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ENERGY CONSUMPTION AND ECONOMIC GROWTH NEXUS: A RE-EXAMINATION OF CAUSAL EVIDENCE IN NIGERIA

Abiodun Adewale Adegboye[1]
Obafemi Awolowo University, Nigeria

Ifeoluwa Bolanle Babalola
National Youth Service Corps, Nigeria

Abstract

The paper asks whether regime shift has influenced causal relation between energy consumption and economic growth in Nigeria. Accounting for structural break in an autoregressive distributed lag cum error correction model the results indicates that there is unidirectional relation from energy consumption to growth in Nigeria. Also, government type has positive but statistically insignificant influence in the relationship, and that the economy shows high speed of adjustment from disequilibrium. Besides the causal relation between sectoral outputs and energy consumption tend to be similar and do not reveal any significant different pattern of behaviour. Essentially, energy consumption and growth nexus in Nigeria does not suggest any time-variation.

JEL Classification Code: O13, Q41, Q43

Keywords: Growth, Energy, Nigeria, Regime, Causality.

1. Introduction

The Nigerian economy was classified as part of the lower income group before 1999. However, as at end of 2015, the International Monetary Fund (IMF) and World Bank classifications have reported some African nations including Nigeria to have transited to a middle-income group, thus suggesting serious implications for understanding the nexus between consumption, production and output growth. Studies on energy-growth relationship have occupied the centre of discussions among policymakers and academics in the last three to four decades. Since the pioneer work of Kraft and Kraft (1978), a large array of literature has provided evidence on the nature (and effects) of the relationship between energy use and economic activity, as well as whether causal relation and long run equilibrium exist between them.

[1] Correspondence to Abiodun Adewale Adegboye, Email: walelife@yahoo.co.uk

Studies by Ozturk (2010), Eggoh, Bangake & Rault (2011) and Omri (2014), provide comprehensive survey of literature on energy-growth nexus. The available empirical evidence is mixed and inconclusive. Concerning direction of causality, there are evidences of unidirectional, bidirectional and or neutral causality. In Nigeria, in recent time, economic growth rate has consistently maintained an upward trend similar to energy demand (see Figures 1 and 2). However existing empirical studies do not provide a unique pattern of causation. A study by Olayeni (2012) for instance suggests that there is no unique way to formulate energy policy decisions due to varying findings that still permeate the literature. One main deficiency in existing studies is that the potential effect of governance or regime type in modelling energy-growth relationship has largely been omitted. Coincidentally, Omri (2014) attributes lack of consensus in literature on energy-growth nexus to many factors including different political and institutional arrangements across various economies. Investigating the nature of causality between energy usage and economic activity in a model that controls for regime change could possibly provide new, additional and useful insights in the relationship, thereby impacting policy choices.

The imperative of establishing clear relationship, including nature of and the direction of causality, between energy demand and economic growth are in many folds. First, Nigeria has been on the move to attract more investments to facilitate production and creation of employments for its teeming unemployed youth. This means that an increase in growth, realized due to increased investment, would increase energy usage, and thus, affirming the growth-led hypothesis. Second, uncertainty associated with energy (price, production and politics) in recent time is more pronounced than before. For instance, uncertainty is reflected in the dwindling global crude oil demand and price, among others. Nigeria depends primarily on crude oil proceeds to implement at least sixty-five per cent of her annual budget. Hence, consideration of energy-related matters becomes vital to explaining the real economy in Nigeria. Therefore, a study such as the present could shed light on energy policy direction. Thirdly, sustained low capacity utilization in Nigeria in the industrial sector has been attributed to the inadequate energy supply (electricity in particular). Power generation is not only insufficient but also epileptic where it is available. Also, the prevalent high cost of production has been argued to generate unfavourable energy (pricing) policies and regulation in some cases.

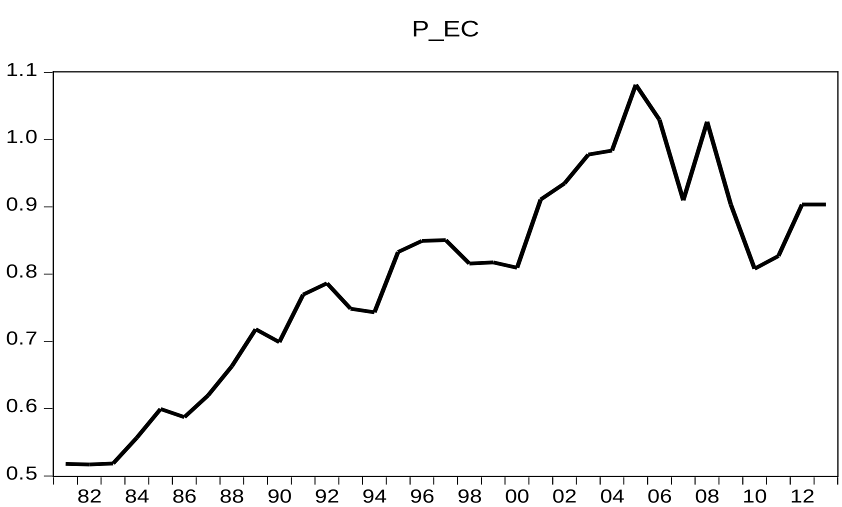

Figure 1: Total Primary Energy Consumption (P_EC) in Nigeria (1981-2013)

The growth of total primary energy consumption in Nigeria shows that it increased initially from 1981-1983, and since 1983, it has been fluctuating over time.

