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ORIGINAL ARTICLE

Petroleum Consumption and Economic Growth Nexus in Nigeria: Evidence from Nonlinear ARDL and Causality Approaches

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Abstract
Nigeria is a major oil-producing country but with a low electricity supply; therefore, the country depends mainly on refined petroleum to power economic activities. The paper uses a multi-methodological approach, which includes nonlinear autoregressive distributed lag model, vector error correction modelling, and Hatemi-J causality tests to examine both asymmetric effect and causal relations between petroleum consumption and economic growth in Nigeria over the period 1980–2016. The results provide evidence in support of cointegration and nonlinearity between petroleum consumption and economic growth. Asides, the results show that causality runs only from economic growth to petroleum consumption is provided. This finding supports the conservation hypothesis, meaning that petroleum conservation measures may not necessarily harm economic growth. Instead, the impact of an increase in petroleum consumption on economic growth may be enhanced by the 'booster-effect' of petroleum conservation policies. In sum, issues of nonlinearity and asymmetry need to be taken into consideration in the examination of the nexus between petroleum consumption and economic growth.

Keywords Petroleum consumption · Economic growth · NARDL · Nigeria

JEL Classification F43 · O44 · P18 · Q43

Introduction

In the comity of the largest oil-producing countries worldwide, Nigeria occupies the 6th position. The country has about 37.2 billion barrels of oil reserves. This figure represents 2.13 percent of global production. In short, quantitatively,

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Nigeria's proven oil reserves represent 3.1 percent of the world total making the country tenth amongst countries with oil reserves. The abundance of oil, coupled with the neglect of other sources of energy, including coal, electricity, and gas, has made the country depend mainly on petroleum to power economic activity. Refined petroleum constitutes a significant input component for almost all sectors, including manufacturing, construction, transportation, service, communication, entertainment, and agriculture. This development explains why the domestic consumption of refined petroleum has risen phenomenally over the years. The high dependence on petroleum for production has severe consequences for the economy's growth that should be analyzed. There is the need to understand the nexus of interaction between domestic petroleum consumption and GDP growth.

Aside from causality between the quantity of petroleum consumed domestically and the GDP growth rate, there is a big question of whether the relationship between the two is linear or nonlinear. Most existing empirical studies on total domestic petroleum consumed and GDP growth assumed a linear relationship between energy consumption and GDP growth. However, the relationship between the two may be nonlinear. Hence, a lack of consensus amongst most existing studies on the energy consumption-GDP growth nexus might have arisen because of the possible nonlinear relationship between them. The possibility of nonlinearity in the relationship between total energy consumed and GDP growth is very high based on the argument that technological progress could affect the relation between them. It is argued in the literature that technological advancement tends to improve the efficiency of energy use, lower energy prices, boost energy consumption, and thus higher GDP growth (Brookes 1990). Likewise, technological advancement may decrease petroleum consumption without necessarily causing economic contraction, especially where expenditures on petroleum do not account for a large portion of aggregate economic activity, and petroleum costs represent a tiny proportion of the total energy costs. Given the various mechanisms through which technological advances could impact the petroleum-growth nexus, there is the need to account for possible asymmetric causal effects in the relation between the two phenomena.

A survey of the existing literature shows that asymmetry has not been explored in the study of petroleum-GDP growth nexus. There is the need to fill this gap in the literature. The results of this study will broaden our understanding of the dynamic relation between domestic petroleum consumption and the growth of the economy. For example, if economic growth leads domestic petroleum consumption, then petroleum conservation policies such as increase petroleum price would be justified as the economy is less dependent on petroleum to generate economic growth. However, if causality runs from domestic petroleum consumption to economic growth, government attempts at reducing petroleum consumption through rationing or increase in price without developing other energy sources could constrain economic growth.

The rest of the article is organized as follows: section "Literature Review" provides a capsule summary of the existing empirical literature. Section "Methods" describes the research methods and data. Section" Empirical Results" presents the results. Section "Conclusion" contains the conclusion.

Literature Review

Theoretically, the economic growth-energy consumption nexus is analysed under four hypotheses. The first, called the growth hypothesis, says that there is one-way causal nexus from energy consumption to economic growth. The second, known as the conservation hypothesis, assumes a one-way causal relation from economic growth to energy consumption. The third refers to as the feedback hypothesis, assumes a bi-directional causality from energy consumption to economic growth. The fourth, called the neutrality hypothesis, says there is no causal nexus between energy consumption and economic growth.

Many empirical works have focused on the causal relationship between energy consumption and GDP growth, with different outcomes/findings obtained depending on the countries used and the econometric techniques adopted. Some results have confirmed the growth hypothesis (e.g., Furuoka 2016; Apergis and Payne 2009; Ghosh and Kanjilal 2014; Yang and Zhao 2014; Odhiambo 2009a; Aslan, et al. 2014; Ouedraogo 2013; Ozturk and Bilgili 2015; Bilgili and Ozturk 2015). Likewise, many others have validated the conservative hypothesis including Huang et al. (2008), Narayan et al. (2010), Ghali and El-Sakka (2004), Fang and Chang (2016), and Wolde-Rufael (2009). In the same vein, few other studies have confirmed the feedback hypothesis (e.g., Behmiri and Manso 2012; Alimulali and Sab 2012; Bildirici and Ozaksoy 2013; Bildirici 2013, 2014; Nasreen and Anwar 2014; Odhiambo 2009b; Shahbaz et al. 2016; Ahmed et al. 2016). Finally, few studies have confirmed the neutrality hypothesis, including Jafari et al. (2012), Eden and Hwang (1984), Altinay and Karagol (2005), Schrawat et al. (2015).

No doubt, many researchers have examined the nexus between energy consumption and GDP growth; only a few of the existing empirical literature explicitly focused on domestic petroleum consumption. These include Wanjiku (2011), Rahman et al. (2016) and Narayan et al. (2017). Wanjiku (2011) confirms a unidirectional causal movement from petroleum consumption to GDP growth in Kenya. The results equally show that the effect of petroleum consumption on economic growth is positive and significant in the long run. Rahmani et al. (2016) show that total petroleum consumed has a significant impact on economic growth in Iran.

The results of the study by Narayan et al. (2017) for wealthier states in India reveal a prevalence of a two-way relationship between petroleum consumption and real GDP in both the short and long run. However, for the panel of 23 major Indian States, the results provide evidence supporting the conservative hypothesis, especially in the short term. In the panels of middle and low Indian States, the results show evidence of significant bidirectional effects. As for the Indian States classified as low income, a decrease in petroleum is caused by higher economic growth.

One major weakness of the few known empirical works that focus on petroleum consumption and the economic growth nexus discussed above is that they neglect the possibility of asymmetric relationship dimension. Hence, this gap in the existing should be filled in the case of Nigeria.

Methods

Several studies have investigated the economic growth-energy consumption nexus using either error correction model (ECM) (e.g., Loganathan and Subramaniam 2010; Wanjiku 2011; Park and Yoo 2014 or Engle and Granger 1987; Ebohon 1996; Wolde-Rufael 2005; Bildirici 2012, 2013) methods. Many other studies have used Banerjee et al. (1998) and, or Toda-Yamamoto Granger tests (Yildirin and Aslam 2012; Payne 2009). However, these methods are only valid where the variables involved are ($I(1)$). In the case where both $I(0)$ and, or $I(1)$ are obtained in a model, the linear co-integration ARDL methodology developed by Pesaran et al. (2001) is used to test simultaneously both the long run and the short-run effects.

