Exchange Rate –Oil Price Nexus: The Role of Asymmetries

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Abstract
Using the case of the Nigerian economy, this paper utilize both the linear and nonlinear ARDL frameworks to investigate the short and long run symmetric and asymmetric response of exchange rate to oil price changes. We fail to reject the null hypothesis of no asymmetry though, the fact that the empirical evidence as established in the context of this study reveals the response of exchange rate to oil price shocks as more significantly pronounced when the changes in oil price is positive is quite instructive not to entirely ignores possible asymmetric implications of exchange rate –oil price relationship in Nigeria.
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1. Introduction
There have been up and down movements in oil price, from the historically low, to the unprecedentedly high, affecting the fortunes of countries for which earnings from oil constitute a significant source of their foreign reserves. The history of oil prices can be divided roughly into three different periods: a calm beginning when oil supply was totally adequate for all demand needs, a middle period when political events and market power shaped the price path, and the present period where the effect of politics is decreasing and the price is affected by more fundamental factors in supply and demand. A number of macroeconomic fundamentals have been empirically validated to be driven by oil price changes and one such variable of interest is exchange rate (see Park and Ratti, 2008; and Le and Chang 2011). This assertion of probable correlation between oil price movement and exchange rate may not be unconnected to the fact that, oil prices are quoted in US dollars and the US dollar exchange rate is the primary channel through which changes in oil prices are transmitted to the real economy and financial markets (Reboredo, 2012). This transmission mechanism however, differs from country to country depending on whether the country is an oil-exporter or oil-importer. In an oil exporting country for example, a rise in world oil prices improves the trade balance, leading to a higher current account surplus, improved net foreign asset position and then the appreciation of exchange rate. On the other hand however, an increase in the world oil prices is expected to worsen the trade balance of net oil-importing countries, leading to a higher current account deficit and a deteriorating net foreign asset position (Abdelaziz et al, 2008). Saying it differently, increases in the oil price will lead to an increase in the relative price of commodities in an oil-exporting country relative to that of an oil-importing country. This leads to an increase in the real exchange rate of the oil-exporter (Chaudhuri and Daniel, 1998) although the magnitude of such an impact on exchange rates depends on the distribution of oil imports across oil-importing countries and on portfolio preferences of both oil-importing and oil-exporting countries (Huang and Guo, 2007).

Being a net oil exporter, Nigerian economy is inevitably vulnerable to oil price fluctuations and is affected by both positive and negative oil price shocks. Positive oil price shocks constitute an opportunity for Nigeria to earn more oil revenue, achieve high growth rate and exchange rate appreciation. The reverse is however the case for negative oil price shocks. Thus, the recent dwindling in the prices of oil and the subsequent reduction in the value of the currencies of several oil exporting countries have once again revived an interest in the interdependence between major commodity prices (oil price) and exchange rates. Using Nigeria as a case study, changes in oil price are expected to affect its foreign reserves and by implication the purchasing power of its local currency relative to USD. Thus, an empirical investigation into the oil price changes implication of US–Nigeria exchange rate will provide useful insights into effective policy formulation by policy makers. Similarly, information about the probable asymmetries transmission of oil price onto the Nigerian exchange rate will provide a useful empirical framework for the Nigerian monetary policy authority on how to deal with exchange rate fluctuation that is due to positive oil price as difference from the one that is due to negative oil price shock.

2. Theoretical Framework
Theoretically, there are two channels through which the exchange rate –oil prices nexus has been explore in the literature (see Benassy-Quere et al., 2007; Beckman and Czudaj, 2013). The first channel often described as ‘terms of trade channel’ traceable to Amano and van Norden (1998) focuses on oil as a major determinant of the terms of trade. The term of trade theory assumes existence of two sectors, namely; a tradables sector and a non-tradables sector; and both sectors have two inputs: a tradable input which is oil, and a non-tradable input which

is labour. According to Benassy-Quere et al. (2007), if we assume that the output prices of both the tradable and non-tradable sector can change following oil price increases (while keeping the law of one price in the tradable sector), it is seen that a rise in the oil price can lead to either an appreciation or depreciation of the exchange rate. Specifically, the effect of such an oil price increase will depend on the oil intensity of both sectors in the country. In a situation where the non-tradable sector is more energy intensive than the tradable sector, both its output price and the real exchange rate will increase. Conversely, if the non-tradable sector is less energy intensive, then the exchange rate will depreciate.

The second theoretical channel for explaining exchange rates and oil price relationship is the 'wealth transmission channel' and this is derived from the work of Krugman (1980), where attention is placed on the balance of payments (see Benassy-Quere et al., 2007; Beckman and Czudaj, 2013). Here, the focus is on the tradables sector and on international portfolio choices. Thus, the assumption is that when the oil price rises it translates to the transfer of wealth from oil-importing to oil-exporting countries. This by implication is expected to lead to appreciation of the exchange rate of the oil-exporting country and depreciation of the exchange rate of the oil-importing country. However, Krugman (1980) shows that the effect of such an oil price increase on the exchange rate will be determined by two factors: (i) the distribution of oil imports across oil-importers; and (ii) on portfolio preferences of both the oil-importers and oil-exporters. If OPEC imports more goods from industrial countries as a result of the wealth from higher oil prices, the direction of change of the exchange rate will depend on the countries from which OPEC imports from.

In attempt validate or refute the aforementioned theoretical stance on exchange rate and oil prices relationship, this paper is concerned with conducting an empirical investigation into the effect of oil prices changes on Nigeria's exchange rate. Our study contributes to the literature in two main ways. Firstly, Nigeria is an oil-exporting country and thus, the results from this study will give an indication whether the theoretical predictions and empirical results from an oil-importing of the effect of oil price leading to appreciation of exchange rate hold for Nigeria.

