Economic growth, energy consumption and government expenditure:evidence from a nonlinear ARDL analysis

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Abstract

This study investigates the nonlinear asymmetric relationship between energy consumption and economic growth by incorporating government expenditure and oil prices into a production function using Nigerian economy from 1980-2014. The nonlinear autoregressive distributed lag bounds testing approach is applied to examine the asymmetric cointegration between the variables. An asymmetric causality test is also employed to examine the causal association between the considered variables. The results indicate cointegration between the variables in the presence of asymmetries. The asymmetric causality results show that negative shocks to energy consumption have impacts on economic growth. Likewise, negative shocks to government expenditure have impacts on economic growth. The implications of these results for growth policies in Nigeria are also examined.

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Introduction

Economic growth is one of the most crucial factors that is given preference when policy makers push for changes in the direction of policies. Different economies globally are facing recessions due to various problems experienced globally. Emerging economies are the most affected in the global economic downturn. For any country to achieve economic growth, it needs to put into consideration various factors while making policies that affect lives of the populace. Energy and government expenditure are very important in driving forward any economy that is aimed at growth. For countries like Nigeria, an emerging market according to the World Bank, there is a need, especially for the policy makers, to have a shift in direction of policy making. This is crucial at a time when oil exporting nations are facing crises due to a fall in oil prices. Having a look into policy making to ensuring that economic growth is sustained over the long run is essential.

This paper is an humble effort to examine the causal relationship between energy, government expenditure and economic growth to establish which direction policy makers must face in policy making. The causal relationship that exists between economic growth and energy has received substantial attention from researchers, and with the studies done so far, the results have been multiplex. Four different theories, so far, have been concluded on the causal relationship between energy and economic growth. All previous studies have shown possibility in each theory. The Growth, Conservative, Feedback and Neutrality theories are the possibilities that previous researches have shown.

Up to date, several techniques using time series analysis have been adopted in testing these theories empirically. Latest of these techniques is a Nonlinear Autoregressive Lag (NARDL). While extensive studies have previously adopted the Autoregressive Distributed Lag (ARDL) in checking for causality between the two variables, study by (Shahbaz, Hoang, Mahalik, & Roubaud, 2017) adopted NARDL. This, as far as the author's knowledge is concerned, is one of the few studies to have used this recent technique to examine the relationship between energy and economic growth. In their study, which used India as a case study, results show that only negative shocks to energy consumption have impacts on economic growth. Equally, this study aims to use the NARDL approach on Nigeria because NARDL relaxes the symmetry and linearity assumptions that ARDL assumes. Hence, is there any nexus between energy and economic growth in Nigeria?

Furthermore, the relationship between government expenditure and economic growth can also be said to be unresolved theoretically. Hypothetically, there are two hypotheses on the relationship between government expenditure and economic growth. Wagner argues that for any country, the causal chain between government expenditure and economic growth is led by economic growth. Government expenditure rises constantly as economic growth increases, in other words, economic growth is the driving force for government expenditure (Hasnul, 2015). Contrary to that, Keynes argues theoretically that economic growth is only achievable provided government expenditure rises (Hasnul, 2015). These two prominent hypotheses have been proven empirically by several studies, however, the results remain mixed. Based on that, would there be any link between government expenditure, and economic growth in Nigeria, using NARDL approach?

We propose using econometric methods recently developed by (Hatemi-J, 2012) and (Shin, Yu, & Greenwood-Nimmo, 2014). These methods allow for the consideration of the asymmetry in studying the cointegration and causality between economic growth, energy consumption and government expenditure, including oil prices, in Nigeria from 1980 to 2014. As such, this study does not only contribute to the understanding of relationship that exists between economic growth and energy consumption, but likewise to government expenditure. This study is different previous studies on Nigeria by both (Akinlo, 2009) and (Iyke, 2015) that have only adopted Autoregressive Lag (ARDL) and a trivariate Vector Error-Correction Model (VECM) respectively. Our study also contribute by expanding sample number of years by (Akinlo, 2009).

The objectives and contributions of this paper can be summarized as follow:
The objectives are three, namely:

1) Is there any nexus between economic growth and energy in Nigeria economy?

2) Does any relationship exist between economic growth and government expenditure in Nigeria?

3) If both energy and government expenditure are combined, would there be any relationship with economic growth?

The contributions are two, namely:

1) A more recent technique Nonlinear Autoregressive Distributed Lag (NARDL) is the first to be used in studying Nigeria.

2) This study is expanding the samples of observation, especially in relation to study by (Akinlo, 2009) that used data from 1980-2004. This study extends it to 2014, making this study freer from any bias.

The rest of the paper is organized as follow. Section 2 reviews the literature on the two principal linkages that we study, which are the energy–growth and energy–expenditure nexuses. Section 3 presents the dataset, the methods used, the discussion of results, and reasons for choosing to study Nigeria. Section 4 of pays attention to the policy implications of the results, and the importance of taking the asymmetry into account. The concluding section highlights the contributions of this study, as well as the limitations and the future.

2. Literature Review

In this study, the literature is divided into three parts. The first will be on the energy and growth relationship, while the second will be on connection between government expenditure and growth.

2.1. The energy-growth relationship

The previous literatures on the relationship between energy and growth have shown divided results on the causal relationship between energy and economic growth. Findings by (Altinay & Karagol, 2005; Cheng, 1997; Masih & Masih, 1996; Narayan & Smyth, 2005; Odhiambo, 2009; Soytas & Sari, 2003; Squalli, 2007; Stern, 2000) support the growth hypothesis of unidirectional causality. The results mean that energy consumption leads the way for economic growth. Other findings supported the conservative hypothesis of unidirectional causality. The findings of (Ghali & El-Sakka, 2004; Kahsai, Nondo, Schaeffer, & Gebremedhin, 2012; Wolde-Rufael, 2009) show that the causal relationship between both variables is conservative. Similar result was found by (Ouedraogo, 2013) in the study of ECOWAS countries. The conservative hypothesis states that economic growth leads the way for energy consumption. Thus, conserving energy for any purpose will not reduce the rate of growth of an economy.

Furthermore, the feedback hypothesis, which holds that the causal relationship between energy consumption and economic growth is bidirectional. In other words, each variable affects the other. The findings by (Akinlo, 2008; Alam, Hassan, & Haque, 2013; Atems & Hotaling, 2018; Belke, Dobnik, & Dreger, 2011) confirms the feedback hypothesis. Results of study by (Coers & Sanders, 2013; Costantini & Martini, 2010) shows similar feedback effect. This mean that both economic growth and energy work together overtime. As energy is causing growth, growth is also causing energy. Hence, the reason for the term feedback.

Lastly, is the neutrality hypothesis which states that there is no nexus between the two variables. The neutral effect indicates that electricity consumption does not lead economic growth and vice versa. The implication of neutral hypothesis is that there is no or minor role of electricity consumption in stimulating economic growth. In such circumstances, energy conservation policies are suitable because they have no adverse effect on economic growth. Similar can be said about the conservation theory. Studies by (Chontanawat, Hunt, & Pierse, 2008; Śmiech & Papiez, 2014; Wolde-Rufael, 2009) have so far validated the hypothesis.