Specifically, the equation of ARDL (p, q) bounds test for ascertaining co-integration is given thus:

$$\Delta y_{t=}\alpha_0 + \rho y_{t-1} + \theta x_{t-1} + \varphi w_t + \sum_{i=1}^{p-1} \alpha i \Delta y_{t-i} + \sum_{i=0}^{q-1} \delta i \Delta x_{t-i} + \mu_t \quad (1)$$

where μ_t is an *iid* stochastic process, and w_t represents a vector of deterministic variables. The condition is that: if $\rho = \theta = 0$, then the two variables in y_t and x_t in Eq. (1) are not co-integrated. To ascertain the presence or otherwise of co-integration, Pesaran et al. (2001) proposed the F-test. If the calculated F-statistic lies above the upper bound of the two critical bounds, then long-run relationship exists between y_t and x_t. However, if the F-statistic is below the lower bound of the two critical bounds, there is no co-integration between the two variables y_t and x_t. If statistics lies within the upper and lower bounds, it is indeterminate. However, the ARDL model specified in Eq. (1) assumes a linear combination of y_t and x_t with a symmetric adjustment not only in the long but also in the short-run. Equation (1) is said to be mis-specified where the relations between y_t and x_t is non-linear and x has an asymmetric impact on y.

In order to assess the potential asymmetric effects in the long run and in the short run, Shin et al. (2014) modify Eq. (1) by breaking x_t into its positive and negative partial sums as follow:

$$x_t = x_0 + x_t^+ + x_t^- \quad (2)$$

where $x_t^+ = \sum_{i=1}^{t} \Delta x_i^+ = \sum_{i=1}^{t} \max\left(\Delta x_i, 0\right)$ and $x_t^- = \sum_{i=1}^{t} \Delta x_i^- = \sum_{i=1}^{t} \min(\Delta x_i, 0)$.

Following Shin et al. (2014), the non-linear asymmetric co-integration regression is depicted thus:

$$y_t = \beta^+ x_t^+ + \beta^- x_t^- + \mu_t \quad (3)$$

where the long run coefficient associated with the positive change in x_t is represented by β^+ and the long-run coefficient associated with negative change in x_t is denoted by β^-. According to Shin et al (2014), if we substitute Eq. (3) in the ARDL (p, q) model specified in Eq. (1), we derive the non-linear asymmetric conditional ARDL (NARDL) given as:

$$\Delta y_t = \alpha_0 + \rho y_{t-1} + \theta^+ x^+_{t-1} + \theta^- x^-_{t-1} + \varphi w_t + \sum_{i=1}^{p-1} \alpha_i \Delta y_{t-i} + \sum_{i=0}^{q-1} \left(\delta_i^+ \Delta x^+_{t-i} + \delta_i^- \Delta x^-_{t-i} \right) + \mu_t \tag{4}$$

where $\beta^+ = -\theta^+/_\rho$ and $\beta^- = -\theta^-/_\rho$.

The implementation of Shin et al. (2014) NARDL model entails four steps. The first step involves conducting the unit root test to obviate the inclusion variable of order 2 (I*(2)*) in the model. The import of this is that the presence of I*(2))* variable renders invalid the computed F-statistics for co-integration. The second step entails estimating Eq. (4) using the standard OLS approach. The third step involves checking the presence or otherwise of cointegration relationship amongst the levels of the series y_t, x_t^+ and x_t^-. This step entails the use of F-*pss* statistic developed by Shin, et al. (2014), otherwise known as the joint hypothesis of no cointegration ($\rho=\theta^+=\theta^-=0$). The fourth step entails testing the short-run and the long-run symmetric by applying the Wald test. The null hypothesis for ascertaining long-run symmetry is stated as: $\theta=\theta^+=\theta^-$. However, the null hypothesis for verify short-run symmetry can take one of the following forms: (1) $\delta_i^+=\delta_i^-$ for all i = 1, 2, …, q or (2) $\sum_{i=0}^{q-1} \delta_i^+=\sum_{i=0}^{q-1} \delta_i^-$.

The last step entails the use of nonlinear ARDL model in Eq. (4) to generate the two dynamic multipliers, m_h^+ and m_h^-. The dynamic multiplier m_h^+ relates to the change in x_t^+ while m_h^- is connected with the change in x_t^-:

$$m_h^+ = \sum_{i=0}^{h} \frac{\partial y_{t+i}}{\partial x^+_{t-1}}, \quad m_h^- = \sum_{i=0}^{h} \frac{\partial y_{t+i}}{\partial x^-_{t-1}} \quad h = 0, 1, 2 \tag{5}$$

$$Note\ that\ as\ h \rightarrow \infty, m_h^+ \rightarrow \beta^+, and m_h^- \rightarrow \beta^-$$

Besides, we further assess the domestic petroleum consumption-economic growth nexus by carrying out the granger causality test, which is based on the error correction modeling approach. And from the estimations, the impulse response functions and the variance decompositions are obtained. Essentially, this modeling approach assists to know the direction of causation and identify the variables that are exogenous and endogenous in the model. The coefficient of the lagged ECM is used to generate information on how long it takes the system to move back to equilibrium when there is a perturbation to the variables. Also, the VDCs and IRFs help to provide information on the relative degree of exogeneity and endogeneity of the variables in the models.

Data

In this study, we utilize annual time-series data over the period 1980–2016. The source of data series is the 2017 edition of Statistical Bulletin published by the Central Bank of Nigeria (CBN). Precisely, GDP growth (i.e., economic growth) is measured as real gross domestic product (gdp) in local currency unit (LCU). Real GDP is obtained by deflating nominal GDP by the consumer price index.

Capital formation is proxy as gross fixed capital formation (cap) in local currency unit, and foreign direct investments were obtained CBN Statistical Bulletin. The domestic petroleum consumption series defined as total domestic refined petroleum consumed (measured as thousand barrels per day) was obtained from opendataforafrica.org and CBN Statistical Bulletin. Exchange rate is the yearly nominal exchange rate (local currency (Naira US$) sourced from CBN Statistical Bulletin. The rate of interest is the annualized cost of credit computed as percentage ratio of interest to the principal. This series was obtained from CBN Statistical Bulletin. Inflation is computed as percentage change in the consumer price index obtained CBN Statistical Bulletin 2017 Edition. All the variables in the model are in natural logarithms form except those in rate.

The Model

In line with previous studies including Raza et al. (2016) and Kisswani (2017), among others), the restricted and full-models estimated are specified as:

Restricted Model

$$lnGDP_t = a_0 + b_1 lnPet_t + b_2 lnFDI_t + b_3 lnCap_t + \mu_t \tag{6}$$

Full Model

$$lnGDP_t = a_0 + b_1 lnPet_t + b_2 lnFDI_t + b_3 lnCap_t + b_4 lnlab_t + b_5 exr_t + b_6 inf_t + b_{71} int + \mu_t \tag{7}$$

where GDP represents real gross domestic product, Pet stands for total petroleum consumed domestically, FDI denotes foreign direct investment, and Cap is gross fixed capital formation, μ_t denotes the random term. α_0 represents the constant term, while b_1–b_3 are induced coefficients for measuring the relative influences of Pet, FDI, and Cap respectively In the literature, several studies have demonstrated the importance of capital for the economy's growth and could affect the relationship between energy consumption and economic growth (Kisswani 2017; Shahbaz et al. 2017). Openness measured as FDI is incorporated to reflect the degree of openness of the economy. It equally serves as a route for transferring advanced technology and managerial skills, especially to the developing economies (Shahbaz 2012). FDI generally assists in promoting technological advancement and helps in its diffusion.

However to account the effects of other macroeconomic fundamentals that affect economic growth, we extend model (6) to include labour, inflation, interest rate, and exchange rate. The inclusion of these variables helps to avoid simultaneity bias in our regression.

