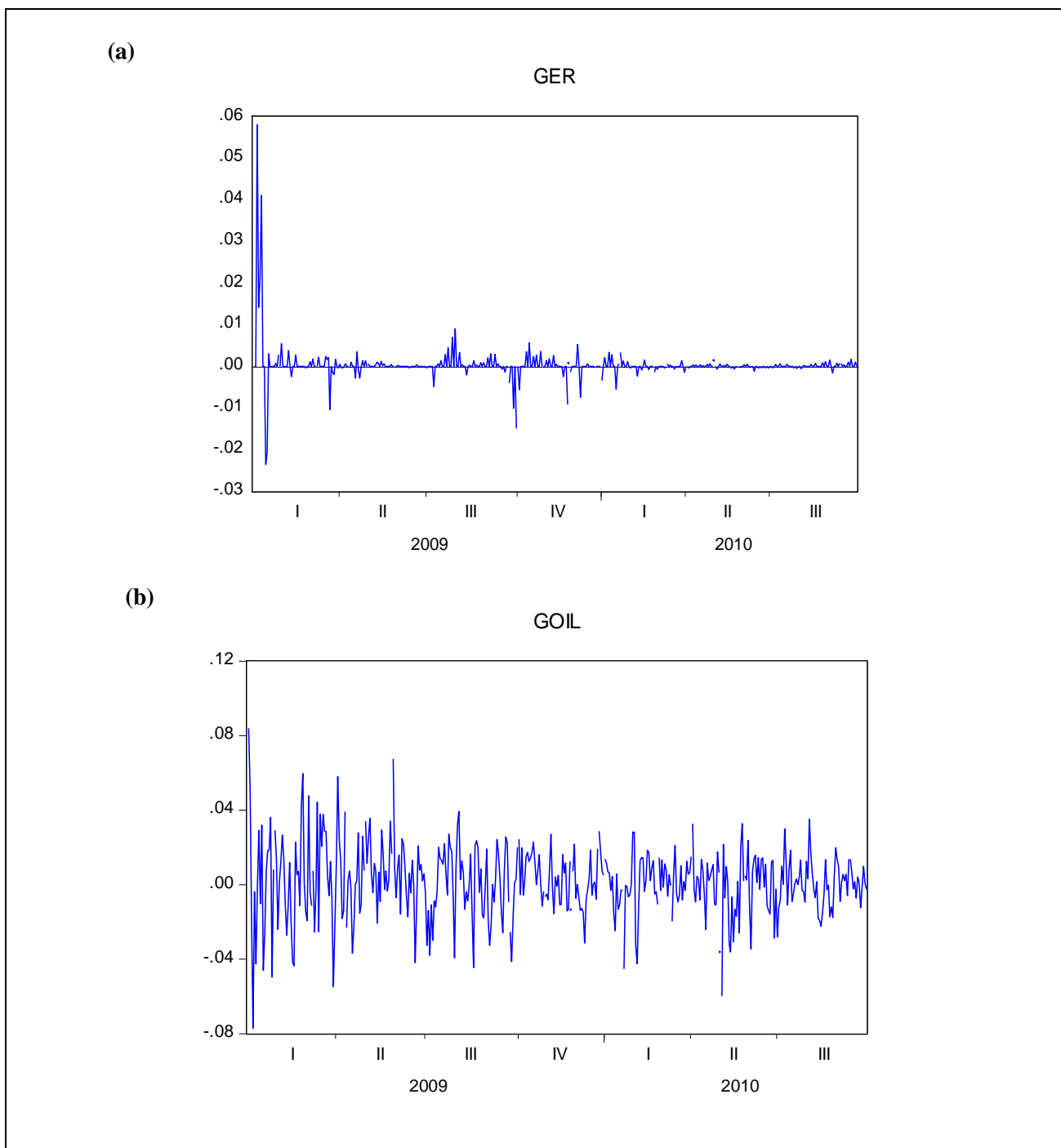
<sup>8</sup> The higher volatility clustering is in consonance with the higher standard deviation earlier reported for oil price returns.