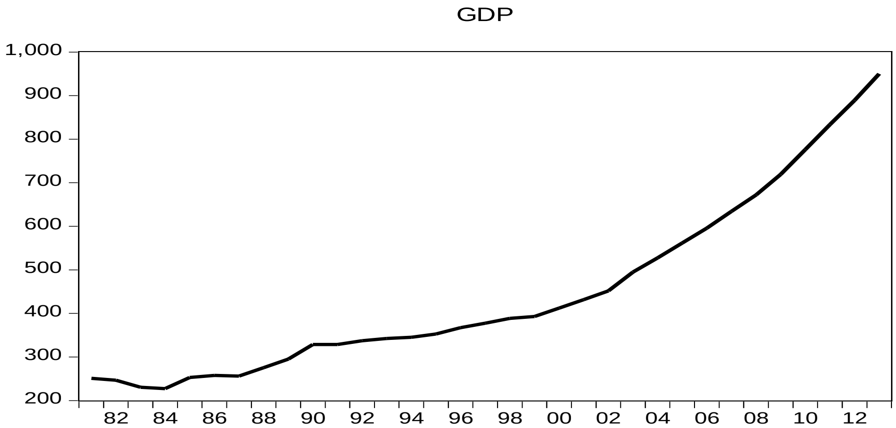

Figure 2: The Trend of Economic Growth in Nigeria (1981-2013)

A cursory look at Figures 1 and 2 (even 3) reveals that real GDP has grown steadily from early 1980s till 2013, whereas energy consumption index fluctuates around an increasing mean up till 2004. Between 2005 and 2013 total energy consumption has assumed downward mean and fluctuating at the same time, around the mean.

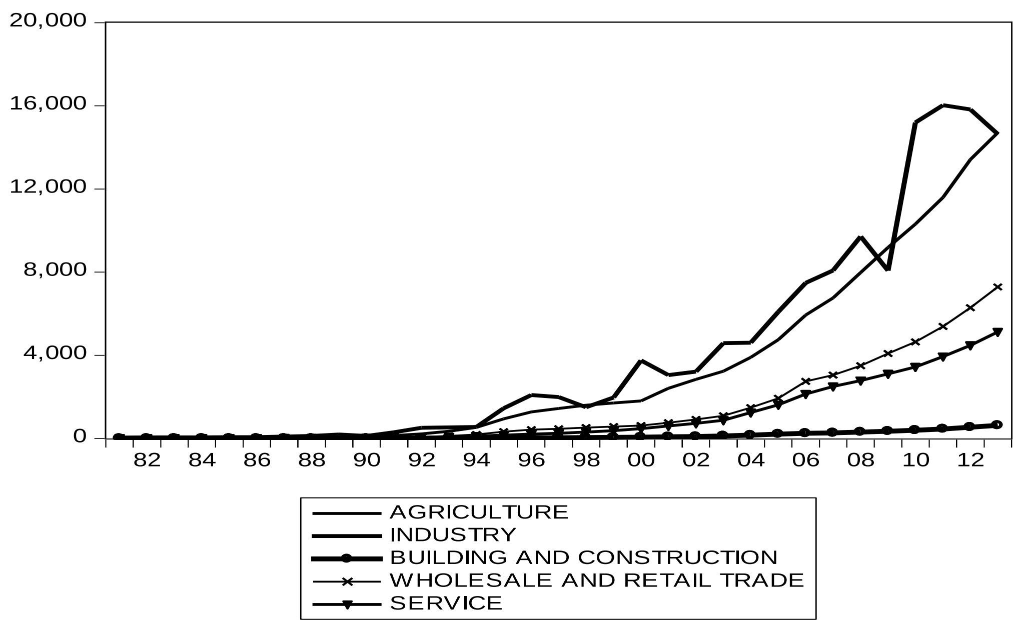

Figure 3: Growth in Real Sectors in Nigeria (1981-2013)

The implication is that the relationship between real GDP and energy may have changed over time due to a number of reasons. One factor that may have caused such is change in governance or regime shift, simply put. Huynh & Jacho-Chavez. (2009) and Qureshi, Khan, Rasli & Zaman (2015) and many other studies find that political regime has significant impact on economic growth, depending on its measure. After many years of military rule and political instability, Nigeria democratically elected a civilian government in May 1999 and since then, there have been smooth transitions, and five successive administrations have reigned in the country. The democratic experiences may have influenced reforms, including energy policies and regulations, which could alter energy-growth nexus. Therefore, the present study attempts to empirically re-examine the direction of causality between energy consumption and economic growth incorporating regime change as an exogenous structural break.

The reminder of the paper is organized as follows: Section 2 contains an overview of the energy sector and Section 3 presents brief recent empirical literature. In Section 4, we discuss the methodology while results of data analysis and discussions of findings are in Section 5. Section 6 concludes.