The reduced-form equations like (6) and (7) are long-run models, and the values of the estimated coefficients depict long-run effects of exogenous variables. To distinguish between long-run effects from short-run effects, Eqs. (6) and (7) are transformed into an error correction form given as Eqs. (8) and (9), respectively:

Restricted Model

$$\Delta lnGDP_t = \alpha_0 + \rho_0 lnGDP_{t-1} + \rho_1 lnPet_{t-1} + \rho_2 lnFDI_{t-1} + \rho_3 lnCap_{t-1} + \sum_{i=1}^{p-1} \omega_i \Delta lnGDP_{t-i} + \sum_{i=0}^{q-1} \tau_i \Delta lnPet_{t-i} + \sum_{i=0}^{q-1} \vartheta_i \Delta lnFDI_{t-i} + \sum_{i=0}^{q-1} \sigma_i \Delta lnCap_{t-i} + \mu_t \quad (8)$$

Full Model

$$\Delta lnGDP_t = \alpha_0 + \rho_0 lnGDP_{t-1} + \rho_1 lnPet_{t-1} + \rho_2 lnFDI_{t-1} + \rho_3 lnCap_{t-1} + \rho_4 lnlab_{t-1} + \rho_5 exr_{t-1} + \rho_6 inf_{t-1} + \rho_7 int_{t-1} + \sum_{i=1}^{p-1} \omega_i \Delta lnGDP_{t-i} + \sum_{i=0}^{q-1} \tau_i \Delta lnPet_{t-i} + \sum_{i=0}^{q-1} \vartheta_i \Delta lnFDI_{t-i} + \sum_{i=0}^{q-1} \sigma_i \Delta lnCap_{t-i} + \sum_{i=0}^{q-1} \sigma_i \Delta lnlab_{t-i} + \sum_{i=0}^{q-1} \sigma_i \Delta exr_{t-i} + \sum_{i=0}^{q-1} \sigma_i \Delta inf_{t-i} + \sum_{i=0}^{q-1} \sigma_i \Delta int_{t-i} + \mu_t \quad (9)$$

In Eqs. (8) and (9), the difference terms are used to capture short-run effects of each variable with the lag length selected using the Akaike Information Criterion (AIC). The long-run effects for the restricted model are obtained by the estimates of $\rho_1 - \rho_3$ normalized on ρ_0, while those for the full model are obtained by the estimates of $\rho_1 - \rho_7$ normalized on ρ_0. To ensure the validity of the long-run estimates, Pesaran et al. (2001) propose using standard F-test to establish the joint significance of lagged level variables in Eqs. (8) and (9) as a sign of cointegration.

The basic assumption of Eqs. (8) and (9) is that changes in any explanatory variable have a symmetry effect on the GDP growth rate. However, based on the argument that technological advances tend to enhance efficiency and energy consumption, which could affect petroleum-economic growth nexus (Bayramoglu and Yildirin 2015), there is a strong possibility of an asymmetric effect of petroleum consumption on GDP growth rate. Consequently, Eqs. (8) and (9) are transformed into a non-linear form by introducing partial sums of positive Pet_t^+ and negative Pet_t^- changes in petroleum consumption into them to obtain Eqs. (10) and (11), respectively.

Restricted Model

$$\Delta lnGDP_t = \alpha_o + \gamma lnGDP_{t-1} + \theta_1^+ lnPet_{t-1}^+ + \theta_1^- lnPet_{t-1}^- + \infty_1 lnFDI_{t-1} + \emptyset_1 lnCap_{t-1} + \sum_{i=1}^{p-1} \partial_i \Delta lnGDP_{t-i} + \sum_{i=0}^{q-1} \delta_{1'i}^+ \Delta lnPet_{t-i}^+ + \sum_{i=0}^{q-1} \delta_{1'i}^- \Delta lnPet_{t-i}^- + \sum_{i=0}^{q-1} \in_i \Delta lnFDI_{t-i} + \sum_{i=0}^{q-1} \pi_i \Delta lnCap_{t-i} + \mu_t \quad (10)$$

Full Model

$$\Delta lnGDP_t = \alpha_o + \gamma lnGDP_{t-1} + \theta_1^+ lnPet_{t-1}^+ + \theta_1^- lnPet_{t-1}^- + \infty_1 lnFDI_{t-1} + \emptyset_1 lnCap_{t-1} + \varphi_1 lnlab_{t-1} + \beta_1 exr_{t-1} + \omega_1 inf_{t-1} + \tau_1 int_{t-1} + \sum_{i=1}^{p-1} \partial_i \Delta lnGDP_{t-i} + \sum_{i=0}^{q-1} \delta_{1'i}^+ \Delta lnPet_{t-i}^+ + \sum_{i=0}^{q-1} \delta_{1'i}^- \Delta lnPet_{t-i}^- + \sum_{i=0}^{q-1} \in_i \Delta lnFDI_{t-i} + \sum_{i=0}^{q-1} \pi_i \Delta lnCap_{t-i} + \sum_{i=0}^{q-1} \pi_i \Delta lnlab_{t-i} + \sum_{i=0}^{q-1} \pi_i \Delta exr_{t-i} + \sum_{i=0}^{q-1} \pi_i \Delta inf_{t-i} + \sum_{i=0}^{q-1} \pi_i \Delta int_{t-i} + \mu_t \quad (11)$$

Equations (10) and (11) become non-linear ARDL models by incorporating Pet_t^+ and Pet_t^- (Shin et al. 2014). If changes in petroleum consumption are to have symmetric effect, the estimated coefficients of Pet_t^+ and Pet_t^- must be the same in sign and size. Otherwise, their effects become asymmetric.

Lastly, we conduct a causality test to ascertain the nature of causal relations between domestic petroleum consumption and GDP growth rate. The beauty of the causality techniques in energy economics is that they help to ascertain whether energy conservation policies have a destructive impact on growth of the economy or vice-versa (Solarin and Ozturk 2015; Al-Mulali et al. 2015). First, we utilize the error correction (VEC) Granger Causality. The VEC used to analyse the relationship between variables is constructed as follows:

$$\Delta Y_t = \alpha_0 + \sum_{i=1}^{m} \beta_i \Delta Y_{t-i} + \sum_{t=1}^{n} \pi_i \Delta X_{t-i} + \omega_1 ECM_{t-1} + \varepsilon_t \quad (12)$$

$$\Delta X_t = \alpha_0 + \sum_{i=1}^{m} \theta_i \Delta X_{t-i} + \sum_{t=1}^{n} \delta_i \Delta Y_{t-i} + \omega_2 ECM_{t-1} + \varepsilon_t \quad (13)$$

where residuals, ε_t is white noise disturbance term; ECM_{t-1} represents the error-correction model resulting from the long-run equilibrium relationship; and β, π, θ, and δ denote the parameters that need to be estimated. ω is the speed of adjustment parameter and provides information on the length of time it takes for the system to come back to equilibrium level after a shock.

However, as the estimated cointegration relationship is asymmetric in structure, we proceed further to utilize Hatemi-J (2012) causality test. This test considers the potential asymmetries by constructing the cumulative sums of positive and negative shocks in the underlying variables. Hence, the modified WALD- (M*WALD*) statistic that tests the null non-Granger causality is given as:

$$\text{M}WALD = (C\beta)' \left[C(Z'Z)^{-1} \; Su)C' \right]^{-1} (C\beta) \quad (14)$$

where $\beta = vec\ (D)$, where vec represents the column-stacking operator, ⊗ denotes the Kronecker product, while C represents a $p\ x\ n(1+np)$ indicator matrix. The elements ‘1’s in the matrix are for restricted parameters. Finally, Su represents the variance–covariance matrix of the unrestricted VAR model, which contains the number of parameters in each vector autoregressive (VAR) equation. Hatemi-J (2012), through bootstrap simulated technique, generates the critical values and modified-WALD (MWALD) statistics that could simultaneously take care of the autoregressive (AR) conditional heteroscedastic effect as it possesses better size and power properties (Tugcu and Topcu 2018; Hatemi-J 2012).

Finally, we generate the IRFs and the VDs from the restricted model. The variance decompositions help us to ascertain the relative endogeneity and exogeneity of the variables. At the same time, the impulse response functions help not only to validate the degree of response but also to determine how long it would take to normalize.

Empirical Results

Descriptive and Pairwise Correlations Results

The results of the descriptive statistics and pairwise correlations are presented in Table 1. The variables are platykurtic except for GDP growth (GDP), inflation (inf), capital formation (Cap) and interest rate (int). This means that the variables have lighter tails than the normal distribution. The Jacque-Bera values show that GDD growth, FDI, Cap, and inf are not normally distributed, while others are normally distributed.