**Table 1: Summary statistics of the variables**

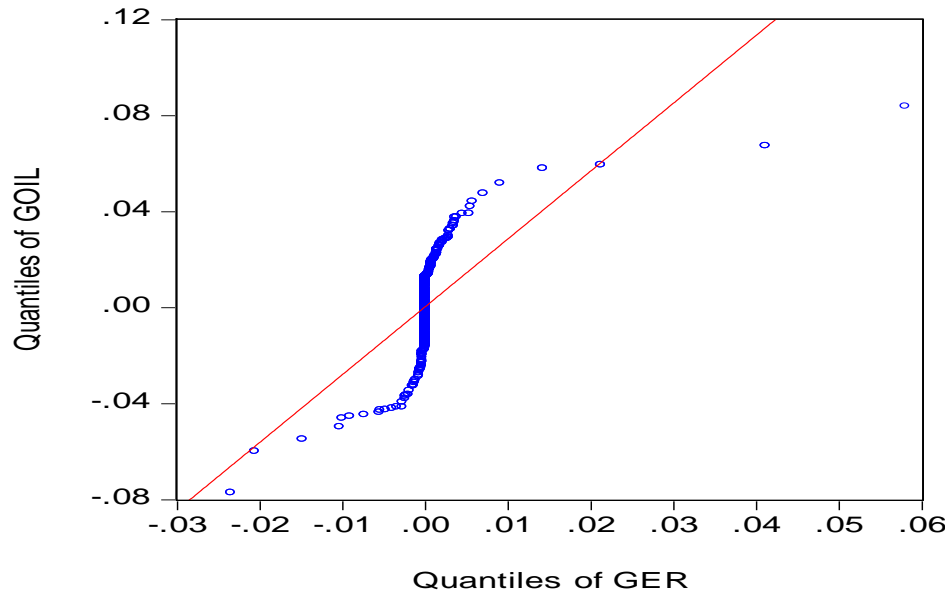
	$roilp_t$	$rer_t$
Mean	0.001453	0.000318
Median	0.001769	0.000000
Maximum	0.083916	0.058015
Minimum	-0.077076	-0.023495
Std. Dev.	0.019292	0.004314
Skewness	-0.078783	7.162928
Kurtosis	4.725281	10.5584
Jarque-Bera	53.02511(0.000)	171.7709(0.000)

*Note: Figures in parenthesis are probability values*

In a similar vein, the quantile-quantile plot of exchange rate and oil prices lends credence to the similarity between both series in terms of distribution.



**Figure1: Panels (a) and (b) are graphical representation of the exchange rate and oil price returns respectively.**



**Figure 2: The quantile-quantile plot**

Following the approach in Narayan et.al (2008) and Ghosh (2011) we characterise the linkage between oil prices and exchange rate with the aid of GARCH (p,q) and EGARCH (p,q) models.<sup>9</sup> The mean equation is given by

$$rer_t = c + \beta oilp_t + v_t \tag{2}$$

where  $v_t$  is the white noise residuals  $N(0, \sigma_t^2)$ .

In terms of the second moment, the variance equation for the GARCH (p, q) is of the form

$$\sigma_t^2 = \theta + \sum_{i=1}^p \phi_i v_{t-i}^2 + \sum_{i=1}^q \varphi_i \sigma_{t-i}^2 \tag{3}$$

Where the conditions  $\theta > 0$ ,  $|\varphi_1| < 1$  and  $(1 - \phi_1 - \varphi_1) > 1$  hold in the case of a GARCH (1, 1) model.

Equation (3) expresses the conditional variance as a linear function of p lagged squared disturbances and q lagged conditional variances. In other words, volatility today depends upon the volatilities for the previous q periods and upon the squared residual for the previous p periods. Often GARCH models with small values of p and q do a very good estimate of volatility with the p = q = 1 case sometimes being adequate (Narayan et. al, 2008; Ghosh, 2011).