1.1. Overview of the Energy Sector in Nigeria

Nigeria is among the four largest economies in Africa and is endowed with abundant wealth of both natural resources (including energy), some of which have been discovered, exploited and explored over time, however some others still remain untapped. A number of energy resources, such as solar, are highly underexploited and also a large reserve of natural gas produced with crude oil are yet to be fully utilized. Nigeria is the continent’s most prolific oil-producing country, which along with Libya, Angola and Algeria accounts for well over two-thirds of Africa’s crude oil reserves. Moreover, Nigeria is also a leading nation in natural gas production.

In Nigeria, energy serves as the key source of wealth creation evident by being the nucleus of operations and engine of growth for most sectors of the economy such as the agricultural sector, the manufacturing sector, building & construction sector, wholesale & retail trade, and the service sector. The consumption of refined petroleum products, biomass, coal, oil & gas, diesel, petroleum, kerosene, solar power, wind power and electricity has dominated Nigeria’s energy consumption mix. The exploitation of the Nigerian energy resources began with coal in 1916 with almost three billion tons of indicated reserves in 17 identified coalfields particularly in the eastern part of the country, and over 600 million tons of proven reserves in Nigeria (Anaekwe, 2010). Coal is used by the railroad, the traditional metal industries, and by power plants to generate electricity. Coal was considered to be the major commercial fossil fuel used in Nigeria until the discovery of oil in commercial quantities in 1956 at Oloibiri, in the present Bayelsa State, which happens to be in the Niger-Delta area of Nigeria, the Africa's most populous.

Crude oil has been a dominant source of government revenue since the 1970s, and accounts for over 95% of governments’ export earnings and 40% of revenue inflows. Nigeria is a leading oil producer in Africa but militancy and oil theft in oil have adversely affected her production, which have resulted in unplanned power outages as high as 500,000 barrels per day (bbl/d).

Asides oil, natural gas also contributes significantly to the revenue in the Nigeria’s economy; which at present represents the mainstay of the economy. As cited in Akinlo (2008) the oil and natural gas industry accounts for 75% of government revenue and 95% of total export revenue. Nigeria had an estimated 180 trillion cubic feet (Tcf) of proved natural gas reserves as of January 2015. This made Nigeria the ninth-largest natural gas reserve holder in the world and the largest in Africa. Moreover, Inspite of huge gas reserves, Nigeria produced 1.35 Tcf of dry natural gas in 2013, ranking among the world's top 30 largest natural gas producers. However, natural gas production is constrained by the lack of infrastructure to store natural gas that is at present being flared. The natural gas industry is also affected by the same security and regulatory issues that affects the oil industry.

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Electricity is another dominant form of modern energy for telecommunications, information, technology, manufacturing, research & development and services. It is also required for basic developmental services like pipe borne water, health care and quality education. Electricity is generated through three major sources, which include hydro, thermal and fossils (see Akinlo, 2009). The electricity generation in Nigeria began as far as 1920. By 1968, the first hydro power station (in Kainji, Niger State) was built. This power plant was centrally located with grid extension (132KV line) to other locations. During this period, the Nigeria Electric Power Authority (NEPA) by virtue of the NEPA Act had monopoly of generation, transmission and distribution of electricity. In 2001, the government embarked on reforms in the power sector, some of which include removal of the monopoly status of the NEPA, and approval of private sector participation in the power sector. This reform necessitated the development of the National Electric Power Policy in September 2001 and formulation, presentation and approval of the National Electric Power Act in 2003. Between 2005 and present, the Federal Government of Nigeria and some state governments, such as Lagos, Akwa-Ibom, Rivers etc. have implemented several independent power projects (IPPs) to boost energy production and supply in the country. However, various targets set for these projects were never met due to myriads of problems encountered - corruption, bureaucratic bottlenecks, inadequate gas supply and obsolete infrastructures (CREDC, 2007 and Vincent-Akpu, 2012).

Importantly, there has been an average upward trend in the generation and consumption of electricity in Nigeria across various segments. For instance, within the period of 1980 to 2005, electricity generation increased from 1000 to 3000 megawatts per hour while electricity consumption increased from over 500 to 1873 mega watt per hour in 2005 (Akinlo, 2009). In 2010, the value for electric power consumption in Nigeria was 21,624,000,000 Kwh. However, shortage in the supply of electricity relative to its demand makes electricity supply deficient, erratic and unreliable. In spite of being the energy giant of Africa, only about 40% Nigerians are connected to the energy grid and where available, often erratic in large part of the time (Aliyu, Ramli & Saleh, 2013).

The deficiency in the supply of electricity creates significant effects on the overall health of the economy. This includes weakening of the industrialization process, increase in production cost and its significant undermining effect on the effort to achieve sustained economic growth, the competitiveness of industries in domestic, regional and global markets (Nnaji, Uzoma & Chukwu, 2010). The inadequate supply of electricity also causes problems for the agricultural sector. Most irrigation lines are run by electricity, so when the source of power is cut out, the crop yield decreases (Kaseke & Hosking, 2013). The epileptic nature of electricity has also created additional demand for petrol (PMS) and kerosene (AGO) because the citizens have resulted to using generating sets and kerosene-powered equipments to provide energy for use at homes. In Nigeria, the shortfall of electricity leads to the overuse of generators for energy. It is estimated that about 30% of energy demand is met in this manner (US Energy Administration, 2013).