3. Review of Empirical Literature

A number of extant literatures have though reveal changes in oil prices as significant for explaining fluctuations in exchange rate, but the results have been largely mixed across data set, samples, methodology and so on. While Brahmasrene (2014), Oriavwote and Eriomo (2012), Bal and Rath (2015), Osuji (2015) and Bouoiyour et al. (2015) are relatively unanimous in their finding of significant causal relationship between exchange rate and changes in oil price, the studies are however, differs on the degree and direction of causality which may not be unconnected to difference their dataset and method of estimation. For Beckmann and Czudaj (2013) particularly, the empirical results obtained from their Markov-switching vector error correction model shows that the time-varying causality patterns mainly runs from nominal exchange rates to nominal oil prices.

Characterizing the oil price –exchange rate relationship for different time scales in an attempt to disentangle the possible existence of contagion and interdependence during the global financial crisis, Reboredo and Rivera-Castroet (2013) employs a wavelet multi-resolution analysis approach to shows that oil prices and exchange rates were not dependent in the pre-crisis period, but after the onset of the crisis. Tiwari et al. (2013), Uddin et al. (2013) and Yang et al. (2017) have also employs wavelet coherence framework to study the co-movement between the crude oil price and the exchange rate markets and they consistently finds that the degree of co-movement between the crude oil price and the exchange rates deviates over time. While Aloui et al. (2013), Fowowe (2014) and Brayek et al. (2015) who explore GARCH based modelling approach in their respective analysis of exchange rate and oil price changes consistently indicates evidence of significance interdependence between exchange rate and oil price changes, Roberodo (2012) on the other hand uses two measures of dependence: correlations and copulas to shows that there is no extreme market dependence between oil prices and exchange rates. Hussain et al (2016) applies a detrended cross-correlation approach (DCCA) to investigate the co-movements of the oil price and exchange rate in 12 Asian countries. Their empirical results support the co-movements of oil prices and exchange rate. Jawadi et al. (2016) investigates the dynamics of oil price volatility by examining interactions between the oil market and the US dollar/euro exchange rate. It finds negative relationship between the US dollar/euro and oil returns, indicating that a US$ appreciation decreases oil price. Secondly, it notes the presence of a volatility spillover from the US exchange market to the oil market

On whether exchange rate respond asymmetrically to changes in oil prices, Berument et al. (2014), Ahmad and Hernandez (2013) and Lizardo and Mollick (2010) are among the few notable to have suggests the likelihood of exchange rate responding differently to positive and negative oil price changes. Lizardo and Mollick (2010) particularly, finds that positive changes in real oil price leads to a significant depreciation of exchange rate of net oil exporter currencies, such as Canada, Mexico, and Russia, while the currencies of oil importers, such as Japan, depreciate relative to the USD when the real oil price goes up. Chen (2016) investigates the impacts of oil price shocks on the bilateral exchange rates of the U.S. dollar against currencies in 16 OECD countries. Their empirical findings indicate that the responses of dollar exchange rates to oil price shocks differ greatly depending on whether changes in oil prices are driven by supply or aggregate demand. Focusing on the effect of oil price shocks on exchange rate movements in five major oil-exporting countries, namely; Russia, Brazil, Mexico, Canada, and Norway, Volkov and Yuhn (2016) attributes the asymmetric behavior of exchange rate volatility among to the efficiency of financial markets rather than to the importance of oil revenues in the economy.

For Bashar et al. (2015), they link the significant exchange rate appreciation pressures in oil exporting economies to oil demand shocks, while Pershin et al (2015) using the case of selected African countries suggest that changes in oil prices matter for exchange rate fluctuation in the selected countries not only before and after the oil peak of July of 2008, but also between each other.

4. Motivation for the Study

The aforementioned though is an indication of the proliferation of papers on oil price – exchange nexus. This notwithstanding, issue on whether exchange rate respond asymmetrically to oil price shocks have continued to throw up debate and largely far from being settled. Despite the popular assertion that the detection of asymmetries in the response of exchange rate to oil price shock constitutes further valuable information that may be exploitable accordingly by authorities to manage exchange rate; only a few of the extant studies on exchange rate –oil price nexus examine the probable of asymmetries in the relationship. Empirical findings from these notable exceptions which include, for example, Ahmad and Hernanadez (2013); Artem et al. (2015); Chou and Tseng (2015); and Jiang and Gu (2016) are yet mixed. While findings from these respective studies uniformly suggests that asymmetries matter in the significance and direction of exchange rate response to oil price shocks. They however, differ on the degree or magnitude of the asymmetries, which may be due to differences in the methods employs to measure asymmetry as well as differences in the type of oil price measure adopted.

To this best of our knowledge, none of these studies consider the likelihood of the degree of the asymmetries being sensitive to oil price measure adopted. There are many oil benchmarks in the oil industry which are used as reference, namely; West Texas Intermediate (WTI), the North Sea Brent Blend, and the Dubai crude. Unlike a number of existing studies that rather make preference between these measures of oil price. This present study instead examines for the likelihood of asymmetries response of exchange rate being sensitive to these varying measure oil prices. Thus, testing for the robustness of the degree of asymmetries response of exchange to oil prices by alternating the measure of oil price therefore, remain the main novelty of this study particularly in the context of Nigerian economy.