The correlation exercise shows that the correlation between domestic petroleum consumption and GDP growth is positive. Also, foreign direct investment, exchange rate, gross capital formation and interest rate have a positive correlation with GDP growth. However, labour and inflation are negatively correlated with GDP growth.

Unit Root Tests

One requirement for the use bound testing approach is that no *I(2)* variables be involved. Hence, the need to conduct a unit-root tests for all the variables using Augmented Dickey-Fuller (ADF) and Phillip-Peron (PP) unit-roots. The results of the ADF and PP unit-test are given in Tables 2 and 3, respectively. The study employs both AIC and SIC in determining the optimal lag order. As shown in Table 2, none of the eight variables is I(2). In Table 3, petroleum consumption, foreign direct investment and inflation are I(0), while GDP growth, capital formation, labour, exchange rate and interest rate are I(1). The combinations of both I(0) and I(1) variable justifies the use of ARDL approach.

Table 1 Descriptive statistics

	GDP	*Pet*	*FDI*	*Cap*	*lab*	*exr*	*inf*	*int*
Mean	21,792.24	258.00	4.99E+08	475,553.9	4.54	74.54	20.28	12.98
Median	4588.99	269.00	2.61E+08	242,256.6	4.54	22.05	12.20	12.50
Maximum	101,489.50	312.00	1.60E+09	2,561,305.0	4.73	253.49	76.85	26.90
Minimum	144.83	170.00	86,100.0	8799.50	4.36	0.55	3.60	6.13
Std. Dev	31,065.72	33.52	5.25E+08	702,809.7	0.10	72.12	18.22	4.77
Skewness	1.376	− 0.70	0.84	1.89	0.44	0.46	1.69	0.53
Kurtosis	3.50	2.80	2.33	5.39	2.29	2.00	4.76	3.16
Jarque.Bera	11.89	3.10	5.06	30.94	1.98	2.86	22.44	1.74
Prob	0.003	0.21	0.07	0.00	0.37	0.24	0.00	0.42
Sum	806,312.8	9546.00	1.85E+10	175,954.0	167.8	275.9	750.30	480.19
Sum Sq.Dev	3.47E+10	40,456.00	9.92E+18	1.78E+13	0.33	187.2	119.92	820.12
Obs	37	37	37	37	37	37	37	37
Pairwise correlation								
GDP	1							
Pet	0.721	1						
FDI	0.772	0.459	1					
Cap	0.844	0.693	0.593	1				
lab	− 0.235	− 0.182	− 0.551	− 0.169	1			
exr	0.986	0.743	0.745	0.830	− 0.174	1		
inf	− 0.237	− 0.041	− 0.162	− 0.159	− 0.076	− 0.195	1	
int	0.338	0.427	0.408	0.317	− 0.241	0.370	0.162	1

ARDL Bound Tests Results

As none of the variable is integrated of order 2 ($I(2)$), we test for the long-run relationship among the variables in the restricted and full models is examined using ARDL bounds test. The bounds F-test is applied to Eqs. (7) and (8). The results of the bounds test for both linear and nonlinear (restricted and full) specifications are presented in Table 4. The F-statistics 3.025 falls between two bounds (upper and lower bounds) at a 5% significant level. The implication of this is that co-integration is indeterminate for the linear model. However, concerning the nonlinear ARDL model, the test shows that the null hypothesis of no co-integration can be rejected (F-*pss* = 5.078) for the restricted model, and (F-*pss* = 15.399) for the full model. The result indicates that the variables are cointegrated, i.e. they co-move in the long run.

ARDL Results: Linear Model

The linear ARDL model is implemented to estimate the parameters of Eq. (6) based on the automatic lag adjustment procedure. Hence, Eq. (8) is estimated through ARDL methodology. The results of the long-run, short-run and diagnostic tests are

Table 2 ADF unit root test

	Level		First difference	
	Constant	Constant & trend	Constant	Constant & trend
GDP	– 0.128	– 1.281	– 3.350*	– 3.290**
Pet	– 2.402	– 2.509	– 6.169***	– 6.329***
FDI	– 1.628	– 2.418	– 5.506***	– 6.416***
Cap	– 1.271	– 1.113	– 3.726**	– 3.835**
lab	– 3.094	– 2.696	– 3.357**	– 3.475**
exr	– 1.386	– 1.309	– 3.703***	– 4.059**
inf	– 1.269	– 2.691	– 5.571***	– 5.534***
int	– 2.983**	– 3.025	– 7.292***	– 7.292***

Note: ***, ** and * indicate significance level for 1%, 5% and 10% respectively

Table 3 Results of the Phillip-Perron unit root test

	Level		First difference	
	Constant	Constant & trend	Constant	Constant & trend
GDP	– 0.224	– 2.045	– 3.293*	– 3.211*
Pet	– 3.467*	– 3.473*	– 8.572***	– 19.153***
FDI	– 2.058	– 3.142	– 8.528***	– 8.427***
Cap	– 1.222	– 1.075	– 5.071***	– 7.441***
lab	– 1.942	– 1.767	– 3.441**	– 3.425*
exr	– 1.212	– 1.533	– 3.703***	– 4.043**
inf	– 3.097	– 3.209*	– 12.421***	– 12.491***
int	– 2.937	– 2.971	– 7.561***	– 7.441***

Note: ***, ** and * indicate significance level for 1%, 5% and 10% respectively

presented in Table 5. The results show that the coefficient of lagged GDP is significant (β = – 0.057, p-value = 0.029). Petroleum consumption carries an insignificant positive value in the long run. However, the coefficient of petroleum consumption is significant in the short run. Foreign direct investment is not significant both in the short-run and long-run. In the same way, gross capital formation has an insignificant positive impact in the short and long-run periods. The results of the linear ARDL model 9 not reported here, for space consideration, are similar to those in Table 5.

ARDL Results: Asymmetric Model

One probable reason for the indeterminacy of long-run co-movement among variables in the linear model is the possible nonlinearity between domestic petroleum consumption and GDP growth. To ascertain this possibility, we employ the

Table 4 Bounds test for cointegration (linear and non-linear specifications)

Dependent variable $\Delta lnGDP$	F_{PSS}	95% Lower bound	95% Upper bound	Result
Linear ARDL	3.025	2.79	3.67	Indeterminate
Non- linear ARDL (Restricted)	5.708***	2.79	3.67	Cointegration
Non- linear ARDL (Full)	15.399***	2.62	3.77	Cointegration

Bounds Test

The exact specifications of the asymmetric models are presented in Tables 6 and 7

F-pss is the PSS F-statistic testing the model hypothesis of (no cointegration under restricted and trend case)

nonlinear ARDL bounds test. Hence, the study estimates Eqs. 10 and 11. Tables 6 and 7 provide the results of the nonlinear estimation for the restricted and full models, respectively. In both the short and long run, the asymmetric impact is established using the Wald test, reported at the bottom of Tables 6 and 7. The results confirm a significant asymmetric relationship between petroleum consumption and GDP growth both in the long and short run periods. The numerical values of the Wald test of 4.93 in the short run and 6.48 in the long run are statistically significant

Table 5 Linear ARDL results

Variable Dependent variable:ΔlnGDP	Coefficient	t-statistic	ρ-value
Constant	− 2.813	− 1.431	0.166
$lnGDP_{t-1}$	− 0.057**	− 2.322	0.029
$lnPet_{t-1}$	0.500	1.272	0.216
$lnFDI_{t-1}$	0.014	1.005	0.327
$lnCap_{t-1}$	0.032	1.341	0.193
$\Delta \ln GDP_{t-1}$	0.186	0.869	0.394
$\Delta lnPet$	0.586**	2.000	0.057
$\Delta \ln Pet_{t-1}$	− 0.035	− 0.132	0.896
$\Delta lnFDI$	− 0.004	0.253	0.803
$\Delta \ln FDI_{t-1}$	0.014	− 1.087	0.289
$\Delta lnCap$	0.053	1.259	0.221
$\Delta \ln Cap_{t-1}$	− 0.024	− 0.597	0.556
Cointegration test statistics			
F-PSS = 3.02			
Statistics and diagnostic tests			
χ^2_{SC}= 2.614(0.2706)		χ^2_{HET} = 0.9634(0.319)	
χ^2_{NORM}= 0.11 (0.945)		χ^2_{FF} = 0.018(0.894)	

χ^2_{SC}, χ^2_{HET}, χ^2_{NORM} and χ^2_{FF} refer to LM test for serail correlation, normality, functionality form and heteroscedasticity, respectively

**Indicates significance level at 5%

for the restricted model. In the same way, the Wald test values of 6.371 in the short run and 14.737 in the long run are significant for the full model. The implication is that economic growth responds differently to an increase compared to a decrease in domestic petroleum consumption in the two time periods (i.e., long- and short-run). This finding suggests that nonlinearity and asymmetry should be taken into consideration when analyzing the petroleum consumption-GDP growth nexus in Nigeria.