Furthermore, in the context of development, the United Nations Economic Commission for Africa, has cited the inadequate provision of energy services in Sub-Saharan Africa, as a limiting factor to economic growth and poverty alleviation efforts. Pre-dominantly, the rural and the urban poor population are without access to modern energy services; resulting in majority of the population living on less than $1 a day (GNESD, 2007). In order to meet daily energy needs,

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majority of the population relies on traditional biomass such as wood, agricultural residues and other primitive energy sources which amplify the problems of environmental and land degradation.

Therefore, based on the effects of the shortfalls in the energy sector, it is necessary for a country in pursuit of economic growth and development to take holistic efforts towards providing solutions to the various uncertainties that militates against the efficiency of the energy sector.

2. Theoretical Issue and Literature Review

The mainstream theories of economic growth pay little attention to the role of energy or other natural resources in promoting economic growth, despite significant attention given to it by economists. Following the theories on production and growth, the different points of view in the theoretical literature on the potential linkages that exist between energy and economic growth range from those that are purely based in the natural sciences (namely the physical theory), to those based in economics. There is also a trans-disciplinary field known as ecological economics which combines ideas in economics, natural sciences and other social sciences in understanding the nature, behaviour and dynamics of the economy-environment system. According to Stern (1993, 2000) the ecological economists' claim is that technological progress and other physical inputs are not likely substitute for energy. Belloumi (2009) reinforce this argument by stating that the ecological theorists have taken energy as the prime source of value because physical factors indeed depend on it. It thus implies that the growth-hypothesis is promoted above others. However, the endogenous growth theory stands out with a clear role that energy plays in the production function through technology and capital, thus supporting feedback hypothesis. The Romer’s model of growth emphasizes technical progress resulting from R&D investment, capital stock, and stock of human capital. Furthermore, it implicitly asserts that energy is a determinant of technology and necessary factor to ensure that technology is utilized. In essence, both ecological and endogenous theories reject the neutrality and conservation hypotheses as against the neoclassical growth theory.

Recent theories also emphasize the role of energy consumption and energy efficiency as important historical causes of growth. The Jevons' paradox proposes that as technology increases, the increase in efficiency with which a resource is used tends to increase (rather than decrease) the rate of consumption of that resource. These various theoretical insights have guided numerous empirical studies in energy-growth literature, and some evidences are discussed next.

Several empirical studies have attempted to examine the nexus between economic growth and energy use, since the pioneer work of Kraft and Kraft (1978) on the USA, and various conclusions have emerged. Notwithstanding, there is yet no consensus on the various aspects of the nature, effects and direction of causality in growth-energy relations. The main reasons for lack of consensus in the existing literature emanate from the methodical issues- including different econometric techniques employed, use of disaggregated components of energy consumption and/or economic growth, divergence across coverage such as country-specific, cross-country or panel studies, varying time scope and model specifications with(out) structural breaks (see Ozturk, 2010 and Eggoh, Bangake & Rault, 2011).

Following the extant literature, most empirical studies have been embarked upon to either identify the effect of energy consumption on economic growth (Olofin, Olayeni & Abogan, 2014; Kwakwa, 2012; Sari, Ewing and Soytas 2008; Odularu & Okonkwo, 2009) or examine the direction of causality between these two variables (Ucan, Aricioglu & Yucel, 2014; Abalaba &

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Dada 2013; Pereira & Pereira, 2010; Soytas & Sari, 2006; Lee, 2005; Yoo & Kim, 2006). Although, the background facts from these studies emphasized that there is a lack of consensus on the existence and direction of causality between energy demand and economic growth, it is observed that causality exists in the literature.

On the direction of causality between the two variables, four possible causal relations have been established in the literature. These include unidirectional causality from energy to growth (i.e. growth hypothesis) as found in Akinlo (2009), Narayan & Singh (2007), Altinay & Karagoal (2005), and from growth to energy (conservation hypothesis) as shown by Binh (2011), Yoo & Kim (2006), Kraft & Kraft (1978). Also, there is a two-way causation (feedback hypothesis) as in Kaplan et al (2011), Chen et al. (2007); and evidences of no causal pattern (neutrality hypothesis) were found in Ghaderi et al. (2006), and Zou & Chau (2006).

In addition, Soytas & Sari (2007) have explained that different economic structure of countries of investigation and that of consumption patterns as well as various sources of energy across economies would lead to variations in empirical findings. Moreover, the mixed results obtained have also been attributed to differences in the characteristics of countries in terms of energy supply and policy, political and economic history, political arrangement, culture and energy policy as well as data and methodologies adopted (Chen, Kuo & Chen, 2007). In order to provide further insight on the lack of consensus regarding causal pattern between energy consumption and economic growth in Nigeria, this study aims at re-investigating this relationship using an Autoregressive Distributed Lag approach to co- integration and the Granger -causality test. The approach allows multivariate analysis, as suggested in literature to avoid conflicting results (see Ozturk, 2010 and Omri, 2014). Moreover, the present study emphasizes the influence of political regime in the energy-growth nexus, in contrast to earlier studies in most countries developing including Nigeria.