Studies conducted on Nigeria have yielded mixed results mostly resulted in negative relationship. In a study conducted on Sub-Saharan regions, (Akinlo, 2008; Richard, 2012) validates the neutrality assumption. In another study by (Akinlo, 2009), conducted on Nigeria, the results was found to support growth hypothesis.

2.2. The government expenditure-growth relationship

Literatures on the nexus between both government expenditure and economic growth are uncountable. Empirical studies have been done testing the validity of Wagner's or Keynesian law of public expenditure. The results so far, have mixed just like economic growth and energy nexus. (Singh & Sahni, 1984) empirical study on the causal link between government expenditure and national income for India shows a feedback relationship which neither confirms Wagner nor Keynes theories. In a cross-country analysis by (Afxentiou & Serletis, 1996) and (Ansari, Gordon, & Akuamoah, 1997), their results found evidence supporting the |Keynes theory and not the Wagner's law Similar result was found by (Abizadeh & Yousefi, 1998). Contrary to Keynes proposition, of the G7 countries examined by (Bohl, Bohl, & T, 1996) found that Wagner's law was valid only United Kingdom and Canada. (Zaman, Khan, Ahmad, & Khilji, 2011) analysis demonstrates that, in the long run, Wagner's Law does not hold in Pakistan.

On studies done about Nigeria, (Oyinlola & Akinnibosun, 2013), validates the Wagner law for long run, while (Fatai, 2015), (Ighodaro & Oriakhi, 2010) confirmed the validity of Keynesian law of public expenditure. Furthermore, a bi-directional causality between government expenditures and economic growth was the results for both short run and long run by (Philip Ifeakachukwu & Ditimi, 2012). With the studies done so far, evidences have shown that the nexus between government expenditure and economic growth remain unresolved. So also, are the results presented about Nigeria.

3. Data, Methodology and Results

3.1. Data Source

This data used in our study is an annual data for the period of 1980-2014. We chose Nigeria because of its status as the biggest economy in Africa after it rebased its gross domestic product (GDP) data in 2014. With its huge population, Nigeria is ironically one of the smallest consumers of energy in the world. However, there have been tremendous changes lately since the beginning of millennium. The total electric power consumption of Nigeria has significantly increased by 178.38 KWh per capita within 2000 to 2013 (Kanya, Golit, Hilili, Uba, & Ochu, 2015). We obtained the energy (electric power) consumption data, denoted as "EGY" and measured in KWh per capita from World Bank Development Indicators. Similarly, we obtained general government final consumption expenditure[3] (percentage of GDP), represented by "GXT", while economic growth, proxy by GDP per capita growth (annual percentage), and represented by "GDP" from the same source. The oil prices (in U.S. dollars per barrel), were however, obtained from OPEC; IEA data source 2018, and it is denoted as "OIL".

3.2. Methodology

In this section, we first tested the unit roots of all our variables to know whether they are all I(0) or I(1) before mechanically starting our study. We used Augmented Dickey-Fuller (ADF), Phillips-Peron (PP) to test for stationarity of our variables. We found using ADF and PP that all our variables can be taken as I(1), while using KPSS, we found that all the variables can be taken as I(0). Due to the nature of our data, an annual time series data, the a priori result of the order of VAR is one or two. However, the result came out to be zero, thereby making results of the next test for cointegration using Engle-Granger and Johansen-Julius to be inflated. This necessitates the use of Autoregressive Distributed Lag (ARDL) because it chooses the appropriate lag order for each variable. Furthermore, the fact that ARDL does not require all the variables to be I(0) or I(1) makes its use justified in checking for cointegration of the variables. We estimated the long run coefficient of our variables using the ARDL long run estimation procedure. The F-Statistic upper and lower bounds approach is used. This, in order to make the coefficients of cointegrating vector consistent with the theoretical and a priori information of the economy.

The adopted NARDL model can be represented as thus:

$$GDP_t = \alpha_0 + \alpha_1 EGY_t^+ + \alpha_2 EGY_t^- + \alpha_3 GXT_t^+ + \alpha_4 GXT_t^- + \alpha_5 OIL_t^+ + \alpha_6 OIL_t^- + e_t \quad (1)$$

[3] General government final consumption expenditure includes all government current expenditures for purchases of goods and services (including compensation of employees). It also includes most expenditures on national defense and security but excludes government military expenditures that are part of government capital formation – Note from the data source.

and

$$EGY_t^+ = \sum_{i=1}^t \Delta EGY_t^+ = \sum_{i=1}^t \max(\Delta EGY_i, 0) \tag{2}$$

and

$$EGY_t^- = \sum_{i=1}^t \Delta EGY_t^- = \sum_{i=1}^t \min(\Delta EGY_i, 0) \tag{3}$$

and

$$GXT_t^+ = \sum_{i=1}^t \Delta GXT_t^+ = \sum_{i=1}^t \max(\Delta GXT_i, 0) \tag{4}$$

and

$$GXT_t^- = \sum_{i=1}^t \Delta GXT_t^- = \sum_{i=1}^t \min(\Delta GXT_i, 0) \tag{5}$$

and

$$OIL_t^+ = \sum_{i=1}^t \Delta OIL_t^+ = \sum_{i=1}^t \max(\Delta OIL_i, 0) \tag{6}$$

and

$$OIL_t^- = \sum_{i=1}^t \Delta OIL_t^- = \sum_{i=1}^t \min(\Delta OIL_i, 0) \tag{7}$$

Though, the ARDL cointegration test seems to be more robust in comparison to both Engle-Granger and Johansen tests, its linearity and symmetry assumptions from OLS regression exposes the results to certain limitations. Hence, the motivation for using the recently proposed nonlinear and asymmetric cointegration test developed by (Shin et al., 2014). We used it to examine the long run and short run asymmetry, and the positive and negative effects. In order to capture the nonlinear and asymmetric cointegration between the variables used in this study, we choose to use the multivariate nonlinear ARDL (NARDL) bounds testing approach developed by (Shin et al., 2014). Besides, NARDL makes distinction between the short-term and long-term effects of the independent variables on the dependent variable.

These tests can also be conducted using a nonlinear threshold Vector Error Correction Model (VECM) or a smooth transition model. However, the convergence problem due to the proliferation of the number of parameters that these models suffer from is a limitation to these models. This problem is not present in NARDL, unlike other error correction models that require the integration order of the considered time series to be same. In NARDL model this restriction is relaxed, thereby allowing for a combination of different integration orders. Lastly, this method chooses appropriate lag order for the variables, thereby solving the issue of multicollinearity. The NARDL model is represented as presented below:

$$\Delta GDP_t = \beta_0 + \beta_1 GDP_{t-1} + \beta_2 EGY^+_{t-1} + \beta_3 EGY^-_{t-1} + \beta_4 GXT^+_{t-1} + \beta_5 GXT^-_{t-1} + \beta_6 OIL^+_{t-1} + \beta_7 OIL^-_{t-1} + \sum_{i=1}^{p} \varphi_i \Delta GDP_{t-i} + \sum_{i=0}^{q} (\theta_i^+ \Delta EGY^+_{t-i} + \theta_i^- \Delta EGY^-_{t-i}) + \sum_{i=0}^{q} (\theta_i^+ \Delta GXT^+_{t-i} + \theta_i^- \Delta GXT^-_{t-i}) + \sum_{i=0}^{q} (\theta_i^+ \Delta OIL^+_{t-i} + \theta_i^- \Delta OIL^-_{t-i}) + u_t \quad (8)$$

Evidence of cointegration fall short of informing us about leading and lagging variables, hence, we proceed to ARDL Error-Correction Model to show us the Granger causality. However, ARDL ECM is able to show which of the variables is exogenous, and which is endogenous, it fails to tell us about relative exogeneity and endogeneity of the variables. Variance Decomposition (VDC) technique is designed to indicate the relativity of variables in terms of exogeneity and endogeneity, so that there can be decomposition of variance of the forecast error of a variable into proportions attributable to shocks in each variable in the system, including its own. We equivalently represent our VDC results by Impulse Response Functions (IRFs) to map out the dynamic response path of a variable because of one-period standard deviation shock to another variable. Finally, we used Persistence Profiles (PP) to estimate the speed at which the variables return to equilibrium when there is a systemwide shock to the long-run equilibrium.