In a similar vein, the EGARCH model which allow for oscillation in the conditional variance can be written as

$$\log(\sigma_t^2) = \omega + \sum_{i=1}^p \alpha_i \left| \frac{u_{t-i}}{\sigma_{t-i}} \right| + \sum_{k=1}^r \lambda_k \frac{u_{t-k}}{\sigma_{t-k}} + \sum_{j=1}^q \beta_j \log(\sigma_{t-j}^2) \tag{4}$$

The parameters of (4) include  $\omega$  the mean of the volatility equation, the size effect ( $\alpha$ ) which is suggestive of the magnitude of the increase in volatility regardless of the direction of shock. The estimate of  $\beta$  captures the persistence of shocks and  $\lambda$  is the sign effect.<sup>10</sup>

<sup>9</sup> It is now widely acknowledged in the literature, following the pioneering works of Bollerslev (1986) and Nelson (1991), that this approach orchestrated towards the joint estimation of the conditional mean and conditional variance equations is well suited to volatile series such as the ones at the centre of the analysis in this study.

### 3. Empirical Results

We start out with tests of the stationarity of the variables. This was implemented using the conventional – augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) - Kwiatkowski-Phillips-Schmidt-Shin (KPSS) tests.<sup>11</sup> All of the tests in Table 2 show that both series are mean reverting. This submission of stationarity thus acquiesces to the existence of a long-run association between daily oil price and exchange rate returns.

**Table 2: Results of alternative stationarity tests**

Variable	ADF	PP	KPSS
Level (constant, no trend)			
$roilp_t$	-16.34697	-16.34697	0.300071
$rer_t$	-11.44554	-15.15191	0.263940
Level (constant and trend)			
$roilp_t$	-14.67561	-16.38304	0.025452
$rer_t$	-11.30922	-15.26439	0.096215

*Note: The optimal lag lengths for the ADF test are obtained by the conventional information criteria.*

By way of reconnaissance, the mean expression (equation 2) is estimated using ordinary least squares (OLS). The results, presented in the second column of Table 3, show that oil price returns is statistically significant in explaining variations in exchange rate returns. This estimate almost completely pales the size of coefficients obtained in the two models discussed subsequently. Specifically, a 100% surge in oil price returns culminates in an appreciation of the value of the Naira by some 3.3 percentage points. Also, the Ljung-Box Q- statistics is indicative of the absence of serial correlation problems with the residuals. This holds out even with the inclusion of up to 36 lags. The other two models attempt to deal with ARCH effects in the residual series. Both GARCH (1, 1) and EGARCH (1, 1) models were estimated using standard maximum likelihood procedure with the attendant assumption of normality in the distribution of the errors. As revealed in Table 3, the mean equation of the GARCH (1, 1) implies that a rise in oil price impacts negatively on the nominal exchange rate. More aptly put, a doubling of oil price returns would lead to a 1.073% appreciation of the Naira in relation to the US dollar.

A similar submission is apropos for the EGARCH (1, 1) model displayed in the last column of Table 3. In this case, however, the magnitude of appreciation is slightly higher standing at about 1.140%. This finding of an appreciation<sup>12</sup> of the Naira-Dollar exchange rate in response to oil price movements is consistent with the theory advanced by Golub (1983), Krugman (1987) among a few others. More importantly, it is also in tandem with the seeming empirical regularity that for oil exporting countries oil prices have Dutch disease effects via exchange rate appreciation. Akram (2004) and Bergvall (2004) for Norway and Olomola and Adejumo (2006) for Nigeria all reported similar conclusions with this study. Finally, it is instructive to also peruse the results of the variance equation. The parameter,  $\gamma$ , captures the notion of asymmetry. It is found to be statistically significant suggesting that within sample, shocks to exchange rate have asymmetric effect. In other words, in terms of magnitude, positive and negative shocks have dissimilar effects on the volatility of exchange rates. The volatility persistence term,  $\beta$ , is positive and statistically significant at the 1% level. This associated coefficient is close to unity (0.963) instructive of the permanence of shocks on exchange rate volatility.

<sup>10</sup> In line with Nelson (1991),  $|\beta| < 1$  guarantees mean reversion and ergodicity for the GARCH (p, q) model. In addition,  $\lambda$  guides the conclusion on whether the effects of a shock are symmetric or asymmetric. A positive lambda signifies that a positive shock has larger effect on volatility than a negative shock, while the converse is also true.