In Table 1 there is a summary of recent studies on the direction of causality between energy and economic growth in Nigeria. The table shows the inconclusiveness in various results obtained.

Table 1: Related studies on energy consumption and economic growth in Nigeria

Akinlo (2008)	1980-2003	ARDL Granger causality based on VECM	No co-integration GNP---EC
Odularu and Okonkwo (2009)	1970-2005	Co-integration technique	Petroleum, coal, and electricity have positive relationship with economic growth
Wolde-Rufael (2009)	1971-2004	Multivariate modified Granger causality	GDP→EC
Esso (2010)	1970-2007 7 Sub-Saharan African countries: Cameroon Cote D'Ivoire Ghana Nigeria South Africa Congo	Gregory and Hansen's threshold co-integration, Toda and Yamamoto's Granger causality test	RGDP−−EC RGDP↔EC RGDP→EC RGDP−−EC RGDP−−EC RGDP→EC

Table 1. Cont.

Nwosa & Akinbobola (2012)	1980-2010	Engel-Granger co-integration technique Bi-variate VAR model	No co-integration Service output→EC Agricultural output↔EC
Abalaba and Dada (2013)	1971-2010	Johansen cointegration test and ECM	EC→EG
Onakoya *et. al.* (2013)	1975-2010	Co-integration and ordinary least squares techniques	petroleum, electricity and the aggregate energy consumption have significant and positive relationship with economic growth
Mustapha and Fagge (2014)	1980-2011	Granger causality test, impulse response and variance decomposition analysis	GDP—EC
Ohwofasa *et. al.* (2015)	1980-2000	ECM, Threshold Co-integration	In the short-run: electricity, government expenditure, and investment exert positive impact on per capita income; export exert negative impact on per capita income. In the long run: there is no relationship between income and the explanatory variables.

Note:
1. GDP/GNP→EC means that causality runs from economic growth to energy consumption; EC→GDP/GNP from economic growth to energy consumption; GDP↔EC means that bidirectional causality; GDP----EC means that no causality.
2. ETC= Electricity; ARDL=Autoregressive Distributed Lag; VAR=Vector Autoregressive Model
VEC=Vector Error Correction Model; ECM=Error Correction Model

3. Methodology

3.1. Model specification

The standard growth theory as well as recent contributions clearly assigned important role to capital in the production function. Given that energy is considered as an intermediate input in production technology, an implicit model for the study, following growth model, is as follows

$$Y = F(K, L, E) \quad \text{(i)}$$

Where: Y= Output

K =Gross fixed capital formation

L =Labour force

E =Energy (TPE)

The econometric approach employed is autoregressive distributed lag (ARDL) co-integration test introduced by Pesaran et al. (2001) and Granger Causality test based on error correction model (ECM). By taking inference from existing empirical studies and various exposition of the growth theories, energy(TPE) is incorporated directly into the production function and by focusing on output, capital and energy variables only and abstracting from labour, the appropriate specification of the ARDL is as follows

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$$\Delta Y_{m,t} = \delta_{10} + \sum_{i=1}^{n} \alpha_{11} \Delta Y_{m,t-i} + \sum_{i=0}^{n} \alpha_{12} \Delta K_{t-i} + \sum_{i=0}^{n} \eta_{13} \Delta E_{t-i} + \sum_{i=1}^{n} \alpha Y_{m,t-1} + \sum_{i=0}^{n} \delta K_{t-1} + \sum_{i=0}^{n} \eta TPE_{t-1} + \varepsilon_t \quad \text{.... (2)}$$

The ARDL-ECM is sensitive to the unit root properties of the variables and on the existence of co-integration among them. However, if the variables are co-integrated, the model must include an error correction term which captures the disequilibrium or short-run dynamics of the long-run relationship among the variables. According to Engle and Granger (1987), Granger causality test which is conducted in the first differences of variables through a VAR model is misleading in the presence of co-integration. Thus, the ARDL-ECM is as follows

$$\Delta Y_{m,t} = \delta_{10} + \sum_{i=1}^{n} \alpha_{11} \Delta Y_{m,t-i} + \sum_{i=0}^{n} \alpha_{12} \Delta K_{t-i} + \sum_{i=0}^{n} \eta_{13} \Delta TPE_{t-i} + \sum_{i=1}^{n} \alpha Y_{m,t-1} + \sum_{i=0}^{n} \delta K_{t-1} + \sum_{i=0}^{n} \eta TPE_{t-1} + \lambda_1 EC_{h,t-1} + \mu_j \quad \text{............. (3)}$$

Where Ym,t = output (m=aggregate, service, building & construction, wholesale & retail, agriculture, industry)

Kt= gross fixed capital formation

TPEt = energy consumption

μ_j = white noise error term (j=1, 2, 3)