3.3. Discussion of Results

Table 1

Descriptive Statistics								
Variable	Obs	Mean	Std. Dev.	Min	Max	Variance	Skewness	Kurtosis
Oil	35	39.91829	30.60118	12.28	109.45	936.4322	1.225062	3.080742
EGY	35	100.0509	26.99116	50.87268	156.733	728.5229	0.5224593	2.317723
GDP	35	1.068435	7.475691	-15.45478	30.35658	55.88596	1.16116	8.617316
GXT	35	9.671695	3.658985	4.833249	17.94384	13.38817	0.5209461	2.039963

From the descriptive statistic table, our highest standard deviation is oil prices. This means oil prices is the most volatile among our variables, while government expenditure (GXT) is the least volatile of the variables. This suggests that GXT has been stable while oil prices have not over years

Unit Root Tests

Table 1 shows that we test the variables' for stationarity properties to ensure that none is integrated at order 2 or I(2). We performed the tests because the NARDL model proposed by (Shin et al., 2014) requires that the variables be integrated at orders 0 or 1 to examine the cointegration between the variables. As a result, we applied the Augmented Dickey–Fuller, Phillips–Perron (PP) and

Kwiatkowski–Phillips–Schmidt–Shin (KPSS) unit root tests, and these tests are presented in Table 1. The empirical evidence reported by the ADF unit root test shows that economic growth, energy consumption, government expenditure, and oil prices contain a unit root at levels associated with the intercept and trend. After being differenced once, the variables are found to be stationary, or integrated at order 1 using the highest Akaike Information Criterion (AIC) and Schwarz Bayesian Criterion (SBC). Similar results were generated by both PP and KPSS.

Augmented Dickey-Fuller Test

	VARIABLE	ADF	VALUE	T-STAT.	C.V.	RESULT
LOG FORM	LOIL	ADF(1)=AIC	- 0.5577	- 2.984	-3.573	Non-Stationary
		ADF(1)=SBC	- 3.2923	- 2.984	-3.573	Non-Stationary
	LEGY	ADF(1)=AIC	22.3559	- 1.778	-3.573	Non-Stationary
		ADF(1)=SBC	19.6214	- 1.778	-3.573	Non-Stationary
	LGDP	ADF(1)=AIC	-16.1854	- 4.681	-3.573	Stationary
		ADF(1)=SBC	-18.9200	- 4.681	-3.573	Stationary
	LGXT	ADF(4)=AIC	- 1.8155	- 5.158	-3.573	Stationary
		ADF(4)=SBC	- 6.6011	- 5.158	-3.573	Stationary

	VARIABLE	ADF	VALUE	T-STAT.	C.V.	RESULT
1ST DIFF. FORM	DOIL	ADF(1)=AIC	- 0.1110	- 5.434	-2.971	Stationary
		ADF(1)=SBC	- 2.1093	- 5.434	-2.971	Stationary
	DEGY	ADF(1)=AIC	21.2173	- 4.331	-2.971	Stationary
		ADF(1)=SBC	19.2190	- 4.331	-2.971	Stationary
	DGDP	ADF(5)=AIC	-14.0310	- 2.540	-2.971	Non-Stationary
		ADF(4)=SBC	-18.4179	- 5.556	-2.971	Stationary
	DGXT	ADF(4)=AIC	- 8.3032	- 3.179	-2.971	Stationary
		ADF(1)=SBC	-12.2261	- 4.114	-2.971	Stationary

Philip Perron Test

	VARIABLE	T-STAT.	C.V.	RESULT
PP LOG FORM	LOIL	- 1.888	-3.547	Non-Stationary
	LEGY	- 3.067	-3.547	Non-Stationary
	LGDP	- 6.493	-3.547	Stationary
	LGXT	- 1.926	-3.547	Non-Stationary

	VARIABLE	T-STAT.	C.V.	RESULT
PP 1ST DIFF. FORM	DOIL	- 6.184	-2.953	Stationary
	DEGY	- 9.707	-2.953	Stationary
	DGDP	-15.922	-2.953	Stationary
	DGXT	- 8.624	-2.953	Stationary

Kwiatkowski–Phillips–Schmidt–Shin (KPSS*)* Tests

	VARIABLE	T-STAT.	C.V.	RESULT
KPSS LOG FORM	LOIL	0.143	0.218	Stationary
	LEGY	0.124	0.218	Stationary
	LGDP	0.171	0.218	Stationary
	LGXT	0.209	0.218	Stationary

	VARIABLE	T-STAT.	C.V.	RESULT
KPSS 1ST DIFF. FORM	DOIL	0.291	0.377	Stationary
	DEGY	0.152	0.377	Stationary
	DGDP	0.203	0.377	Stationary
	DGXT	0.260	0.377	Stationary

Table 2 shows that our VAR lag order at highest AIC and SBC is zero, thus making subsequent results generated using the lag inflated. Our Engle-Granger and Johansen results, under Table 3 (cointegration tests), show that we have cointegration of long run relationship among the variables. The results by both Engle-Granger and Johansen are however, set aside for ARDL results because the results were generated using a zero-lag order at highest AIC and SBC values. As stated above, ARDL is more efficient because it selects appropriate lag for each of the variables.