<sup>11</sup> The null for the ADF and PP tests is that the series under scrutiny has a unit root against the alternative hypothesis that it is mean reverting. The complimentary KPSS test, on the other hand, has stationarity as the null hypothesis.

<sup>12</sup> One subtlety here regards the definition of exchange rate movements. In this study, for instance, an increase in nominal exchange rate implies that more of the Nigerian currency (Naira) chases each unit of the US dollar and therefore there is depreciation of the Naira vis-à-vis the dollar. In line with our findings, therefore, an increase in oil price leads to a fall in the nominal exchange rate which is equivalent to an appreciation.

**Table 3: Model estimation results**

Parameter/Model	OLS	GARCH(1, 1)	EGARCH(1, 1)
<b>I. Mean Equation</b>			
$c$	0.00037 (1.7601)	0.00019 (5.2963)	0.00016 (5.0951)
$\theta$	-0.03314* (-3.0784)	-0.01073* (-6.7834)	-0.01139* (-7.3289)
$\lambda$	---	---	----
<b>II. Variance Equation</b>			
$\omega$	---	4.25E-08 (2.7586)	-0.81529 (-9.3236)
$\alpha_1$	---	0.48523* (16.1490)	---
$\delta_1$	---	0.71687* (67.7527)	---
$\alpha$	---	----	0.57311* (29.0261)
$\gamma$	---	----	-0.06171* (-3.3436)
$\beta$	---	-----	0.96318* (13.1363)
<b>III. Diagnostics</b>			
Q- statistics (6)	---	20.310 [0.002]	20.316 [0.002]
Q-statistics (24)	---	36.020 [0.055]	37.591 [0.038]
Q-statistics (36)	---	43.139 [0.192]	45.635 [0.130]

Notes: Figures in ( ) are t-statistics for the OLS model while for the GARCH (1, 1) and EGARCH ( 1, 1) models the parenthesis contains the z- statistics. [ ] houses the probability values for the Ljung-Box serial correlation tests at the displayed lags.

#### 4. Conclusion and policy implications

This paper examined the oil price- exchange rate nexus for Nigeria deploying daily observation spanning the period from 2<sup>nd</sup> January, 2009 to 28<sup>th</sup> September, 2010. We used the GARCH and EGARCH models to gauge the influence of oil prices on the nominal exchange rate. We tread differently vis-a- vis the extant literature on Nigeria particularly in terms of data frequency (daily) and a theory consistent model specification. The results, for the GARCH models, indicate that a 100% increase in oil price returns would lead to a 1.073% appreciation of the Naira with respect to the US dollar, while for the EGARCH the magnitude of response is slightly higher at about 1.140%. Also, in agreement with some existing studies, positive and negative oil shocks have asymmetric effect on the volatility of Nigeria’s nominal exchange rate returns. To sum up the findings, a permanent effect of oil price shocks on exchange rate volatility is equally suggested by the  $\beta$  coefficient of the relevant equation. There are a number of avenues for extension and eventual improvement on the merits of this enquiry. First, it would be insightful to consider the use of the nominal effective exchange rate. This is to capture the notion of the possibility of simultaneous appreciation and/or depreciation against different currencies. Hence, the weight of trade with Nigeria’s major trading partners can be brought to bear on the analysis. Second, structural breaks in the series needs to be formally tested with a view to addressing power concerns raised about the conventional unit root testing approaches. Third, paying some heed to out-of-sample performance of our models could hold considerable promise.



This can be attempted by conducting forecasting competitions between the models developed in this paper and alternative models such as the pure random walk as well as TAR and GJR-GARCH. Four, non-linear oil price measures<sup>13</sup> could also be constructed and used as robustness check.