Also, Δ is the difference operator. $\{\delta_{10}, \delta_{20}, \delta_{30}\}$ →the intercepts

$$\begin{Bmatrix} \alpha_{11}, \alpha_{12}, \eta_{13} \\ \alpha_{21}, \alpha_{22}, \eta_{23} \\ \alpha_{31}, \alpha_{32}, \eta_{33} \end{Bmatrix}$$

→ the slope coefficients. $\{\lambda_1, \lambda_2, \lambda_3\}$ →the coefficients of the error correction term

$\{EC_{h,t-1}\}$ →the error correction term, and

$$\begin{Bmatrix} \alpha_{11}, \alpha_{12}, \eta_{13} \\ \alpha_{21}, \alpha_{22}, \eta_{23} \\ \alpha_{31}, \alpha_{32}, \eta_{33} \end{Bmatrix}$$

A priori expectations: >0 ; $-1 < \{\lambda_1, \lambda_2, \lambda_3\} < 0$

3.2 Model Variables and Data

Output (Ym,t) is measured by real gross domestic product (GDP at 1990 constant price) in Nigeria and the contributions of each of the five sectors to the overall output namely: agriculture

(AGR), industry (IND), building & construction (BCT), wholesale & retail trade (WRT), services(SVS).These variables are measured in billion naira and are natural logarithm transformed in subsequent analysis. Data on output measures are collected from the Central Bank of Nigeria (CBN) Statistical Bulletin (2014 edition). Capital (K) is measured by gross fixed capital formation. Series for capital are collected from CBN Statistical Bulletin. Energy consumption (TPE) is measured by total primary energy in Quadrillion British Thermal Unit (btu). Data in energy measure are from the International Energy Agency (2014 edition). In addition to these major variables, this study incorporates a dummy variable to capture regime type (ROG) as a dummy instrument in the model to capture the change in governance in Nigeria. '0' stands for military and '1' for civilian.

3.3 Estimation Methods

Descriptive techniques were employed to present data and enhance the comparison of the results of the variables in this study. The dual econometric approaches employed the well tested autoregressive distributed lag (ARDL) bounds test approach to co-integration introduced by Pesaran et. al (2001) and the Granger causality test based on error correction model (ECM).

The advantages of the ARDL bounds testing approach compared to other co-integration procedures include: it is simple as opposed to other multivariate co-integration techniques such as the Johansen and Juselius co-integration technique, and allows the co-integration relationship to be estimated by OLS once the lag order of the model is identified. Also, it is applicable irrespective of the degree of integration of the variables (i.e.) whether the underlying variables are purely I(0), I(1), or a mixture of both and thus avoids the pre-testing of the order of the integration of the variables. The long-run and short-run parameters of the model are estimated simultaneously since it takes into account the error correction term in its lagged period. The ARDL approach is more robust and performs better for small sample sizes and the approach is useful, also for the long-run relationship, causality or causal relationship.

In addition, the use of the ARDL approach was recommended by Ozturk (2010) in avoiding conflicting and unreliable results when examining the energy-growth nexus. Furthermore, to ascertain the goodness of fit of the ARDL model, and the diagnostic test are conducted.

4. Estimation Results

Preliminary investigations show that the series are I (0) and I(1) only at 5 (or 10) per cent level of significance, using the Augmented Dickey Fuller (ADF) and Phillip Perron (PP) tests to the natural logarithmic transformed series. The results are reported in Table 2, but not included for lack of space. The ARDL framework is applied to establish the presence of long run relationship with normalization on energy consumption (E) and each of the output variables one after the other. Based on Schwarz Bayesian Criterion (SBC) for lag selection, a maximum lag of order 1 was found optimal and chosen. According to Pesaran and Pesaran (1997), any result that supports co-integration in at least one lag structure provides evidence for the existence of a level equilibrium. We find co-integration when the regression is normalized on total primary energy (TPE) only. The calculated F-statistic with the corresponding critical upper and lower bounds values are reported in Table 3.

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Table 2: Results from unit root tests

Augmented Dickey Fuller (ADF) test				*Phillip Perron (PP) test*		
Variables	*Levels*	*First Difference*	*Status*	*Levels*	*First Difference*	*Status*
L_RGDP	2.80986	3.812143*,**,***	I (1)	2.709543***	-	I(0)
L_AGR	1.446318	-2.980448**	I(1)	-1.372463	-2.888243***	I(1)
L_IND	-1.415018	-5.755082*,**,***	I(1)	-1.198273	-7.091493*,**,***	I(1)
L_BCT	1.319847	-3.629441***	I(1)	0.705358***	-	I(0)
L_WRT	-1.114779	-3.503476**, ***	I(1)	-0.644876	-3.359272**, ***	I(1)
L_SVS	0.547189	-3.35229**, ***	I(1)	0.210582	-3.331452**, ***	I(1)
E	-1.726079*	-	I(0)	-1.713343	-6.130343*, **, ***	I(1)
GFCF	-1.9068	4.053199*,**,***	I(1)	-2.258329	4.053199*, **, ***	I(1)
ROG	-0.822851	-5.567764*,**,***	I(1)	-0.822857	-5.568385*,**,***	I(1)