5. Model Specification

In the spirit of Cheung et al. (2005), but with an emphasis on movements in oil prices, a composite model that incorporates the oil price shocks as a determinant of the Naira/USD exchange rate can be specified as below.

$$e_t = \beta_0 + \beta_1(m_t - m_t^*) + \beta_2(y_t - y_t^*) + \beta_3 ops_t + \mu_t \qquad (1)$$

where e_t denoting exchange rate is measured as Nigeria Naira per one unit of US dollar, $m_t - m_t^*$ denotes the Nigerian money supply which is measure via broad money (M2) relative to foreign money supply also measures using foreign (M2), $y_t - y_t^*$ is Nigerian output relative to the foreign output and is measures using Nigerian industrial production index relative to the foreign industrial production index, while ops_t represents oil price shock at time *t* to be proxy by prominent oil price benchmarks, namely; West Texas Intermediate (WTI) and the North Sea Brent Blend. Since apositive oil price shocks would prompts rising oil exporter's currency and since a rise in the value of naira as against USD implies appreciation of Naira, one should expect β3>0 for oil exporting countries. Meanwhile, since oil price shocks is assumed to have different effects on exchange rates such that, negative oil price shocks do not have an equivalent effect with positive oil price shocks as previously mentioned. We therefore, partition oil price shock in equation (1) into positive and negative oil price shocks, hence; the revised equation becomes;

$$e_t = \beta_0 + \beta_1(m_t - m_t^*) + \beta_2(y_t - y_t^*) + \beta_3 ops_t^+ + \beta_4 ops_t^- + \mu_t \qquad (2)$$

A non-linear autoregressive distribution lag (NARDL) approach of Shin et al. (2014) would be employs to model the relationship between exchange rate and oil price shocks. Highlighting some of the advantages of the NARDL approach, Hoang et al. (2016) state that, it allows modelling the cointegration relation that could exist between the dependent and independent variables; it permits to test both the linear and nonlinear cointegration; it distinguishes between the short and long-run effects from the independent variable to the dependent variable. While these advantages may of course be also valid for nonlinear threshold Vector Error Correction Models (VECM) or smooth transition models. These latter models may however, suffer from the convergence problem due to the proliferation of the number of parameters. For the purpose of robustness however, this study consider both the traditional ARDL (symmetric approach) and the Non-linear ARDL (asymmetric approach). The econometric representations of these models are therefore represented as follows:

5.1 Traditional ARDL (Symmetric) Approach

Following the standard Pesaran et al. (2001) framework, the specification of the symmetric ARDL model is as given below.

$$\Delta e_t = \alpha_0 + \alpha_1 e_{t-1} + \alpha_2 (m - m^*)_{t-1} + \alpha_3 (y - y^*)_{t-1} + \alpha_4 ops_{t-1} + \sum_{i=1}^{N1} \lambda_i \Delta e_{t-i} + \sum_{j=0}^{N2} \gamma_j \Delta (m - m^*)_{t-j} + \sum_{j=0}^{N3} \gamma_j \Delta (y - y^*)_{t-j} + \sum_{j=0}^{4} \gamma_j \Delta ops_{t-j} + \varepsilon_t \qquad (3)$$

The long run parameters for the intercept and slope coefficients are computed as $-\frac{\alpha_0}{\alpha_1}$, $-\frac{\alpha_2}{\alpha_1}$, $-\frac{\alpha_3}{\alpha_1}$ and $-\frac{\alpha_4}{\alpha_1}$ respectively since in the long run it is assumed that $\Delta e_{t-i} = 0$, $\Delta(m-m^*)_{t-j} = 0$, $\Delta(y-y^*)_{t-j} = 0$ and $\Delta ops_{t-j} = 0$ However, the short run estimates are obtained as λ_i for exchange rate and γ_j for money supply, output and oil price shock respectively. Since the variables in first differences can accommodate more than one lag, determining the optimal lag combination for the ARDL becomes necessary.

The optimal lag length can be selected using Akaike Information Criterion (AIC), Hannan-Quinn Information Criterion (HIC) or Schwartz Information Criterion (SIC). The lag combination with the least value of the chosen criterion among the competing lag orders is considered the optimal lag. Consequently, the preferred ARDL model is used to test for long run relationship in the model. This approach of testing for cointegration is referred to as Bounds testing as it involves the upper and lower bounds. The test follows an F distribution and therefore, if the calculated F-statistic is greater than the upper bound, there is cointegration; if it is less than the lower bound, there is no cointegration and if it lies in between the two bounds, then, the test is considered inconclusive. In the spirit of our model, the null hypothesis of no cointegration can be expressed as $H_0: \ \alpha_1 = \alpha_2 = \alpha_3 = \alpha_4 = 0$ while the alternative of cointegration is symbolized as $H_1: \ \alpha_1 \neq \alpha_2 \neq \alpha_3 \neq \alpha_4 \neq 0$. While other variables in the model remains as earlier defined, ε_t denotes error term. The equation (3) can be re-specified to include an error correction term as follows:

$$\Delta e_t = \delta\mu_{t-1} + \alpha \sum_{i=1}^{N1} \lambda_i \Delta e_{t-i} + \sum_{j=0}^{N2} \gamma_j \Delta (m-m^*)_{t-j} + \sum_{j=0}^{N3} \gamma_j \Delta (y-y^*)_{t-j} + \sum_{j=0}^{N4} \gamma_j \Delta ops_{t-j} + \varepsilon_t \qquad (4)$$

Where μ_{t-1} is the linear error correction term; the parameter δ is the speed of adjustment while the underlying long run parameters remain as previously defined. Note that in both equations (3) and (4), there are no decompositions of oil price into positive and negative changes; hence, the assumption of symmetric behaviour of oil price shock on exchange rate under this scenario.