Table 2

VAR Lag Order

Order	AIC	SBC	p-Value	C.V.
0	-12.23	-15.16	[.305]	5%

Table 3

Co-integration Tests

Engle-Granger Co-integration Results

	VARIABLE	ADF	VALUE	T-STAT.	95% C.V.	RESULT
LOG FORM	LOIL	ADF(1)=AIC	-13.0734	-2.5314	-4.4962	no cointegration
		ADF(1)=SBC	-14.4407	-2.5314	-4.4962	no cointegration
	LEGY	ADF(4)=AIC	15.0146	- 3.233	-4.4962	no cointegration
		ADF(5)=SBC	11.0058	-3.5499	-4.4962	no cointegration
	LGDP	ADF(1)=AIC	-18.4295	-4.5157	-4.4962	cointegration
		ADF(1)=SBC	-19.7968	-4.5157	-4.4962	cointegration
	LGXT	ADF(4)=AIC	-3.7552	-4.7607	-4.4962	cointegration
		ADF(4)=SBC	-7.1735	-4.7607	-4.4962	cointegration

Johansen Co-integration Results

Cointegration LR Test Based on Maximal Eigenvalue of the Stochastic Matrix

Null	**Alternative**	**Statistic**	**95% Critical Value**	**90% Critical Value**	**Result**
r = 0	r = 1	45.9075	31.79	29.13	1 cointegration at 5% CV
r<= 1	r = 2	20.7624	25.420	23.100	

Cointegration LR Test Based on Trace of the Stochastic Matrix

Null	**Alternative**	**Statistic**	**95% Critical Value**	**90% Critical Value**	**Result**
r = 0	r>= 1	78.4017	63	59.16	1 cointegration at 5% CV
r<= 1	r>= 2	32.4941	42.34	39.34	

In our ARDL model, we check for long run relationship among the variables by using F-Statistic upper and lower bounds approach[4]. Our results in the cointegration tests section, under ARDL results show that there is a long run relationship, in other words there is cointegration. Evidence of cointegration in our model implies that the relationship among the variables is not spurious, i.e., there is a theoretical relationship among the variables and that they are in equilibrium in the long run (although they could deviate from each other in the short run). Similarly, the evidence of a cointegrating relationship implies that there is a common force that brings economic growth, energy, government expenditure and oil prices together in the long term.

Nevertheless, to establish leading and following variables (cause and effect), which cointegration tests does not inform, we also employed the ARDL error-correction model approach. Our results in Table 4 show that Oil at the highest AIC and SBC is exogenous while others are endogenous. The p-values of all the endogenous variables are less than 5%, necessitating the rejection of the null of exogeneity. The p-value of oil is greater than 5%, hence, we fail to reject the null of exogeneity on oil. The implication is that oil prices leads, while others follow. This is not counter intuitive because

[4] If F-Statistic it is lesser than the lower bound, then we cannot reject the null of no long-run relationship among the variables. If greater than the upper bound, then we reject the null hypothesis. However, if the value falls in between the lower and upper bounds, then the result is inconclusive.

oil prices are determined globally, hence, the reason for its exogeneity. Other variables are endogenous because, directly or indirectly, the actions of policy maker tend to influence the outcome of these variables, as a result, they are endogenous to oil prices.

ARDL Results

ARDL Cointegration Test	ARDL	F-Statistic	95% Lower Bound	95% Upper Bound	Result
dLGXT	ARDL (AIC)	2.3876	3.6837	4.9636	No cointegrate
	ARDL (SBC)	2.3876	3.6837	4.9636	No cointegrate
dLGDP	ARDL (AIC)	6.1475	3.6917	5.0111	Cointegrate
	ARDL (SBC)	4.0793	3.6933	5.0246	Inconclusive
dLEGY	ARDL (AIC)	6.5781	3.6837	4.9636	Cointegrate
	ARDL (SBC)	4.9737	3.6837	4.9636	Cointegrate
dLOIL	ARDL (AIC)	1.2812	3.6837	4.9636	No cointegrate
	ARDL (SBC)	1.028	3.6837	4.9636	No cointegrate

NARDL Results

To capture asymmetry and nonlinear information in our data, we choose to use NARDL.

In summary, our results in (in Fig. 1) show that previous year shocks in GDP growth have significant negative impact on the future GDP growth. For energy it seems that positive and negative previous year shocks have significant impact on GDP growth of the country. However, the previous year negative shock in energy caused government expenditure to have a negative effect on the GDP. Similarly, a positive shock in the short run in EGY made both EGY and GXT combined to have a negative effect on GDP. While a change in the GDP will make the impact of both EGY and GXT combined on GDP to be positive impact. Finally, a negative shock in GXT will also make both EGY and GXT have negative impact on GDP.

Our results from fig. 2 show that Energy does not have any significant long run and short run asymmetry relationship with GDP. Similarly, there is no long run positive and negative effects. However, GXT display a significant long run asymmetry at 5%, long run positive effect at 10%. It also shows a negative long run effect on GDP at 5%, while there is short run asymmetry relationship between GXT and GDP. This means intuitively that both GDP and GXT are not moving at the same speed in the long run. GXT has both positive and negative effects on the GDP in the long run. The positive effect can be due to good administration and good institutions. Therefore, for the expenses of the government to have positive and meaningful impact on economic growth per capita of Nigeria, the policy makers need to have good, efficient and non-corrupt institutions put in place so that the positive impacts can be felt on GDP. While the negative effect can be because of poor governance and institutions that accommodate bureaucrats, or because of corruption.

Furthermore, when both variables are combined, they both show long run asymmetry relationship with GDP. While EGY shows at 10%, GXT shows at 5%. They both do not have long run effect and short run asymmetry relationship with GDP. However, GXT has a long run negative effect on GDP, while EGY does not have any long run effect. Both GXT and EGY combined, are not moving in the same direction as GDP and at the same speed. While the effect of GXT on GDP is negative in the long run when combined with EGY.

Fig. 1

Assymetric Impact of Energy and Gov't Expenditure on Economic Growth			
	Energy	***Gov't Expenditure***	***Energy and Gov't Expenditure***
GDP_{t-1}	-0.973*	-1.483**	-2.090***
	[0.35]	[0.42]	[0.44]
EGY_{t-1}^{+}	-0.064	-0.990	0.153
	[0.13]	[0.58]	[0.18]
EGY_{t-1}^{-}	-0.174	-1.334*	0.753
	[0.21]	[0.59]	[0.51]
ΔGDP_{t-1}	0.150	0.424	0.763*
	[0.27]	[0.32]	[0.29]
ΔGDP_{t-2}	0.028	0.190	0.487
	[0.22]	[0.20]	[0.23]
ΔEGY^{+}	0.250	-0.249	0.210
	[0.19]	[0.65]	[0.17]
ΔEGY_{t-1}^{+}	0.001	0.567	-0.141
	[0.21]	[0.74]	[0.27]
ΔEGY_{t-2}^{+}	0.124	0.261	0.225
	[0.19]	[0.75]	[0.18]
ΔEGY^{-}	-0.251	0.314	0.175
	[0.36]	[0.88]	[0.46]
ΔEGY_{t-1}^{+}	0.102	-0.142	-0.834*
	[0.31]	[0.91]	[0.35]
ΔEGY_{t-2}^{+}	0.272	0.535	-0.520
	[0.30]	[0.76]	[0.32]
GXT_{t-1}^{+}			-1.216
			[0.82]
GXT_{t-1}^{-}			-3.021**
			[0.82]
ΔGXT^{+}			0.104
			[0.56]
ΔGXT_{t-1}^{+}			0.779
			[0.78]
ΔGXT_{t-2}^{+}			0.174
			[0.70]
ΔGXT^{-}			-0.595
			[0.93]
ΔGXT_{t-1}^{-}			0.030
			[0.90]
ΔGXT_{t-2}^{-}			0.369
			[0.85]
Constant	-5.701	-9.976*	-9.851
	[5.33]	[4.66]	[12.85]
Observations	32	32	32
Adjusted R-squared	0.33	0.41	0.59
Log likelihood	-101.51	-99.37	-85.59