Table 3 shows that the computed F-statistics are higher than their upper bound critical values at both 5% and 10% levels of significance. Thus, the null hypothesis of no co-integration is rejected, suggesting economic growth has long-run equilibrium with energy consumption in Nigeria. Following the existence of level relationship, we estimate the long-run and short-run effects and their corresponding error correction estimates- based on equation (3)

Table 3: Bounds Test for Co-integration

Dependent variable	*With intercept and no deterministic trend element*		*Critical Values*			
	SBC lags	F-statistics	5%		10%	
			Upper bound	Lower bound	Upper Bound	Lower Bound
FTPE (TPE/GFCF, L_RGDP, ROG)	1	23.2090	17.5009	17.5009	14.2675	14.2675
FTPE (TPE/GFCF, L_AGR, ROG)	1	90.7894	18.7318	18.7318	15.3452	15.3452
FTPE (TPE/GFCF, L_IND, ROG)	1	21.5970	18.6256	18.6256	15.1736	15.1736
FTPE (TPE/GFCF, L_BCT, ROG)	1	23.7305	18.2148	18.2148	15.0009	15.0009
FTPE (TPE/GFCF, L_WRT, ROG)	1	20.4028	18.6662	18.6662	15.3009	15.3009
FTPE (TPE/GFCF, L_SVS, ROG)	1	21.5664	18.3131	18.3131	15.0359	15.0359

4.1 Long-Run Estimates

In Table 4, we report the coefficient estimates of the long-run relationship for all models. The result of the long run relationship shows that; real GDP has a positive effect on energy consumption during the military regime and it is statistically significant at 1%. The result gives that a 1% increase in real GDP makes energy consumption to increase by about 0.932 units whereas, during the civilian regime, there is a marginal effect of 0.963 (0.932+0.031) units increase in energy consumption given a 1% increase in real GDP. When this aggregated real GDP was disaggregated, the results shows that the civilian regime experienced an increase in energy consumption given a percentage increase in the respective real output of each sector. From table 2, 1% increase in agricultural output makes energy consumption to increase by about 0.14 units. This was in the military regime whereas; the civilian regime experienced about 0.208 (0.14+0.068) units increase in energy consumption at 1% increase in real agricultural output. Real industrial output has a positive effect on energy consumption during the military regime and it is statistically significant at 1%. The result gives that a 1% increase in real industrial output makes energy consumption to increase by about 0.157 units whereas, during the civilian regime, there is a

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marginal effect of 0.214 (0.157+0.057) units increase in energy consumption given a 1% increase in real industrial output.

When there is a 1% increase in the output from the building and construction sector in the military regime, it made energy consumption increase by about 0.217 units. In the civilian regime, about 0.220 (0.17+0.003) units increase was observed in energy consumption at when there is a 1% increase in real output from the building and construction sector. In both the military and civilian regimes, the real service sector output has a positive effect on energy consumption and it is statistically significant at 1%. As observed, a 1% increase in real service sector output makes energy consumption to increase by about 0.184 units whereas, during the civilian regime, there is a marginal effect of 0.191 (0.184+0.007) units increase in energy consumption given a 1% increase in real service sector. When there is a 1% increase in the output from the trade sector in the military regime, it made energy consumption increase by about 0.137 units. In the civilian regime, about 0.198 (0.137+0.061) units increase was observed in energy consumption at when there is a 1% increase in real output from the trade sector.

Table 4: Long- Run Coefficient Estimates Models

Regressors	*TPEtg*	*TPEtA*	*TPEti*	*TPEtBC*	*TPEtS*	*TPEtW*
GFCFt	-0.004 (0.000)	-0.002 (0.001)	-0.002 (0.000)	-0.003 (0.000)	-0.003 (0.000)	-0.002(0.000)
RGDPt	0.932 (0.000)					
AGRt		0.140 (0.000)				
INDt			0.157 (0.000)			
BCTt				0.217 (0.000)		
SVSt					0.184 (0.000)	
WRTt						0.137 (0.000)
ROGt	0.031(0.605)	0.068(0.205)	0.057 (0.278)	0.003 (0.957)	0.007 (0.908)	0.061 (0.228)
Constant	-1.442 (0.004)	0.500 (0.000)	0.430 (0.000)	0.616 (0.000)	0.510 (0.000)	0.573 (0.000)

Note: Numbers inside the () are the probability of t-statistic

4.2 Short-Run Estimates

Reported in Table 5 are the results of the models for the short-run relationship; all in the current period. The result shows that; real GDP has a positive effect on energy consumption during the military regime and it is statistically significant at 1%. The result gives that a 1% increase in real GDP makes energy consumption to increase by about 0.432 units whereas, during the civilian regime, there is a marginal effect of 0.461 (0.432+0.015) units increase in energy consumption given a 1% increase in real GDP. When this aggregated real GDP was disaggregated, the results shows that the civilian regime experienced an increase in energy consumption given a percentage increase in the respective real output of each sector. 1% increase in agricultural output makes energy consumption to increase by about 0.073 units. This was in the military regime whereas; the civilian regime experienced about 0.109 (0.073+0.036) units increase in energy consumption at 1% increase in real agricultural output. Real industrial output has a positive effect on energy consumption during the military regime and it is statistically significant at 1%. The result gives that a 1% increase in real industrial output makes energy consumption to increase by about 0.081 units whereas, during the civilian regime, there is a marginal effect of 0.111 (0.081+0.030) units increase in energy consumption given a 1% increase in real industrial output.