5.2 Non-Linear ARDL (Asymmetric) Approach

Here, the oil price shock variable (*ops*) is decomposed into positive and negative changes such that in the analysis, we are able to capture probable asymmetric behaviour of oil price shock on exchange rate. The consideration of oil price asymmetry is premised on the fact that economic agents such as households, business entities and government, may respond differently to positive and negative changes in oil price. However, the approach used here follows the NARDL of Shin et al. (2014) which appears less computationally intensive compared to other asymmetric models and does not require identical order of integration [i.e. *I*(1)] for all the series in the model. The NARDL is given as:

$$\Delta e_t = \alpha_0 + \alpha_1 e_{t-1} + \alpha_2 (m - m^*)_{t-1} + \alpha_3 (y - y^*)_{t-1} + \alpha_4 ops^+_{t-1} + \alpha_5 ops^-_{t-1} + \sum_{i=1}^{N1} \lambda_i \Delta e_{t-i} + \sum_{j=0}^{N2} \gamma_j \Delta (m - m^*)_{t-j} + \sum_{j=0}^{N3} \gamma_j \Delta (y - y^*)_{t-j} + \sum_{j=0}^{4} (\gamma_j^+ \Delta ops^+_{t-j} + \gamma_j^- \Delta ops^-_{t-j}) + \varepsilon_t \quad (5)$$

In equation (5), the oil price shock variable (ops_t) has now been decomposed into ops_t^+ and ops_t^- denoting positive and negative changes of oil price respectively. These decomposed prices are defined theoretically as:

$$ops_t^+ = \sum_{j=1}^{t} \Delta ops_j^+ = \sum_{j=1}^{t} \max\left(\Delta ops_j, 0\right) \quad (5.1)$$

$$ops_t^- = \sum_{j=1}^{t} \Delta ops_j^- = \sum_{j=1}^{t} \min\left(\Delta ops_j, 0\right) \quad (5.2)$$

We can re-specify equation (5) to include an error correction term thus:

$$\Delta e_t = \rho \psi_{t-1} + \sum_{i=1}^{N1} \lambda_i \Delta e_{t-i} + \sum_{j=0}^{N2} \gamma_j \Delta (m - m^*)_{t-j} + \sum_{j=0}^{N3} \gamma_j \Delta (y - y^*)_{t-j} + \sum_{j=0}^{4} (\gamma_j^+ \Delta ops^+_{t-j} + \gamma_j^- \Delta ops^-_{t-j}) + \varepsilon_t \quad (6)$$

In equation (6), the error-correction term that captures the long run equilibrium in the NARDL is represented as ψ_{t-1} while it's associated parameter (ρ) [the speed of adjustment] measures how long it takes the system to adjust to its long run when there is a shock. It is important to note here that, just like the linear ARDL (symmetry), the long run is estimated only if there is presence of cointegration. Thus, pre-testing for cointegration is necessary even under NARDL and this involves the Bounds testing that is *F* distributed. However, the underlying hypotheses for cointegration involve the long run asymmetric parameters. In other words, the null hypothesis of no cointegration expressed as $H_0:\ \alpha_1 = \alpha_2 = \alpha_3 = \alpha_4 = \alpha_5 = 0$ is tested against the alternative hypothesis of cointegration given as $H_1:\ \alpha_1 \neq \alpha_2 \neq \alpha_3 \neq \alpha_4 \neq \alpha_5 \neq 0$. In addition, we also employ the Wald test for testing restrictions to ascertain whether the asymmetries matter both in the long run and short run. For the Wald test, the null hypothesis of no asymmetries - $H_0:\ \alpha_4 = \alpha_5$ (for long run) and $H_0: \sum_{j=0}^{N1} \gamma_j^+ = \sum_{j=0}^{N2} \gamma_j^-$ (for short run) is tested against the alternative of presence of asymmetries - $H_1:\ \alpha_2 \neq \alpha_3$ (for long run) and $H_1: \sum_{j=0}^{N1} \gamma_j^+ \neq \sum_{j=0}^{N2} \gamma_j^-$ (for short run).

6. Data and Preliminary Analysis

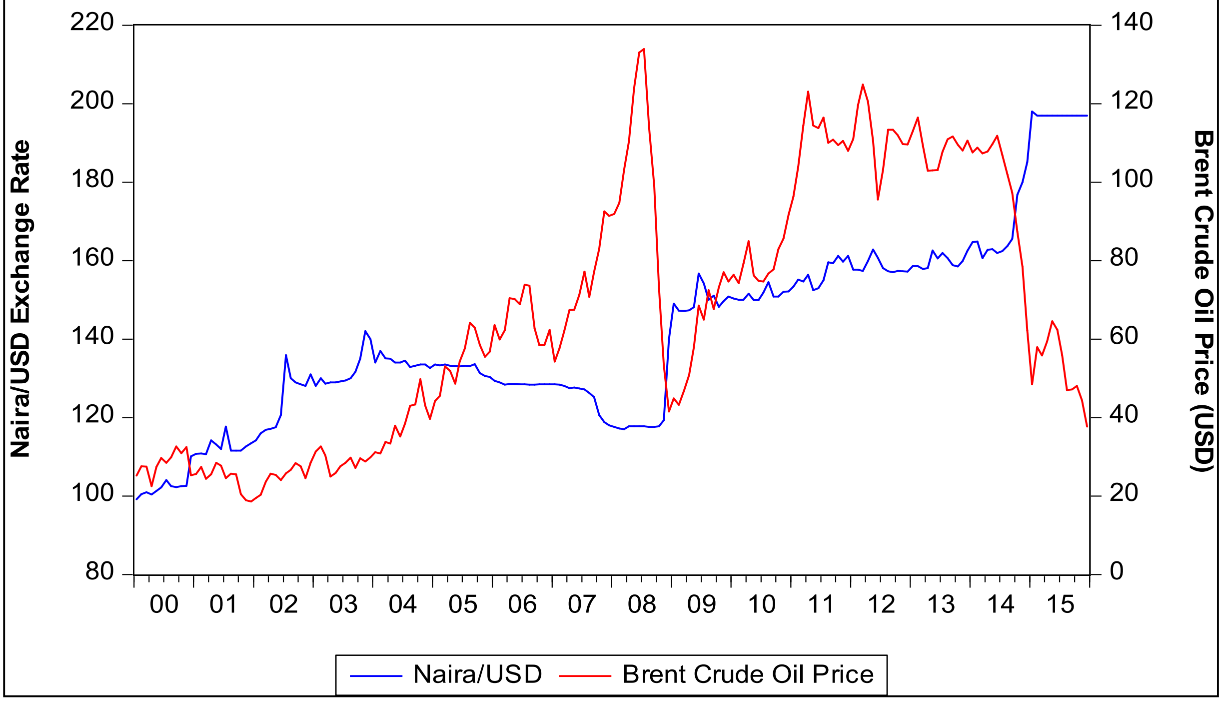
6.1 Data Source and Description

The empirically analysis relies on monthly dataset to include to include exchange rates, money supply, output growth and oil prices covering the period from January 2000 to December 2015. All the data are sourced mainly from the International Financial Statistics IMF database with the exemption of crude oil price variables, which are sourced from the Energy Information Administration (EIA).