In the restricted model, the coefficients of positive (Pet_t^+) and negative (Pet_t^-) partial sums decompositions of petroleum consumption are positive but only significant for the former. This result suggests that an increase (decrease) in petroleum consumption will increase (reduce) economic growth. Foreign direct investment has a significant positive effect on economic growth in the long-run and short-run. In contrast, gross capital formation hurts GDP growth. However, the coefficient is significant only in the short-run period.

The long-run coefficient of positive changes in petroleum consumption is 6.929, while the negative is 1.64. This result shows that a 1 percent increase in petroleum consumption will lead to a 6.929 percent increase in GDP growth. Similarly, a 1 percent reduction in petroleum consumption will lead to a 1.64 percent reduction in GDP growth. Consequently, the positive effect exceeds the adverse effect. Many studies have confirmed the positive impact of energy consumption on economic growth, including Bayramoglu and Yildirim (2017).

In the full model, the coefficients of positive (Pet_t^+) and negative (Pet_t^-) partial sums decompositions of petroleum consumption are positive and statistically significant. The results from full nonlinear model confirm the asymmetric relationship in the short- and long run. Focusing on the estimated long-run coefficients of the asymmetric ARDL full model, we note that for the petroleum consumption, significance is confirmed for positive ($LR^+_{\ln Pet}$) and negative ($LR^-_{\ln Pet}$) long-run coefficient, with the signs being positive and negative, respectively.

The estimated long-run coefficient on $lnPet^+$ and $lnPet^-$ are 5.311 and − 4.743, respectively. Hence, we may conclude that a 1 per cent increase in petroleum consumption results in a 5.311 percent rise in economic growth. Similarly, a 1 percent decrease in petroleum consumption leads to a 4.743 percent increase in economic growth. Thus, the results indicate that greater effect comes from positive changes. The coefficient of capital lagged one-period has a significant positive effect on economic growth in the short- and long-run. Labour lagged one-period hurts economic growth in the short run. Foreign direct investment harms economic growth both in short- and- long run. However, foreign direct investment lagged one period has a positive effect on economic growth in the short run. Exchange rate lagged one-period hurts economic growth in the long run but enhances economic growth in the short run. Inflation lagged one-period boosts economic growth in the short run. Interest rate lagged one-period enhances economic growth in the long run but harms economic growth in the short run.

The lower panel of Tables 6 and 7 provide some diagnostic tests of the estimated models. The tests for serial correlation LM (χ^2_{SC}) and ARCH $\chi^2_{(HET)}$ test for heteroscedasticity confirm a well-specified estimated model. Also, the plots of the CUSUM and CUSUMSQ statistics for nonlinear models (restricted and full) confirm model stability (see Figs. 4, 5, 6, 7, Appendix 1). The confirmation of model

Table 6 NARDL estimation results for restricted model

Variable Dependent Variable:$\Delta lnGDP$	Coefficient	t-statistic	ρ-value
Constant	0.252	0.903	0.379
$lnGDP_{t-1}$	− 0.336***	− 4.769	0.0002
$lnPet^{+}_{t-1}$	2.327***	3.999	0.001
$lnPet^{-}_{t-1}$	0.551	0.973	0.345
$lnFDI_{t-1}$	0.057***	3.19	0.006
$lnCap_{t-1}$	− 0.008	− 0.234	0.818
$\Delta \ln GDP_{t-1}$	0.012	0.065	0.949
$\Delta \ln GDP_{t-2}$	0.179	0.898	0.383
$\Delta \ln GDP_{t-3}$	− 0.253	− 1.257	0.227
$\Delta \ln Pet^{+}_{t}$	1.363***	2.757	0.014
$\Delta \ln Pet^{-}_{t}$	1.167	− 1.548	0.141
$\Delta \ln Pet^{-}_{t-1}$	− 2.603***	− 2.747	0.014
$\Delta \ln Pet^{-}_{t-2}$	− 2.401***	− 2.991	0.009
$\Delta \ln FDI$	− 0.007	− 0.397	0.097
$\Delta \ln FDI_{t-1}$	0.049***	− 3.679	0.002
$\Delta \ln FDI_{t-2}$	0.032***	2.866	0.011
$\Delta \ln Cap$	− 0.089**	2.456	0.026
Long run (LR) asymmetric coefficient		Long and short run asymmetric tests	
$LR^{+}_{\ln Pet}$= 6.929***(0.000)		$W_{LR,lnPet}$= 6.48**(0.0391)	
$LR^{-}_{\ln Pet}$= 1.640(0.372)		$W_{SR,lnPet}$= 4.93**(0.057)	
Statistics and diagnostic tests			
χ^2_{SC}= 3.592(0.166)		χ^2_{HET}= 0.246(0.620)	
χ^2_{NORM}= 0.667 (0.716)		χ^2_{FF}= 4.894(0.043)	

W_{LR}, W_{SR} and wald test for the null of long and short-run symmetry, respectively

W_{LR}, W_{SR}: Wald test for the null of long- and short-run symmetry respectively. χ^2_{SC}, χ^2_{NORM}, χ^2_{HET} and χ^2_{FF} symbolize LM test for serial correlation, normality, functional form and heteroscedasticity, respectively

*, **, and ***, indicate significance level for 10%, 5%, and 1%, respectively

stability means that all the coefficients in the estimated model are stable as the statistics lie within the critical bounds.

To examine the pattern of dynamic asymmetric adjustment of economic growth from its initial equilibrium to the new steady-state in the long-run shock, albeit from its initial equilibrium, the study adopts the dynamic multiplier propose by Shin et al. (2014). Figures 8, 9 reveal the dynamic effects of negative and positive changes in petroleum consumption. As shown in Fig. 8, economic growth responds more rapidly to an increase in petroleum consumption compared to a decrease. The negative (dotted line) and positive (undotted line) curves reveal the asymmetric adjustment to negative and positive shocks at a given forecast, respectively (See Fig. 8, "Appendix 2"). Regarding full model, the gap between the effect of positive and negative