** p<0.05 ** p<0.1 *** p<0.01"*

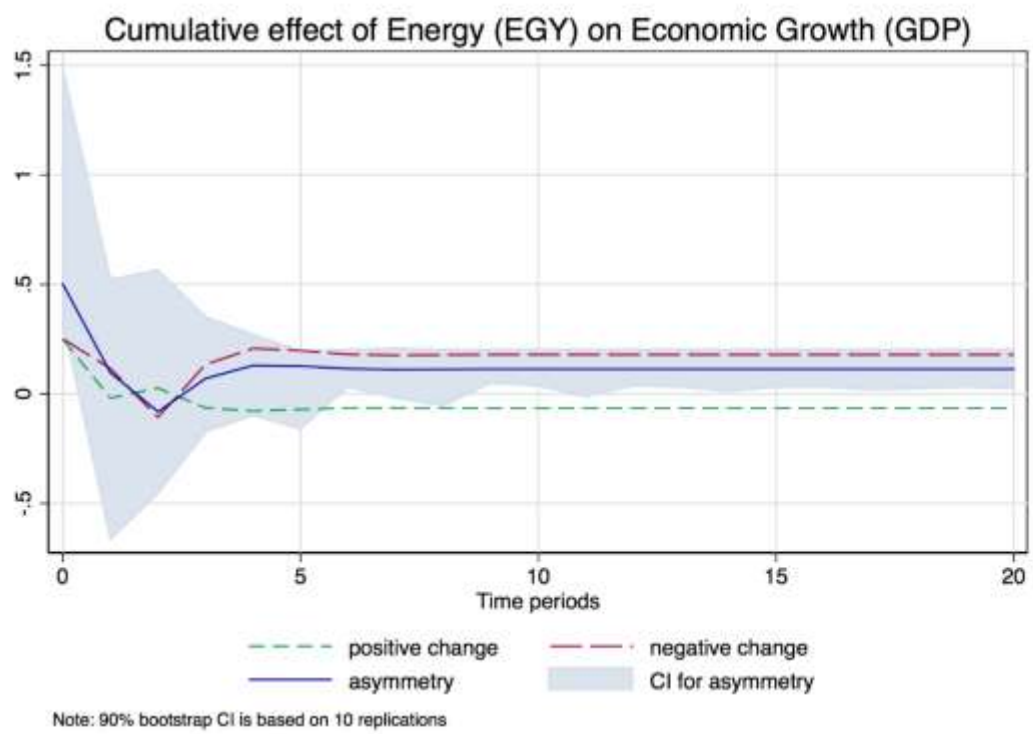
Pilot NARDL estimation for Nigeria (Energy and Government Expenditure)

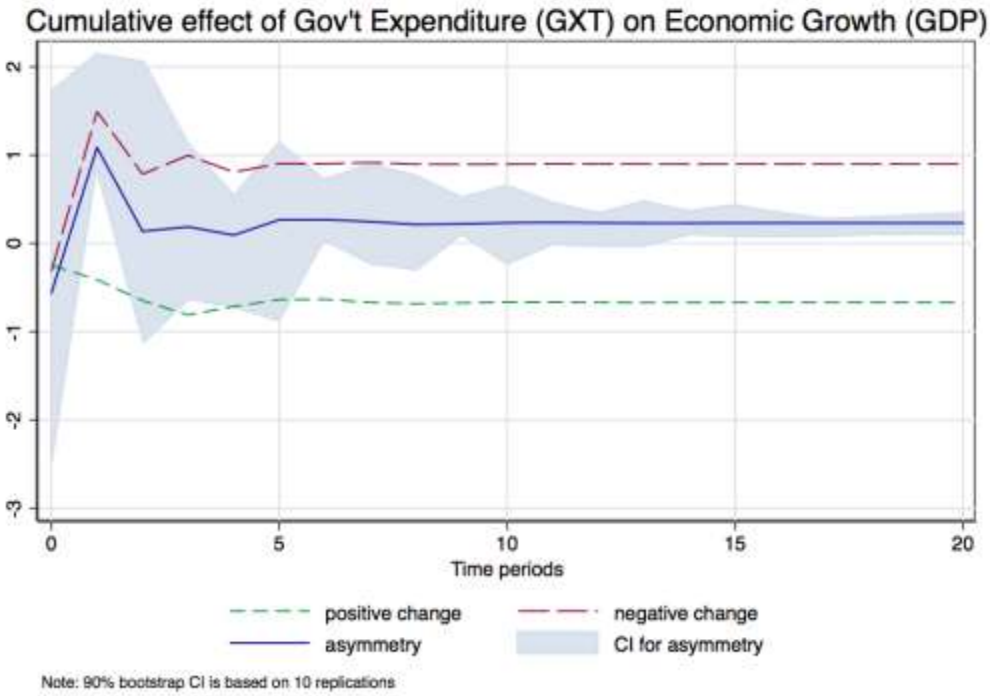
Fig. 2

Assymetry statistics: Impact of Energy and Gov't Expenditure on Economic Growth										
	Energy			***Gov't Expenditure***			***Energy + Gov't Expenditure***			
	Coefficient	***F-Stat***	***P>F***	***Coefficient***	***F-Stat***	***P>F***	***Coefficient***		***F-Stat***	***P>F***
Longrun Asymmetry		1.348	0.259		**7.773**	**0.011***	**EGY**		**3.847**	**0.073****
							GXT		**7.628**	**0.017***
Longrun Effect **[+]**	-0.066	0.2334	0.634	**-0.668**	**3.561**	**0.074****	EGY	0.073	0.8451	0.376
							GXT	-0.582	2.154	0.168
Longrun Effect **[-]**	0.179	0.6259	0.438	**0.899**	**7.533**	**0.012***	EGY	-0.36	2.703	0.126
							GXT	**1.446**	**23.59**	**0***
Shortrun Asymmetry		0.1427	0.71		0.004163	0.949	EGY		2.586	0.134
							GXT		0.2348	0.637
Remarks	*Energy does not show significant longrun asymmetry, nor longrun positive and negative effect, and neither shortrun asymmetry.*			*Government Expenditure shows a significant long asymmetry, longrun positive and negative effect, but no shortrun asymmetry.*			*Combining both variables, they show significant long asymmetry, while Government Expenditure shows a negative longrun effect on*			
** p<0.05 ** p<0.1 *** p<0.01"*										
Pilot NARDL estimation for Nigeria (Energy and Government Expenditure)										

Fig. 3

The images of our dynamic multipliers.