6.2 Preliminary Analysis

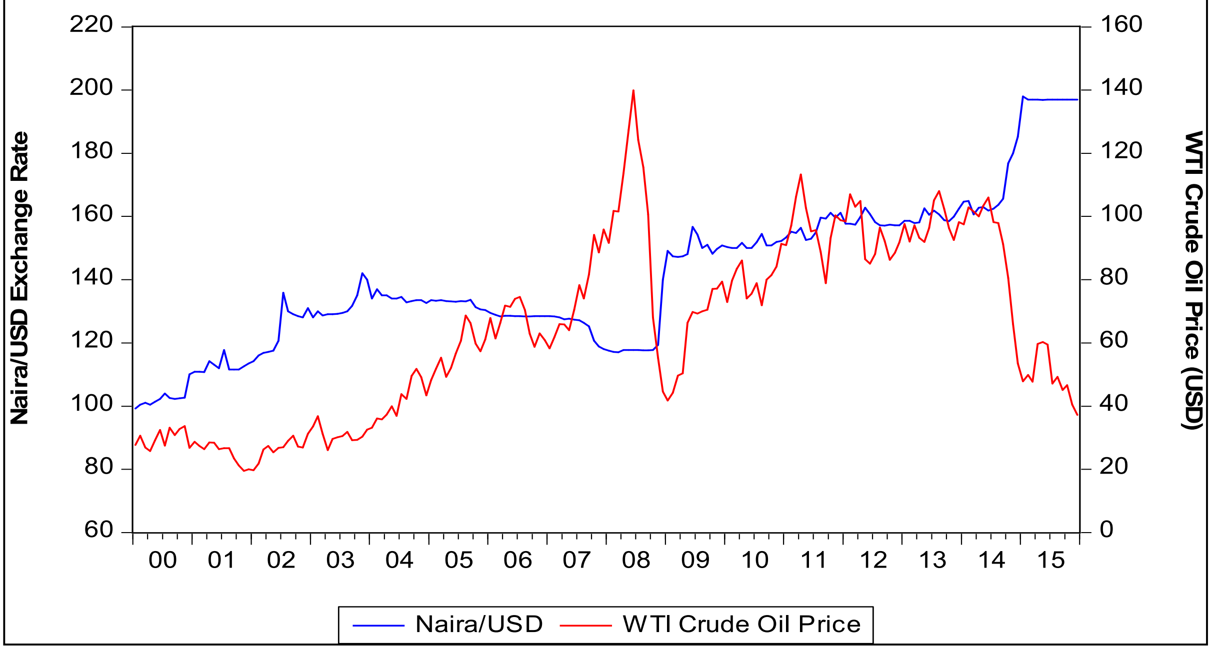
As shown in the figures below, we attempt to trace any possible co-movement between exchange rate and oil price over time. Figure 1 for instance, depicts trend in exchange rate and Brent crude oil price while Figure 2 reflects the historical co-movement between exchange rate and WTI crude oil price. The essence is to illustrate particularly, the likelihood of exchange rate movement in Nigerian being sensitive to fluctuation in the world oil prices.

Figure 1: Trends in Exchange Rate and Brent Oil Prices (2000:M1-2015:M12)



Source: The Author using data sourced from IFS database

Figure 2: Trends in Exchange Rate and WTI Oil Price (2000:M1-2015M12)



Source: The Author using data sourced from IFS database

As reflected in Figures however, there are rather episodes of exchange rate depreciations against an upward oil price trend between the 2002 and 2005. However, the period between June 2014 and January 2015 shows that movement between exchange rate and the international oil prices are in opposite direction. This particular seems to be in consonance with the current unprecedented depreciation of exchange rate which has been attributed to the dwindling in the international oil prices. These among others though reflect possible interactions between Nigerian exchange rate and the international oil prices, but the extent and significant of such interaction yet remain an empirical issue.

We further consider the summary statistics of the various dependent and independent time series variables under consideration. Starting with Naira/USD exchange rate, the summary statistics reported in Table 1 shows that average exchange for the period under consideration was N140 naira for $1, while the maximum and minimum for the same period was N198 and N99 respectively. Relative to foreign money supply growth, Nigeria average money supply growth for the period under consideration was 15.45 per cent as against 22.75 for the USA economy. Consequently, the maximum and minimum money supply growth was 16.81 per cent and 13.53 per cent for Nigeria, while for USA it is 23.24 per cent and 22.26 per cent respectively. In a similar development, the average monthly output which is measure via industrial production index is also relatively lower to the foreign output and so is the maximum and minimum domestic output relative to the foreign output. Table 4.1 also presents descriptive statistics of Brent and WTI crude oil prices [measured in U.S dollars]. We see that on average, Brent costs $66.23 while WTI costs $64.04. However, WTI with maximum value of $139.96 records the highest crude oil price, while Brent with minimum value of $18.60 records the lowest crude oil price for the period under consideration.