Table 7 NARDL estimation results for full model

Variable Dependent variable:$\Delta InGDP_t$	Coefficient	t-statistic	ρ-value
constant	− 2.029	− 1.252	0.246
$InGDP_{t-1}$	− 0.238***	− 5.997	0.000
$InPet^{+}_{t-1}$	1.264***	3.216	0.012
$InPet^{-}_{t-1}$	− 1.129***	3.571	0.007
$InCap_{t-1}$	0.129***	6.891	0.001
$Inlab_{t-1}$	1.486	1.467	0.181
$InFDI_{t-1}$	− 0.052***	− 4.075	0.004
exr_{t-1}	− 0.005***	− 4.863	0.001
inf_{t-1}	− 0.004	− 0.004	0.656
int_{t-1}	0.024***	5.177	0.001
$\Delta InGDP_{t-1}$	0.221	1.714	0.125
$\Delta InPet^{+}_{t}$	0.181	0.653	0.532
$\Delta InPet^{+}_{t-1}$	0.253	0.878	0.406
$\Delta InPet^{-}_{t}$	0.585	1.695	0.129
$\Delta InCap_t$	0.082***	3.979	0.004
$\Delta Inlab_t$	− 0.379	− 0.469	0.652
$\Delta Inlab_{t-1}$	− 2.064**	− 2.529	0.035
$\Delta InFDI_t$	− 0.047***	− 6.088	0.000
$\Delta InFDI_{t-1}$	0.014***	2.184	0.000
Δexr_t	− 0.002	− 0.534	0.608
Δexr_{t-1}	0.005***	5.992	0.003
Δinf_t	0.001	0.220	0.831
Δinf_{t-1}	0.024***	3.890	0.005
Δint_t	0.002	1.035	0.331
Δint_{t-1}	− 0.022***	− 7.040	0.001
Long run (LR) asymmetric coefficients		Long− and Short run asymmetric tests	
LR^{+}_{InPET}= 5.311*** (0.005)		$W_{LR,InPET}$= 14.737***(0.005)	
LR^{-}_{InPET}= − 4.743*** (0.012)		$W_{SR,InPET}$= 6.371** (0.036)	
Statistics and diagnostics tests			
X^2_{SC}= 0.023(0.883)		X^2_{HET} = 1.850 (0.185)	
X^2_{NORM}= 0.878(0.645)		X^2_{FF}= 2.231 (0.119)	

W_{LR}, W_{SR} and wald test for the null of long and short− run symmetry, respectively

W_{LR}, W_{SR}: Wald test for the null of long- and short-run symmetry, respectively. χ^2_{SC}, χ^2_{NORM}, χ^2_{HET} and χ^2_{FF} symbolize LM test for serial correlation, normality, functional form and heteroscedasticity, respectively

*, **, and ***, indicate significance level for 10%, 5%, and 1%, respectively

changes in petroleum consumption at the beginning is larger and, over the horizon, gets smoother (See Fig. 9, "Appendix 2").

Granger Causality Results Based on VECM

The paper conducts Granger causality based on the VEC model to assess the direction of causation. The approach assists in confirming the long-run relationship and identify the exogenous (strong) and endogenous (weak) variables in the model. The one lagged error correction term ($ECM_{(-1)}$) represents the speed of adjustment. It provides information on how long it takes to revert to long-term equilibrium if the adjustment variable is perturbed. The VECM results are presented in Table 8. The results of the causal channels are presented in Table 8. As shown from the t-statistic of the error correction model (ECM), foreign direct investment is endogenous as the coefficient is significant. Other variables, namely petroleum consumption, GDP growth, and gross capital formation, are not significant and thus exogenous. The finding implies that a shock to FDI will produce a strong and significant effect on economic growth, petroleum consumption, and capital formation. Hence, macroeconomic policies must focus on greater openness through increased FDI as it tends to produce a significant and profound impact on capital formation and economic growth.

Regarding the direction of causation, the results in Table 9 reveal that economic growth Granger causes FDI and not otherwise. Also, the results show one-way causality running from GDP growth to petroleum consumption.

However, the results of causality from the modified WALD (MWald) statistic are presented in Table 10. The results show that, where the cumulative sums of negative and, or positive changes are excluded, unidirectional causality that runs from GDP growth to petroleum consumption holds. This result supports the finding from the VECM-ECM causality test.

The results show a one-way causality moving from petroleum consumption to GDP given that the cumulative sums of negative changes are excluded. In contrast, a unidirectional causality running from GDP growth to petroleum is found given that the cumulative sums of positive changes are excluded.

The VEC model can indeed reveal the absolute exogeneity or endogeneity of a variable; however, it cannot provide information on the relative degree of exogeneity and endogeneity of a variable. Hence, there is a need to obtain the variance

Table 8 Error correction model

Variables	Coefficient	Standard error	T-statistics	Significance	Results
ΔGDP	– 0.0328	0.0251	– 1.3098	Not Significant	Exogenous
ΔPet	0.0342	0.0181	1.8872	Not Significant	Exogenous
ΔFDI	0.8941***	0.3457	2.2868	Significant	Endogenous
ΔCap	– 0.0161	0.1345	– 0.1193	Not Significant	Exogenous

Note: *** denotes significance at 1%

Table 9 Granger causality

Dependent variables		Independent variables		
		X^2 of lagged first difference term P-value		
	ΔGDP	ΔPet	ΔFDI	ΔCap
ΔGDP	–	2.735 (0.255)	1.735 (0.742)	0.758 (0.684)
ΔPet	5.015* (0.082)	–	0.597 (0.742)	0.448 (0.799)
ΔFDI	9.459*** (0.009)	5.272* (0.072)	–	1.093 (0.579)
ΔCap	0.598 (0.742)	1.964 (0.375)	0.105 (0.949)	–

***, ** and * indicate significance level for 1%, 5% and 10% respectively. *p*-value in parenthesis

Table 10 Direction of causality

Pet →GDP	=0.56
GDP →Pet	=5.447**
Pet^{+}→ GDP^{+}	=3.128*
GDP^{+}→Pet^{+}	=0.181
Pet^{-}→GDP^{-}	=0.201
GDP^{-} → Pet	=3.447*

Note: *significant at 10%, and ** significant5%

decompositions (VDCs) of the variables. The VDCs results for three, six, nine, and twelve year's horizons are shown in Table 10. The leading variable is the one that has the highest rank and thus should be marked as the immediate target variable by the policymakers. As shown in Table 11, for the 3, 6, 9 and 12- year's horizons, GDP growth is the most exogenous. In all the horizons, own shock accounts for average of over 90 percent. This is followed by gross capital formation, while petroleum consumption is third and FDI fourth.

$$\text{Exogeneity Order: LGDP} \rightarrow \text{LCap} \rightarrow \text{LPet} \rightarrow \text{LFDI}.$$

One possible reason for the high exogeneity of GDP is that oil production accounts for a considerably large share of economic activity in Nigeria. Indeed, studies have established that GDP growth leads financial, services, and building & construction sectors of the economy. Also, that FDI comes as the most endogenous variable should not come as a surprise because a substantial share of FDI goes into the oil sector. GDP growth leading petroleum consumption means that this finding from the VDCs supports the hypothesis of conservatism, that is, one-way causality moving from GDP growth to petroleum consumption. The policy implication of this finding is that the economy is not entirely petroleum-dependent. Hence, the government may adopt petroleum conservation policies without a significant adverse impact on economic growth. Finally, the results reveal that GDP growth leads foreign direct investment. This finding supports the results of Edoumiekuno (2009) for Nigeria and Bakir and Eryilmaz (2015) for Turkey. The results from VDCs are in line with results from ARDL-ECM.

We continue the analysis by finding the impact of a perturbation (shock) to one variable on others using the Impulse Response functions (IRFs). This analysis will help to ascertain the degree of response and duration of the normalization process. Figures 7, 8, and 9 are the graphs for the periods 10, 20, and 30 years. A shock to endogeneity variable, namely foreign direct investment, has a profound effect on the exogenous variables. It takes a longer horizon to normalize. As shown in the three graphs, when there is a perturbation to FDI, the response from exogenous variables, namely petroleum consumption, economic growth and gross capital formation, is relatively slow. The rest of the variables shock equally takes a longer response with normalization being visible when impulses for 20–30 years.