## References

- Akram, Q. F. (2004). Oil Prices and Exchange Rates: Norwegian Evidence. *Econometrics Journal*, 7:476–504.
- Amano, R.A., van Norden, S. (1998a). Oil Prices and the Rise and Fall of the US Real Exchange Rate. *Journal of International Money and Finance*, 17, 299–316.
- Amano, R.A. and van Norden, S. (1998b) “Exchange Rates and Oil Prices. *Review of International Economics*, 6(4): 683.
- Andrews, D. (1993). Tests for Parameter Instability and Structural Change without Unknown Change Point. *Econometrica*, 61, 821–856.
- Ayadi, O.F., A. Chatterjee and C.P. Obi. (2000). A Vector Autoregressive Analysis of an Oil-Dependent Emerging Economy – Nigeria”. *OPEC Review*: 330-349.
- Ayadi, O.F. (2005). “Oil Price Fluctuations and the Nigerian Economy”. *OPEC Review*: 199-217.
- Bergvall, A. (2004). What Determines Real Exchange Rates? The Nordic Countries. *Scandinavian Journal of Economics*, 106(2), 315–337.
- Bollerslev, T. (1986). Generalised Autoregressive Conditional Heteroskedasticity. *Journal of Econometrics* 31, 307–327.
- Chaudhuri K, Daniel B. C. (1998) Long-run Equilibrium Real Exchange Rates and Oil Prices. *Economics Letters* 58(2):231–8.
- Corden, W. M. (1984). Booming Sector and Dutch Disease Economics: Survey and Consolidations. *Oxford Economic Papers*, 36, 359-380.
- Ghosh, S. (2011). Examining Crude Oil Price – Exchange Rate nexus for India during the period of extreme oil price volatility. *Applied Energy*, 88, 1886–1889.
- Golub S. (1983). Oil Prices and Exchange Rates. *The Economic Journal*, 93, 576–93.
- Hamilton, J. (1996). This is what happened to the oil price–macroeconomy relationship? *Journal of Monetary Economics*, 38, 195–213.
- Issa, R, R. Lafrance and Murray, J. (2008). The turning black tide: energy prices and the Canadian dollar. *Canadian Journal of Economics*, 41(3), 737-759.
- Iwayemi, A and B. Fowowe (2011). Impact of Oil Price Shocks on Selected Macroeconomic Variables in Nigeria. *Energy Policy*, 39, 603–612.
- Joyce, J. P and L. Kamas. (2003) Real and Nominal Determinants of Real Exchange Rates in Latin America: Short-Run Dynamics and Long-Run Equilibrium.” *The Journal of Development Studies*, 39(6), 155-
- Kalcheva, K and Oomes, N. (2007) Dutch disease: does Russia have the symptoms? IMF Working Paper, 07/102. International Monetary Fund, Washington DC
- Koranchelian, T. (2005). The equilibrium real exchange rate in a commodity exporting country: Algeria’s experience, Working Paper 05/135. International Monetary Fund, Washington DC
- Krugman, P. (1983), Oil shocks and exchange rate dynamics In *Exchange Rates and International Macroeconomics*, University of Chicago Press.
- Narayan P.K, S. Narayan and A. Prasad (2008). Understanding the Oil Price – Exchange rate nexus for the Fiji Islands. *Energy Economics* 30(5):2686–96.
- Nelson, D, (1991). Conditional Heteroskedasticity in Asset Return: A New Approach. *Econometrica* 59, 347–370.
- Lee, K, S. Ni, and R. Ratti (1995). “Oil Shocks and the Macroeconomy: The Role of Price Variability,” *Energy Journal* 18, 39-56.
- Mork, K. A (1989). “Oil and the Macroeconomy when Prices Go Up and Down: An Extension of Hamilton’s Results,” *Journal of Political Economy* 97, 740-4.
- Olomola, P.A., A.V Adejumo (2006). Oil Price Shocks and Macroeconomic Activities in Nigeria. *International Research Journal of Finance and Economics* , 3, 28–34.
- Zalduendo, J. (2006). Determinants of Venezuela’s equilibrium real exchange rate, Working Paper 06/74. International Monetary Fund, Washington DC

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<sup>13</sup> It is standard in the recent literature on the oil price- macroeconomy relationship to use various transformations of the oil price series (see Mork, 1989; Hamilton, 1996; Lee et.al, 1995 and Iwayemi and Fowowe, 2011 for details on the construction of some of such non-linear oil shock indicators).