Table 1: Descriptive and Summary Statistics

Variable/Statistics	Mean	Max	Min	Std. Dev.	Skewness	Kurtosis	Jarque-Bera
e_t	140.7269	198.0000	99.1700	23.5505	0.5645	3.0223	10.1998 (0.00)
m_t	15.4470	16.8163	13.5279	1.0145	-0.2672	1.6190	17.5418 (0.00)
m_t^*	22.7544	23.2410	22.2641	0.2765	0.0339	1.8845	9.9923 (0.00)
y_t	95.7052	104.3502	86.3034	3.2307	0.2404	4.0146	10.0834 (0.00)
y_t^*	103.8155	114.3000	92.4000	4.9191	-0.0189	2.2823	4.1320 (0.13)
Brent	66.2284	133.9000	18.6000	32.8853	0.2471	1.7273	14.9120 (0.00)
WTI	64.0407	139.9600	19.4600	28.7031	0.1653	1.8903	10.7260 (0.00)

Note: All the series are expressed in their level form except for the domestic and foreign money supply date that are expressed in logarithm form for uniformity sake.

The standard deviation statistic shows that, the degree of the dispersion of the series from their mean value is relatively more pronounced for the crude oil price series particularly the Brent crude oil price measure. Next to the oil price in the rank of most volatile series is exchange rate whose standard deviation value is 23.55, which measure the rate of its dispersion from rate mean value. The money supply growth seems the least volatile of all the series, but the stability is relative more pronounced for the foreign money supply growth and the reverse is the case for output series. With respective to the statistical distribution of the series, the skewness of the distribution is positive for exchange rate and the two measures of oil prices considered. In the case of kurtosis, the distribution is mostly platykurtic except for the exchange rate and the domestic output that are leptokurtic in nature. As expected therefore, the Jarque-Bera (JB) statistic that takes into consideration information from skewness and kurtosis to test for normality suggests non-normality of all the variables with the exception being the foreign output series.

6.2.1 Unit Root/Stationarity Test Results

Following a standard time series analysis procedure in the literature, we further subjects the concern series, namely; log of exchange rate (e_t), log of domestic money supply (m_t) and log of foreign money supply (m_t^*), log of domestic output (y_t) and log of foreign output (y_t^*) as well as log of Brent oil price and log of WTI. Although the proposed ARDL and NADR Bound cointegrating estimation framework requires not, the pre-testing of variables for unit root. It is however, necessary to performed unit root test in order to verify and ascertain that none of the series included in the specified models exhibits an integrated order higher than one (i.e. I(1). Essentially, we explore three different efficient unit root tests to include; Augmented Dickey-Fuller (ADF) unit root test, Ng-Perron (Ng-P) unit root test and Kwiatkwoski-Phillips-Schmidt-Shin (KPSS) unit root test. The null hypothesis for ADF and Ng-P is that an observable time series is not stationary (i.e. has unit root) while that of KPSS test is that the series is stationary. Hence, the outcomes of the unit root and stationarity tests for the respective aforementioned series are represented in Table 2 as follow.

Table 2: Unit Root and Stationarity Test Results

Variable	ADF			Ng-P			KPSS		
	Level	*First Diff.*	*I(d)*	*Level*	*First Diff.*	*I(d)*	*Level*	*First Diff.*	*I(d)*
$\log(e_t)$	-2.015[a]	-12.569[a]***	*I(1)*	-1.7878[a]	-6.846***[b]	*I(1)*	1.426[a]	0.081[b]***	*I(1)*
$\log(m_t)$	-1.635[a]	-3.535[a]***	*I(1)*	-1.2521[b]	-3.487[b]***	*I(1)*	0.327[b]	0.087[b]***	*I(1)*
$\log(m_t^*)$	-3.181[b]*	-	*I(0)*	-4.999[b]***	-	*I(0)*	0.142[b]***	-	*I(0)*
$\log(y_t)$	-1.771[a]	-3.699[a]***	*I(1)*	-1.103[b]	-5.364[b]***	*I(1)*	0.296	0.101[b]***	*I(1)*
$\log(y_t^*)$	-1.879[a]	-7.187[a]***	*I(1)*	-1.638[a]*	-	*I(0)*	0.099[b]***	-	*I(0)*
$\log(Brent)$	-1.582[a]	-11.019[b]***	*I(1)*	-1.447[b]	-6.559[b]***	*I(1)*	0.264[b]	0.089[b]***	*I(I)*
$\log(WTI)$	-1.626[a]	-11.827[a]***	*I(1)*	-1.502[b]	-6.697[b]***	*I(1)*	0.298[b]	0.071[b]***	*I(1)*

Note: [a] Indicates a model with constant but without deterministic trend; [b] is the model with constant and deterministic trend as exogenous lags are selected based on Schwarz info criteria. ****, **, * imply that the series is stationary at 1%, 5% and 10% respectively.

Although the order of cointegration for the concerns series as indicated across the three unit root test considered hovered between I(0) and I(1). On the one hand for instance, log of exchange rate, log of domestic money supply and log of domestic output are all but difference series irrespective of the unit root test considered. On the other hand however, the three unit root tests consider uniformly rejects the null of hypothesis of non-stationarity in the case of log of foreign money supply, the log foreign output is however, non-stationary for ADF, but stationary in the case of Ng-Perron and KPSS unit root test. The unit root tests are further consistent in their indications of the two oil price measure as non-statioanry series. This evidence mixed order of integration (i.e. I(0) and I(1)) though implies that combining these series in their level form for empirical estimation may result in spurious regressions and a consequence of this is that the results may spuriously indicate a significant relationship, even when that is not the case. However, that the series exhibit mixed order of integration is no indication that they are entirely redundant, rather we would focus on a class of linear and/or non-linear regression that allow us to find out if despite their difference order of cointegration, there exists a long run relationship or equilibrium among the series. This therefore, further justifies the choice of the ARDL and NARDL as the study's estimation framework. The next section discusses the regression results including diagnostics and robustness checks.