Cumulative effect of Gov't Expenditure (GXT) on Economic Growth (GDP)
Time periods
positive change
negative change
asymmetry
CI for asymmetry
Note: 90% bootstrap CI is based on 10 replications

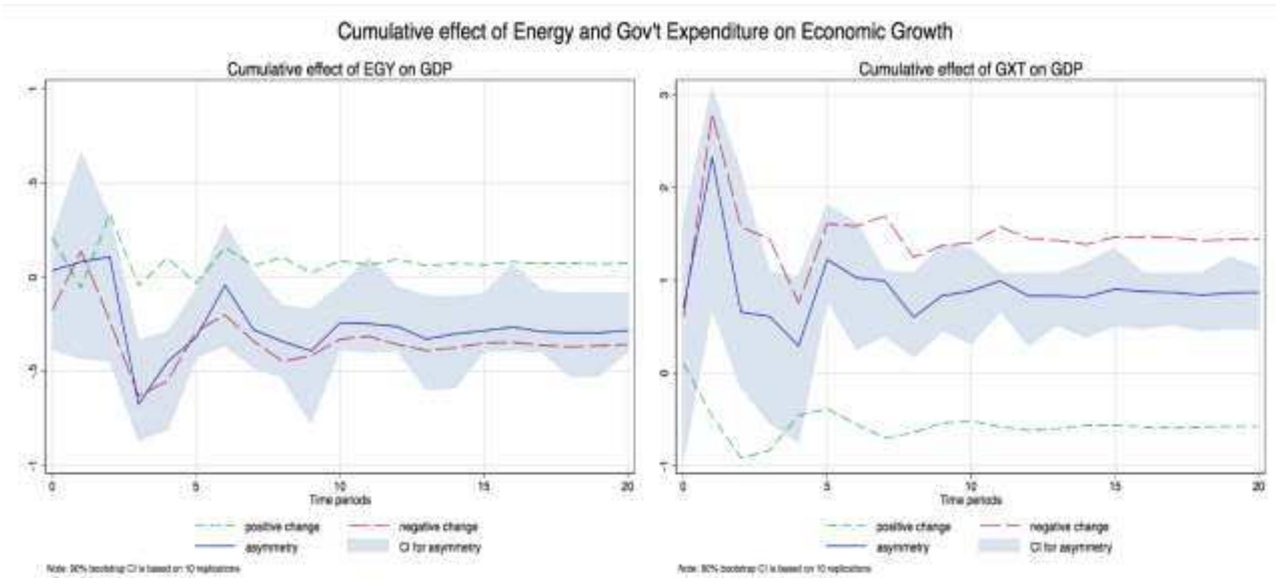

Cumulative effect of Energy and Gov't Expenditure on Economic Growth
Cumulative effect of EGY on GDP
Cumulative effect of GXT on GDP
Time periods
positive change
negative change
asymmetry
CI for asymmetry

Table 4

ARDL Error Correction Model

ecm1(-1)	ARDL	Coefficient	Standard Error	T-Ratio [Prob.]	C.V.	Result
dLGXT	ARDL (AIC)	-0.38715	0.16246	-2.3830[.024]	5%	Endogenous
	ARDL (SBC)	-0.38715	0.16246	-2.3830[.024]	5%	Endogenous
dLGDP	ARDL (AIC)	-1.2904	0.27422	-4.7058[.000]	5%	Endogenous
	ARDL (SBC)	-1.3831	0.4258	-3.2481[.006]	5%	Endogenous
dLEGY	ARDL (AIC)	-0.62063	0.12359	-5.0218[.000]	5%	Endogenous
	ARDL (SBC)	-0.54692	0.12566	-4.3523[.000]	5%	Endogenous
dLOIL	ARDL (AIC)	-0.18866	0.10912	-1.7289[.095]	5%	Exogenous
	ARDL (SBC)	-0.15626	0.10953	-1.4266[.165]	5%	Exogenous

Variance Decomposition Results

While the ARDL ECM tests informs us about exogeneity and endogeneity of variables, it does not tell us the relativity of exogeneity and endogeneity of each variables to know how they rank in order. To do this, we adopt Variance Decomposition approach to know the relative exogeneity of the variables. The results from orthogonalised VDC are not reliable because it tends to be biased toward the order of variables, hence, we use generalized approach to determine the ranking of our variables. The normalized generalized approach made GXT to be the most exogenous variable at three, six, nine and twelve horizons. EGY follows, while Oil is third, and GDP is the last in the order. The reason for Oil prices to rank third in the order can be explained by the fact that major corruption cases in Nigeria have been through the oil sector. Therefore, it is of no surprise that the impact of oil is not felt on the GDP of the country. GXT leads the way because most of goods and services produce in Nigeria have been government driven through its expenses and policies. Energy leading GDP means that the result supports the growth hypothesis of unidirectional causality by (Altinay & Karagol, 2005; Cheng, 1997; Masih & Masih, 1996; Narayan & Smyth, 2005; Odhiambo, 2009; Soytas & Sari, 2003; Squalli, 2007; Stern, 2000)**.** Similarly, the result validates the Keynes argument that government expenditure leads the way for economic growth. This result is in congruence with the findings of (Fatai, 2015), (Ighodaro & Oriakhi, 2010).

Table 5

Orthogonalised VDC

Variable	Horizon	LGXT	LGDP	LEGY	LOIL	Total
GXT	3	87.26%	0.97%	0.48%	11.29%	100.00%
GDP		20.59%	54.03%	16.76%	8.62%	100.00%
EGY		0.86%	12.36%	85.21%	1.57%	100.00%
OIL		10.29%	16.60%	1.98%	71.13%	100.00%
Exogeneity		**87.26%**	**54.03%**	**85.21%**	**71.13%**	
Rank		1	4	2	3	
Variable	**Horizon**	**LGXT**	**LGDP**	**LEGY**	**LOIL**	**Total**
GXT	6	85.89%	1.21%	0.51%	12.39%	100.00%
GDP		27.06%	46.79%	18.09%	8.06%	100.00%
EGY		0.99%	14.95%	82.13%	1.93%	100.00%
OIL		11.06%	17.78%	1.86%	69.29%	100.00%
Exogeneity		**85.89%**	**46.79%**	**82.13%**	**69.29%**	
Rank		1	4	2	3	
Variable	**Horizon**	**LGXT**	**LGDP**	**LEGY**	**LOIL**	**Total**
GXT	9	85.38%	1.31%	0.53%	12.79%	100.00%
GDP		31.85%	41.47%	18.98%	7.71%	100.00%
EGY		1.05%	16.01%	80.85%	2.09%	100.00%
OIL		11.35%	18.30%	1.80%	68.55%	100.00%
Exogeneity		**85.38%**	**41.47%**	**80.85%**	**68.55%**	
Rank		1	4	2	3	
Variable	**Horizon**	**LGXT**	**LGDP**	**LEGY**	**LOIL**	**Total**
GXT	12	85.11%	1.36%	0.54%	13.00%	100.00%
GDP		35.61%	37.27%	19.66%	7.46%	100.00%
EGY		1.08%	16.59%	80.16%	2.18%	100.00%
OIL		11.50%	18.59%	1.76%	68.15%	100.00%
Exogeneity		**85.11%**	**37.27%**	**80.16%**	**68.15%**	
Rank		1	4	2	3	

Generalised VDC (Unnormalized Result)

Variable	Horizon	LGXT	LGDP	LEGY	LOIL	Total
GXT	3	87.26%	0.67%	1.92%	4.63%	94.48%
GDP		20.59%	54.34%	22.85%	17.96%	115.74%
EGY		0.86%	12.49%	92.48%	3.05%	108.87%
OIL		10.29%	17.18%	0.37%	97.13%	124.98%
Exogeneity		**87.26%**	**54.34%**	**92.48%**	**97.13%**	
Rank		3	4	2	1	

Variable	Horizon	LGXT	LGDP	LEGY	LOIL	Total
GXT	6	85.89%	0.84%	1.99%	4.29%	93.01%
GDP		27.06%	47.11%	24.68%	15.66%	114.52%
EGY		0.99%	15.11%	90.63%	3.85%	110.58%
OIL		11.06%	18.41%	0.27%	96.86%	126.60%
Exogeneity		**85.89%**	**47.11%**	**90.63%**	**96.86%**	
Rank		3	4	2	1	