Table 11 Orthogonalized variance decompositions (VDCs)

Variable	Horizon	LGDP	LPet	LFDI	LCap	Total
LGDP		98.911	0.262	0.019	0.808	100
LPst		42.267	57.031	0.621	0.081	100
LFDI	3	22.144	22.926	54.137	0.793	100
LCap		16.490	4.697	5.695	73.118	100
Exogeneity		98.911	57.031	54.137	73.118	
Rank		1	3	4	2	
LGDP		93.331	1.666	1.306	3.697	100
LPet		40.512	57.258	2.092	0.138	100
LFDI	6	18.566	34.696	46.004	0.734	100
LCap		25.759	2.486	5.416	66.339	100
Exogeneity		93.331	57.259	46.005	66.339	
Rank		1	3	4	2	
LGDP		90.870	2.130	1.881	5.119	100
LPet		39.244	57.228	3.224	0.304	100
LFDI	9	18.174	38.185	42.956	0.685	100
LCap		31.107	1.502	5.575	61.816	100
Exogeneity		90.870	57.229	42.956	61.816	
Rank		1	3	4	2	
LGDP		89.138	2.517	2.312	6.033	100
LPet		36.782	58.257	4.346	0.615	100
LFDI	12	16.895	41.170	41.273	0.662	100
LCap		34.705	1.017	5.676	58.602	100
Exogeneity		89.138	58.257	41.273	58.602	
Rank		1	3	4	2	

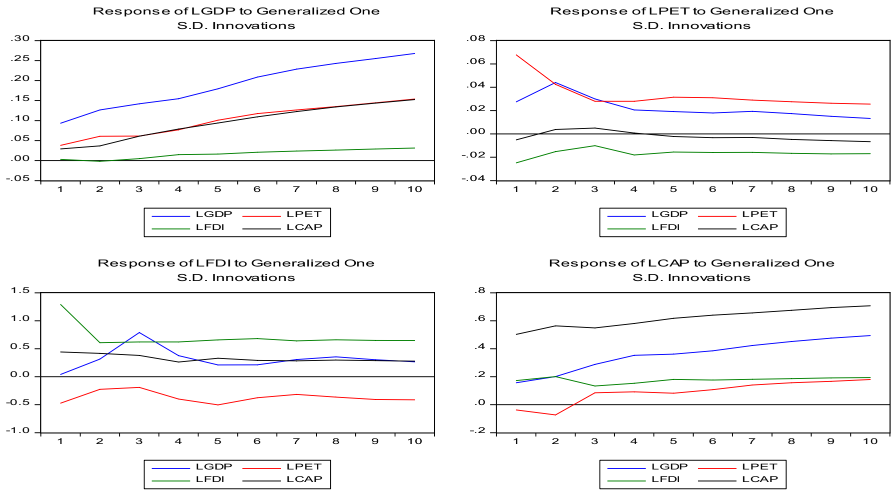

Fig. 1 Results of Impulse Response Functions (IRFs)—10 years

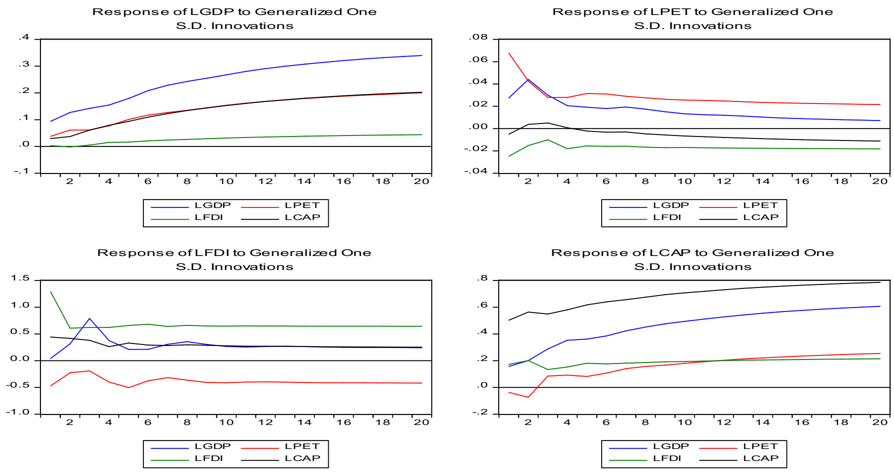

Fig. 2 Results of Impulse Response Functions (IRFs)—20 years

Conclusion

The economy of Nigeria depends mainly on oil. The country not only exports a large quantity of crude oil but also import a large proportion of refined petroleum due to the limited capacity of domestic refineries in meeting domestic consumption. In the face of low electricity generation and distribution, the country depends mainly on refined oil to drive economic activities. The paper examines the asymmetric impact of domestic petroleum consumption shocks on GDP growth in Nigeria over the period 1980–2016.

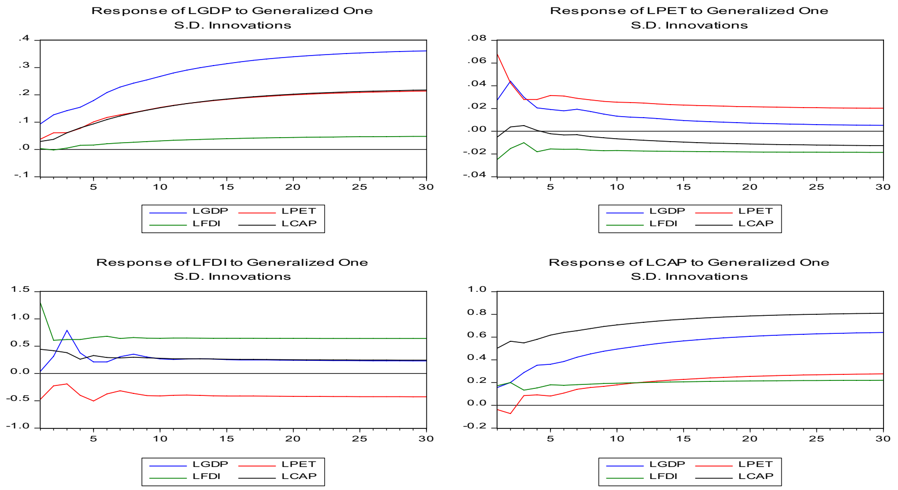

Fig. 3 Results of Impulse Response Functions (IRFs)—30 years

The paper utilizes the nonlinear ARDL approach proposed by Shin et al. (2014), vector error correction model (VECM), variance decompositions (VDs), and Impulse response functions (IRFs) techniques. The nonlinear ARDL enables us to test the short-run and long-run asymmetric response of economic growth to the negative and positive partial sums decompositions of petroleum consumption.

The investigation starts by examining the linear ARDL model, and the results reveal that the long-run relationship between petroleum consumption and GDP growth is indeterminate. The F-statistic lies between the lower and upper bounds. Consequently, we further examine the nonlinear ARDL using the Shin et al. (2014) technique. As shown from the results, the potential asymmetric effect of any change in petroleum consumption on GDP growth is both a long- and short run phenomenon in Nigeria. Also, the dynamic multiplier analysis of the asymmetric adjustment of economic growth provided further evidence that economic growth responds more to a rise in petroleum consumption than to a decrease. In short, our findings show that the most efficient and effective model for analyzing GDP growth and domestic petroleum consumption should incorporate asymmetric both in the long- and short run.

The VECM based granger causality test shows one-way causality from GDP growth to petroleum consumption, thus supporting the conservation hypothesis. This finding shows that petroleum conservation measures may not necessarily harm economic growth. Instead, the impact of increased petroleum consumption on economic growth may be enhanced by the 'booster-effect' of petroleum conservation policies. The main implication of our findings is that nonlinearity and asymmetry must be taken into account when analyzing domestic petroleum consumption-economic growth nexus in Nigeria.

Appendix 1

Restricted Model.

See Figs. 4, 5.

Full model

See Figs. 6, 7.