7. Empirical Results and Discussions

As earlier mentioned, this study employs both the linear and nonlinear ARDL framework to empirically engage its various set of objectives. Presented in Table 3 therefore, are empirical estimates from both the linear (symmetry) and nonlinear (asymmetry) ARDL empirical estimations. Also included in the table are the post estimation reports resulting from the implementation of various post estimation diagnostic tests such as; normality test (using Jarque-Bera test), serial correlation test (using Breusch-Godfrey Serial Correlation LM test) and heteroscedasticity test (using ARCH LM test). Others are the adjusted R-square and F-statistic which measures the explanatory powers and the joint significant of the independent variable included in the model respectively. The Bound test F-statistic in the table is meant to determine the long run dynamic of the response of fiscal policy in Nigeria to oil price volatility. In the final section of the Table is the Wald test result, which is meant to determine the significance or otherwise of asymmetry for both the short and long run situations.

In order to evaluate the accuracy of the models from which the above reported empirical results are obtained. This present study therefore, commences its discussion of the empirical findings from the post-estimation results to ascertain the accuracy or viability of the estimated models. Starting with the explanatory power of the independent variables included in the models, the adjusted R-square for both the symmetry and asymmetric models shows that, 98 per cent of the variations in exchange rate is likely to be due to changes in oil prices and other explanatory factors included in the respective models. Also, the F-statistic which test for the join significance of the independent variables is reported as significant for the symmetric and asymmetric models thus implies that the overall goodness of fit of the models are satisfactory.

We further examined the presence of autocorrelation using Breusch-Godfrey LM and the rejection of null hypothesis of serial correction is appears to be consistent for both the symmetric. Consequently, Heteroscedasticity test which examine for the presence of time varying conditional variance in the model is carried out using ARCH LM test, and the null hypothesis of heteroscedasticity is found to be rejected for both the symmetric and asymmetric models respectively. This among others is indications that the empirical estimates obtained from the estimated models are efficient and robust for policy inference.

Table 3: Regression Results

Long Run	Symmetry Model (Linear ARDL)			Asymmetry Model (Nonlinear ARDL)		
	Coefficient	***Std. Error***	***T – stat.***	***Coefficient***	***Std. Error***	***T – stat.***
$\log(m_t)$	-0.0622	0.0934	-0.6656	-0.0588	0.0964	-0.6102
$\log(m_t^*)$	0.9570	0.6803	1.4067	0.9939	0.7017	1.4162
$\log(y_t)$	0.3975	0.3520	1.1290	0.3847	0.3624	1.0614
$\log(y_t^*)$	-0.7727**	0.3743	-2.0638	-0.7788**	0.3845	-2.0254
$\log(op_t)$	-0.1488***	0.0545	-2.7281			
$\log(op_t^+)$				-0.1474***	0.0559	-2.6344
$\log(op_t^-)$				-0.1432**	0.0559	-2.5602
Short Run						
Constant	-2.0802	2.3331	-0.8916	-2.1446	2.3361	-0.9180
$\Delta\log(m_t)$	-0.0095	0.0152	-0.6255	-0.0088	0.0153	-0.5747
$\Delta\log(m_t^*)$	0.1471	0.1037	1.4190	0.1488	0.1038	1.4340
$\Delta\log(y_t)$	0.0611	0.0568	1.0757	0.0576	0.0570	1.0103
$\Delta\log(y_t^*)$	-0.1188*	0.0668	-1.7777	-0.1166*	0.0669	-1.7425
$\Delta\log(op_t)$	-0.0228***	0.0073	-3.1207			
$\Delta\log(op_t^+)$				-0.0220***	0.0074	-2.9813
$\Delta\log(op_t^-)$				-0.0214***	0.0075	-2.8453
ECT	-0.1537***	0.0308	-4.9805	-0.1497***	0.0312	-4.7912
$AdjR^2$	0.9849			0.9848		
$JB\ stat.$	943.9957 (0.0000)			967.2696 (0.0000)		
$F-stat.$	1773.667 (0.0000)			1549.618 (0.0000)		
$LM\ test$	0.7681 (0.4654)			0.7825 (0.4588)		
$ARCH\ test$	0.9675 (0.3819)			1.0302 (0.3589)		
Bound Test (F-stat.)	5.0548***			4.6328***		
Lag Selection (SIC)	(1, 0, 0, 0, 0, 0)			(1, 0, 0, 0, 0, 0, 0)		
Short-Run Asymmetry Wald test Results W_{SR} F – stat. = 0.7133 (0.3994)				***Lon-Run Asymmetry Wald test Results*** W_{LR} F – stat. = 0.6578 (0.4184)		

***, ** and * denotes significance at 1%, 5% and 10% level of significance

Haven established the accuracy of the estimated models as suggested by the varying diagnostic and post estimation tests considered. The next is to evaluate the economic and empirical implications of the regression results. Essentially, the study explore Wald restriction test to evaluate the significance and/or otherwise of asymmetries in the response of the Nigerian exchange rate to movement in the international oil prices. While one of the main innovations of this study as earlier stated is on whether asymmetries matter in the exchange rate –oil price relationship. However, the Wald test outcome in this regard fails to reject null hypothesis of no asymmetry for both the short and long run situations. In addition to this statistical outcome of the Wald test, which suggest that asymmetry matters not in the response of the Nigerian exchange rate to oil price shock. The negativity of the oil price shocks coefficient as evident in the above empirical results further suggest the likelihood of appreciation of Nigerian exchange rate in response to both the positive and negative oil price shocks.

On whether the appreciation and/or depreciation of Nigerian exchange rate in response to change in oil price is short or long run phenomenon. The significant of the Bound cointrgeration test results across both the symmetric and asymmetric implies the rejection of null hypothesis of no long run relationship at 5 per cent level of significant. In consonance with, this significant evidence of long run relationship between exchange rate and oil price is the sign and significance of the cointegrating equation coefficient as denoted by the error correction term (ECT). The ECT for both the symmetric and asymmetric models is correctly sign and significance such that, 15 per cent and 14 per cent of disequilibrium due to last month shocks would be corrected for in the present month in the symmetric and asymmetric models respectively. More so, the evidences of the significant response of exchange rate to oil price changes as reported in the above table are shown to be consistent in both the short and long run situation irrespective of the symmetric or asymmetric nature of the oil price shocks.