Variable	Horizon	LGXT	LGDP	LEGY	LOIL	Total
GXT	9	85.38%	0.90%	2.04%	4.12%	92.44%
GDP		31.85%	41.81%	25.93%	13.85%	113.44%
EGY		1.05%	16.19%	89.85%	4.19%	111.28%
OIL		11.35%	18.95%	0.23%	96.75%	127.28%
Exogeneity		**85.38%**	**41.81%**	**89.85%**	**96.75%**	
Rank		3	4	2	1	

Variable	Horizon	LGXT	LGDP	LEGY	LOIL	Total
GXT	12	85.11%	0.94%	2.06%	4.02%	92.13%
GDP		35.61%	37.62%	26.89%	12.43%	112.55%
EGY		1.08%	16.77%	89.43%	4.39%	111.66%
OIL		11.50%	19.25%	0.20%	96.70%	127.65%
Exogeneity		**85.11%**	**37.62%**	**89.43%**	**96.70%**	
Rank		3	4	2	1	

Generalised VDC (Normalised)

LGXT	LGDP	LEGY	LOIL	Total
92.36%	0.71%	2.04%	4.90%	100.00%
17.79%	46.95%	19.75%	15.51%	100.00%
0.79%	11.47%	84.94%	2.80%	100.00%
8.23%	13.75%	0.30%	77.72%	100.00%
92.36%	**46.95%**	**84.94%**	**77.72%**	
1	4	2	3	

LGXT	LGDP	LEGY	LOIL	Total
92.34%	0.90%	2.14%	4.62%	100.00%
23.63%	41.14%	21.55%	13.68%	100.00%
0.90%	13.66%	81.96%	3.48%	100.00%
8.74%	14.54%	0.21%	76.50%	100.00%
92.34%	**41.14%**	**81.96%**	**76.50%**	
1	4	2	3	

LGXT	LGDP	LEGY	LOIL	Total
92.37%	0.98%	2.20%	4.45%	100.00%
28.07%	36.85%	22.86%	12.21%	100.00%
0.94%	14.55%	80.74%	3.77%	100.00%
8.92%	14.89%	0.18%	76.02%	100.00%
92.37%	**36.85%**	**80.74%**	**76.02%**	
1	4	2	3	

LGXT	LGDP	LEGY	LOIL	Total
92.38%	1.02%	2.24%	4.36%	100.00%
31.64%	33.42%	23.89%	11.04%	100.00%
0.96%	15.02%	80.09%	3.93%	100.00%
9.01%	15.08%	0.16%	75.75%	100.00%
92.38%	**33.42%**	**80.09%**	**75.75%**	
1	4	2	3	

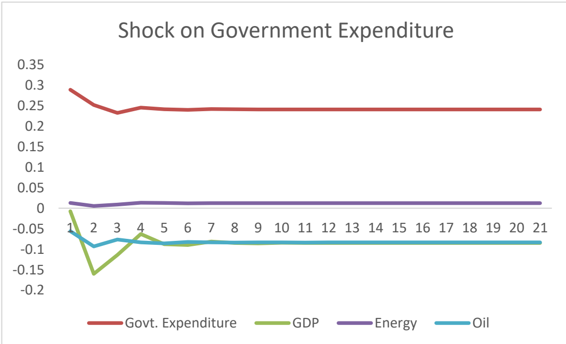
Granger Causality Chain

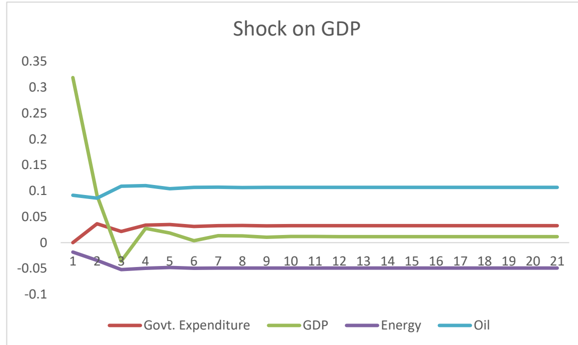
GDP	←	**OIL**	←	**EGY**	←	**GXT Exogeneity Order**

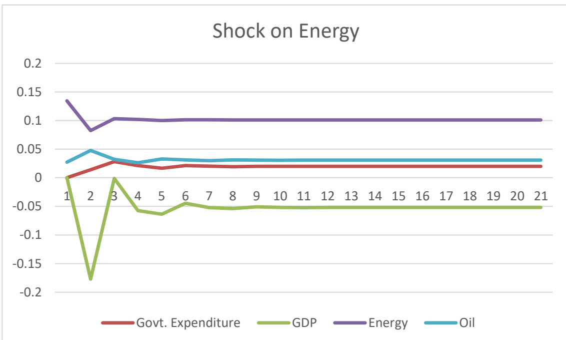
Table 6

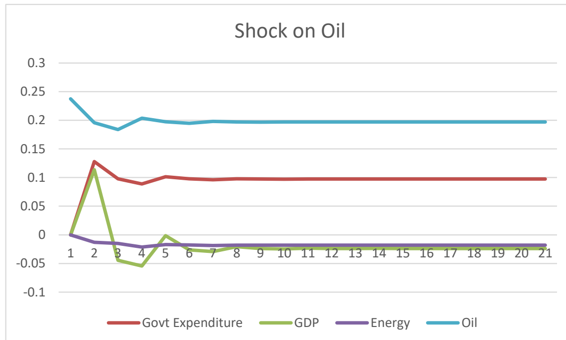
Impulse Response Function (IRF)