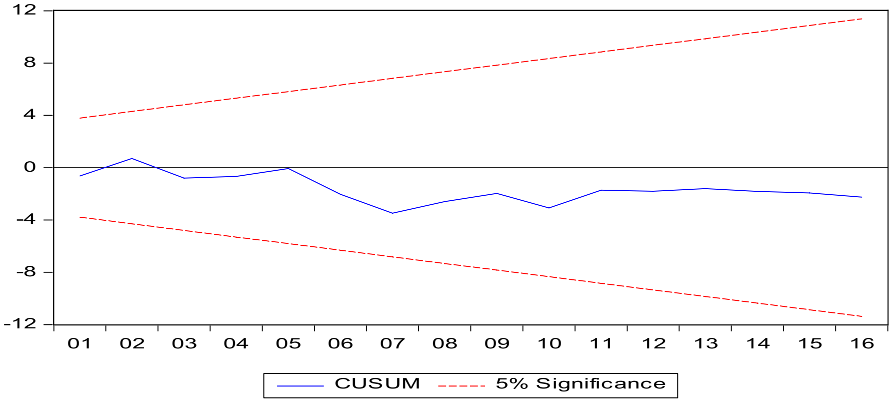

Fig. 4 Plot of CUSUM test for the nonlinear ARDL Model

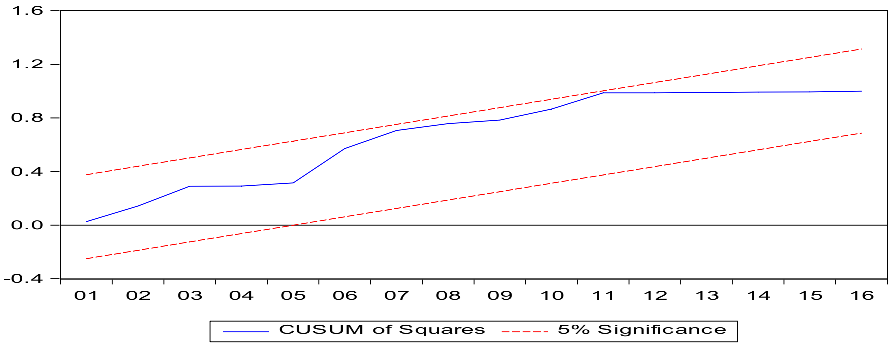

Fig. 5 CUSUMQ test for the nonlinear ARDL model

Appendix 2

See Figs. 8, 9.

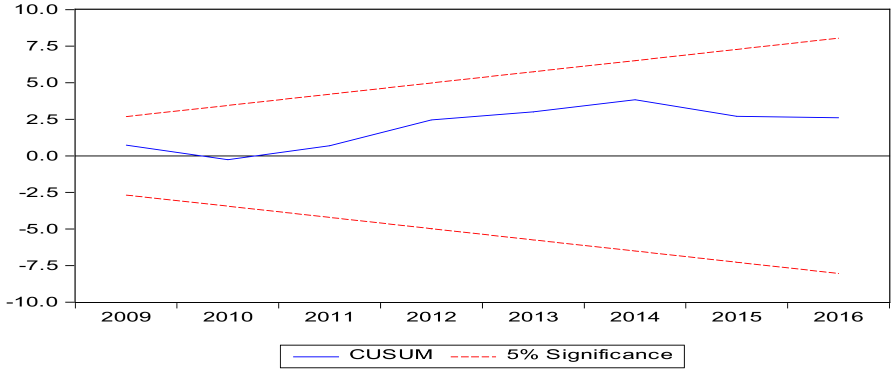

Fig. 6 Plot of CUSUM test for the nonlinear ARDL model (full Model)

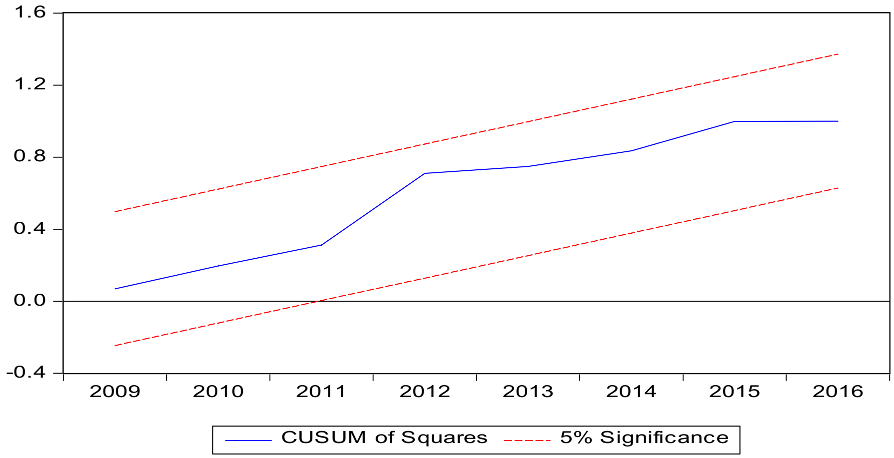

Fig. 7 CUSUMQ test for the nonlinear ARDL model (full model)

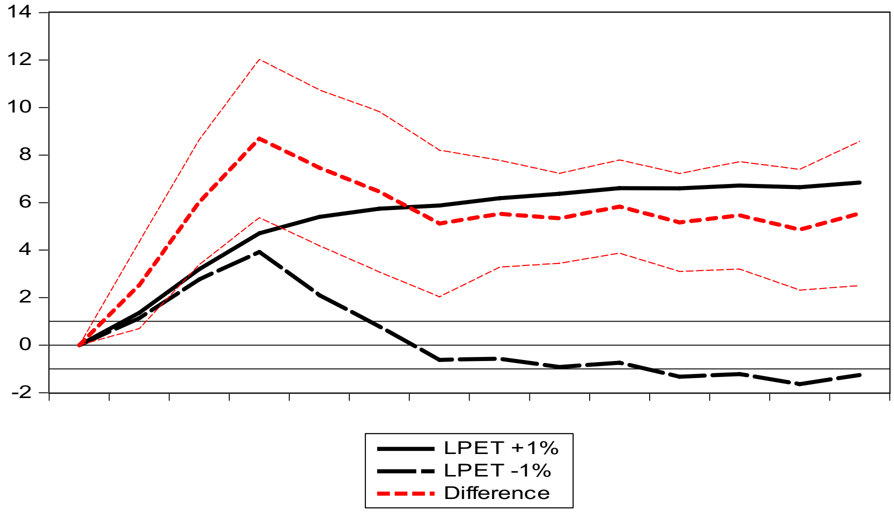

Fig. 8 Dynamic multipliers effects (restricted model)

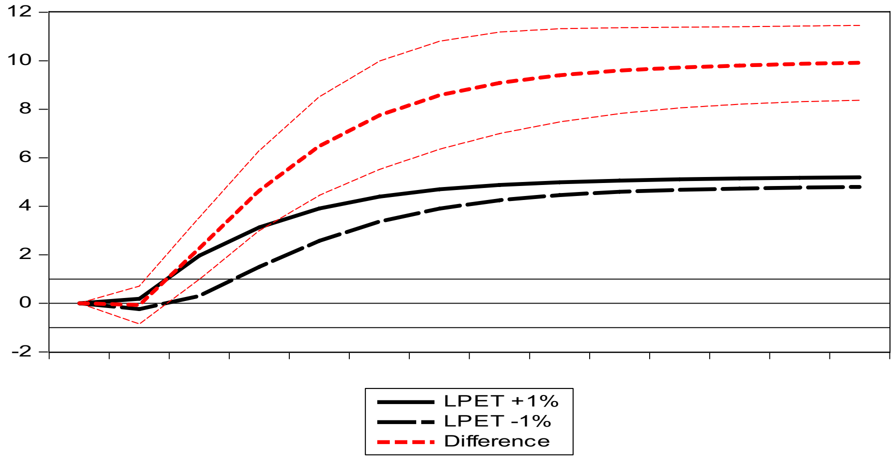

Fig. 9 Dynamic multiplier effects (full model)

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Code availability E-views 10 software.

Declarations

Conflict of interest I have no conflict of interest.

Ethics approval Not applicable.

Consent to participate Not applicable.

Consent for publication I hereby give my consent for the publication of identifiable details within the text to be published in the Journal of Quantitative Economics. Consequently, anyone can read material published in the Journal.

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