The above notwithstanding, the magnitude of at which changes in oil price tend to induces appreciation of the Nigerian exchange rate seems to be more pronounced in the long run across both the symmetric and asymmetric model. Thus, the degree of appreciation in the Nigeria exchange rate that may be due to changes in oil prices appears to be more pronounce for positive oil prices changes at least in the long run. This however, may not be unconnected to the oil exporting peculiarity of the Nigerian economy. As a net oil exporting economy, a positive oil price shocks means more dollar is accrue to Nigeria in exchange for the sale of crude oil and demand for more naira as against dollar for Nigerian crude oil will as empirically established strengthening naira against dollar.

In addition to oil price shocks, the relative foreign output is also empirical reveals as significant for explaining exchange rate appreciation in Nigeria. The negative and significant coefficient of relative foreign output suggest that increase in foreign output relative to Nigerian output has the tendency of strengthening the Nigerian naira against US dollar. That is, all things being equal, as more output is relatively produce in the foreign country where crude oil is require as input factor, more Naira is likely to be demanded for importation of the Nigerian crude and consequently strengthening naira against US dollar.

7.1 Robustness Check Results

One of the objectives as well novelty of this study centered on whether the symmetric and/or asymmetric impact of oil price shocks on the Nigerian exchange rate is robust to the alternative measures of oil price shocks. To achieve this objective, we replaced the oil price proxy with WTI and thereafter re-estimated all the equations and the results are represented in Table 4 as follows:

Table 4: Robustness Check Results

Long Run	Symmetry Model (Linear ARDL)			Asymmetry Model (Nonlinear ARDL)		
	Coefficient	*Std. Error*	*T – stat.*	*Coefficient*	*Std. Error*	*T – stat.*
$\log(m_t)$	-0.0480	0.0979	-0.4910	-0.0420	0.0956	-0.4394
$\log(m_t^*)$	0.9284	0.6891	1.3472	0.8652	0.6690	1.2933
$\log(y_t)$	0.4988	0.3564	1.3995	0.4877	0.3454	1.4120
$\log(y_t^*)$	-0.7781**	0.3759	-2.0701	-0.7094*	0.3750	-1.8919
$\log(op_t)$	-0.1613***	0.0592	-2.7243			
$\log(op_t^+)$				-0.1667***	0.0582	-2.8652
$\log(op_t^-)$				-0.1710***	0.0593	-2.8833
Short Run						
Constant	-2.6081	2.3236	-1.1224	-1.9446	2.3362	-0.8323
$\Delta\log(m_t)$	-0.0073	0.0156	-0.4681	-0.0065	0.0156	-0.4218
$\Delta\log(m_t^*)$	0.1410	0.1041	1.3545	0.1358	0.1043	1.3018
$\Delta\log(y_t)$	0.0757	0.0571	1.3265	0.0766	0.0571	1.3396
$\Delta\log(y_t^*)$	-0.1182*	0.0666	-1.7731	-0.1114*	0.0671	-1.6583
$\Delta\log(op_t)$	-0.0245***	0.0077	-3.1673			
$\Delta\log(op_t^+)$				-0.0261***	0.0079	-3.2820
$\Delta\log(op_t^-)$				-0.0268***	0.0081	-3.2762
ECT	-0.1519***	0.0308	-4.9305	-0.1570***	0.0313	-5.0034
$AdjR^2$	0.9847			0.9849		
$JB\,stat.$	1056.680 (0.0000)			1041.166 (0.0000)		
$F-stat.$	2048.088 (0.0000)			1552.414 (0.0000)		
$LM\ test$	0.7251 (0.4856)			0.7070 (0.4944)		
$ARCH\ test$	0.7394 (0.4788)			0.7595 (0.4693)		
Bound Test (F-stat.)	5.3341**			4.5008**		
Lag Selection (SIC)	(1, 0, 0, 0, 0, 0)			(1, 0, 0, 0, 0, 0, 0)		
Short-Run Asymmetry Wald test Results W_{SR} F – stat. = 0.7600 (0.3845)				***Lon-Run Asymmetry Wald test Results*** W_{LR} F – stat. = 0.7872 (0.3761)		

Note: the oil price shock (op) is now proxy by WTI for robustness purpose, while ***, ** and * still denotes significance at 1%, 5% and 10% level of significance

Hence, the robustness test results as represented in Table 4 above shows that the empirical estimates as well the estimated model are robust to oil price proxies. In other words, using different oil price proxies (particularly Brent and WTI) when dealing with exchange rate -oil price shock nexus will produce the similar conclusions for both the short-run and long-run relationships except for few differences in terms of the magnitude of the influence.

8. Conclusion

Given the period under consideration in line with the aforementioned empirical findings, it is only rationale therefore, to infer that a positive shock to the international oil prices has the tendency of strengthening the Nigerian Naira against US Dollar. While this inference is drawn on the basis probable appreciation of the Nigerian exchange rate in response to positive oil prices as empirically established in the course of this study. The assertion that asymmetries matters in the response of exchange rate to oil price may not likely hold in the case of Nigeria at least statistically as suggested by the non-rejection of the null hypothesis of asymmetry in the course of our empirical analysis. In addition to changes in the movement of international oil price, relative foreign out, rather than money supply seems the more potential factor that can significantly influence exchange rate performance in Nigeria. The non-rejection of the null-hypothesis of asymmetry though, the fact that the empirical evidence as established in the context of this study suggests that; the significant response of exchange rate to oil price shocks is more pronounced for positive oil price shock is an indication that probable asymmetric implications of exchange rate –oil price relationship cannot be entirely ignored.

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