Orthogonalised IRF

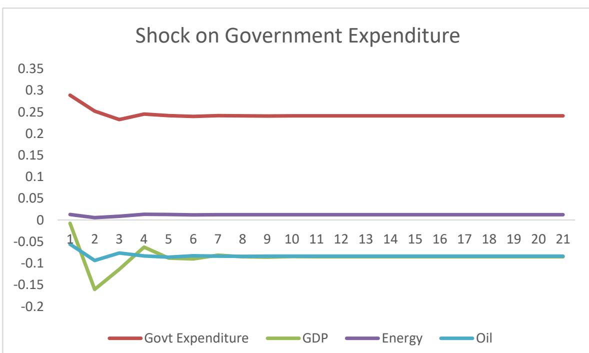


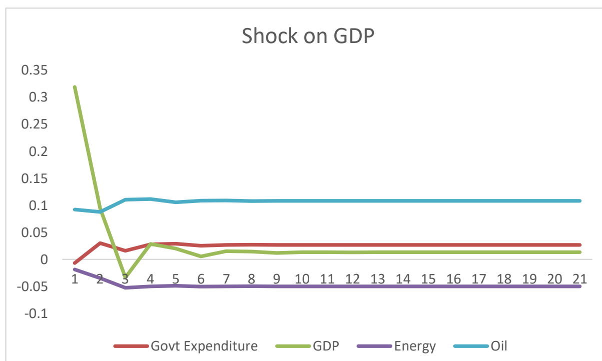


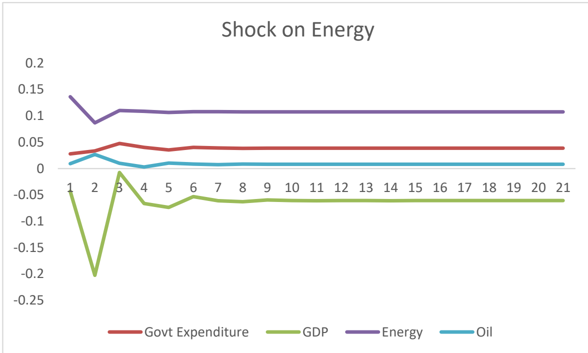


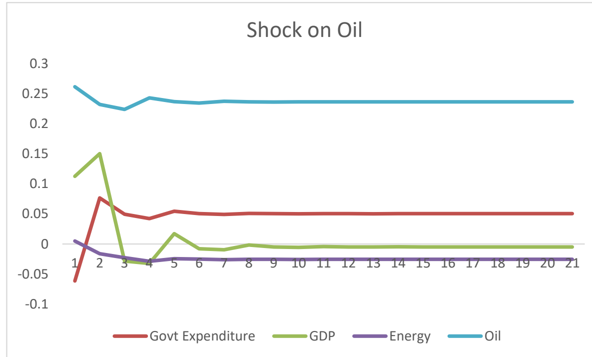


Generalized IRF





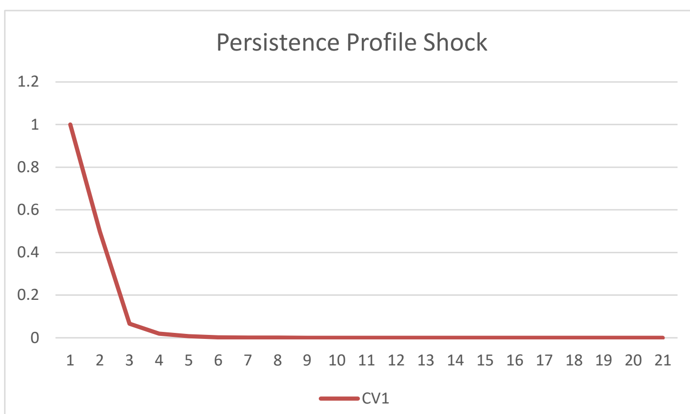




Using the IRF, to graphically represent our VDC results, we shock each variable to know how other variables respond to the shock. We applied both orthogonalised and generalized IRF. Though, our graphs look similar, they are however no the same, and preference is given to the generalized graphical representation because it is not bias towards the first variable in the order. A shock in GXT shows that it takes other variables an average of seven years before they are normalized. In a shock in GDP, while it took EGY about six years to normalize, GXT seven years, it takes OIL about nine years. EGY tend to affect the GDP significantly because it takes about fifteen years before it normalized, but other variables are quick to get normalized. A shock in OIL affects GXT more than other variables. Being an oil exporting country, which generates about 80% of its income from oil, it is not paradoxical that GXT is the most affected when there is a shock to oil prices.

Table 7

Persistence Profile



We apply persistence profile to know how long it will take the variables to return to equilibrium if there is a shock to the whole system. The results of our persistence profile show that any system-wide shock to the system will take the variables at least, six to seven years before they get back to equilibrium.

Robustness Check

For robustness check, we run LRSM to test for theoretical relationship. We equated GDP to one, then, restricted other variables. Our results show that PANEL B is the only incorrect restriction provided we reject the null of correct restriction at 5%. This shows that GXT is very important in driving forward economic growth of Nigeria.

LRSM

VRBL	PANEL A	PANEL B	PANEL C	PANEL D	PANEL E	PANEL F	PANEL G
LOIL	-0.16696	0.029508	0.025709	0.00	0.066589	0.00	0.00
	(.16986)	(.15152)	(.10446)	(*NONE*)	(.11209)	(*NONE*)	(*NONE*)
LEGY	0.8833	0.19789	0.00	0.44854	0.00	0.26401	0.00
	(.57197)	(.51634)	(*NONE*)	(.33977)	(*NONE*)	0.39695	(*NONE*)
LGDP	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
	(*NONE*)	(*NONE*)	(*NONE*)	(*NONE*)	(*NONE*)	(*NONE*)	(*NONE*)
LGXT	0.45673	0.00	0.25983	0.32831	0.00	0.00	0.27117
	(.19817)	(*NONE*)	(.15136)	0.14419	(*NONE*)	(*NONE*)	0.14573
Trend	-0.024023	-0.02082	-0.016383	-0.024702	-0.018761	-0.020443	-0.014796
	(.0092121)	(.010354)	(.0081404)	(.0086888)	0.0088371	0.010368	0.0051132
CHSQ(1)	NONE	5.1386[.023]	2.7404[.098]	1.1173[.291]	5.2925[.071]	5.1753[.075]	2.7997[.247]

s.e. in parentheses

VECM

ecm1(-1)	Coefficient	Standard Error	T-Ratio [Prob.]	C.V.	Result
DLGXT	-0.065583	0.1387	-.47284[.640]	5%	Exogenous
DLGDP	-1.1108	0.15311	-7.2549[.000]	5%	Endogenous
DLEGY	-0.11656	0.065418	-1.7817[.086]	5%	Exogenous
DLOIL	0.13265	0.12567	1.0555[.301]	5%	Exogenous

Similarly, we check for the causality among our variables using VECM approach different from ARDL approach of error-correction model. Our results also show oil prices as an exogenous variable, while GDP remain endogenous. This confirms our results using ARDL approach that both oil prices and GDP are exogenous and endogenous respectively.

4. Conclusion and policy implications

In this study, we examined the relationship between economic growth, energy consumption, and government expenditure, by incorporating oil prices into the Nigerian economy. The study used annual data for period 1980-2014. The asymmetric nexus between the variables was investigated through the nonlinear and asymmetric ARDL cointegration approach developed by (Shin et al., 2014). The empirical results provide strong support for the presence of an asymmetric cointegration association between the variables under study. With energy consumption leading the way for economic growth, our study supports the growth hypothesis. From the results, policy makers need to ensure that energy production is increased and made available to every populace to enhance the growth of the economy. Our results for government expenditure also show that economic growth is dependent on government expenditure as hypothesized by Keynes law. Therefore, policy makers must ensure that government expenditure is kept stable over time to avoid any negative impact on the economic growth of Nigeria.

In summary, from our findings, answers to our objectives can be stated below:

1) There is relationship between energy and economic growth in Nigeria. An answer to our first objective.

2) There is relationship between government expenditure and economic growth in Nigeria. An answer to our second objective.

3) When energy and government expenditure are both prioritized jointly there is relationship between them and economic growth in Nigeria. An answer to our third objective.

5. Limitations and Futures

This study only used 35 years period of observation, hence, the results generated in this study can be bias as a result of few samples of observation. Though, the NARDL approach has been used by this study, there is need for further use of other techniques that can predict the relationship that exists among the variables in Nigeria. Likewise, there is need to use the NARDL and other sophisticated techniques in extending literatures on Sub-Saharan African (SSA) countries. Previous studies on SSA so far have fall short of using the recently developed NARDL and other advanced techniques.

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