When there is a 1% increase in the output from the building and construction sector in the military regime, it made energy consumption increase by about 0.119 units. In the civilian regime, about 0.121 (0.119+0.002) units increase was observed in energy consumption at when there is a 1% increase in real output from the building and construction sector. In both the military and civilian regimes, the real service sector output has a positive effect on energy consumption and it is statistically significant at 1%. As observed, a 1% increase in real service sector output makes energy consumption to increase by about 0.10 units whereas, during the civilian regime, there is a marginal effect of 0.104 (0.100+0.004) units increase in energy consumption given a 1% increase in real service sector. When there is a 1% increase in the output from the trade sector in the military regime, it made energy consumption increase by about 0.075 units. In the civilian regime, about 0.108 (0.075+0.033) units increase was observed in energy consumption at when there is a 1% increase in real output from the trade sector.

The capital stock also has a significantly low negative effect on energy consumption. A 1% increase in capital utilized in economy-wide production leads to 0.3% fall in energy consumption. A 1% increase in capital leads to a decrease of approximately 0.2% in energy consumption in the agricultural sector. Furthermore, the negative impact of capital on energy consumption in the long run is insignificant. However, the relationship between capital and energy consumption in the building & construction sector is neither positive nor significant. Capital also has a low and negative but significant relationship with energy consumption in the short-run.

The governance regime type has a positive relationship with energy consumption both in long and short runs but the effects are statistically insignificant. The results show a positive and statistically significant effect on energy consumption in the long run. The estimated coefficients of the short-run model show that capital stock has a positive and significant effect on energy demand. The governance indicator still has a positive but not significant impact on energy consumption.

The error correction coefficients are all negative and significant, ranging from -0.47 to -0.55, and implies that when energy consumption deviates from its equilibrium level due to a shock, it will take approximately 47% to 55% within the first year to ensure convergence to the equilibrium level. It would therefore require more or less than 2 years to fully adjust to its long-run level. Thus, this result confirms a prior expectation of a positive relationship between energy consumption and economic growth as earlier stated but this is not the case with capital in the long run.

Therefore, the a priori expectation on the relationship between energy consumption and growth in the agricultural sector is confirmed. However, this result contradicts the a priori expectation of a positive relationship between energy consumption and the use of capital in the agricultural sector of Nigeria both in the short and long run. This result confirms the a priori expectation of a positive relationship between growth in the industrial sector and energy consumption but finds a negative relationship between capital and energy consumption in the long and short run.

All the models satisfy necessary diagnostic checks as shown in Table 3. The goodness of fit is above average, ranging from 53% to 58%. Moreover, no serial correlation, asymmetricity, heteroscedasticity, and functional form misspecification are observed in the models. These tests are chi-squared based with one degree of freedom except normality test which has two. Also, all the models are stable as measured by CUSUM and CUSUMSQ tests of the residuals.

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Table 5: Error Correction Representation of ARDL Model: Dependent Variable - ΔTPE

Regressors	*TPEtG*	*TPEtA*	*TPEtI*	*TPETbc*	*TPEtS*	*TPEtW*
ΔGFCFt	0.002 (0.000)	-0.001 (0.000)	-0.001 (0.000)	-0.002 (0.000)	-0.001(0.000)	0.001 (0.000)
ΔROGt	0.015 (0.606)	0.036 (0.197)	0.030 (0.275)	0.002 (0.957)	0.004 (0.908)	0.033 (0.220)
ΔRGDPt	0.436 (0.001)					
ΔAGRt		0.073(0.000)				
ΔINDt			0.081 (0.002)			
ΔBCTt				0.119 (0.001)		
ΔSVSt					0.100 (0.000)	
ΔWRTt						0.075 (0.003)
ecmt-1	-0.467 (0.000)	-0.521 (0.000)	-0.519 (0.000)	- 0.546 (0.000)	-0.546 (0.000)	-0.544(0.000)
			Diagnostics Tests			
Serial Correlation	0.944 (0.331)	0.147 (0.702)	0.005 (0.943)	0.001 (0.969)	0.364 (0.985)	0.150 (0.698)
Functional Form	1.830 (0.176)	0.705 (0.401)	0.918 (0.338)	0.123 (0.726)	0.401 (0.527)	1.027 (0.311)
Normality	12.463 (0.002)	7.794 (0.020)	9.334 (0.009)	8.352 (0.015)	6.802 (0.033)	8.469 (0.014)
Heteroscedasticity	1.422 (0.233)	2.334 (0.127)	2.733 (0.098)	1.68 (0.195)	1.924 (0.165)	2.190 (0.139)
R-Squared	0.57	0.53	0.56	0.58	0.56	0.55
F-Statistic	8.988 (0.000)	7.677 (0.000)	8.483 (0.000)	9.151(0.000)	8.523 (0.000)	8.192 (0.000)
DW-Statistic	2.172	2.069	2.003	1.971	1.9682	2.064
AIC	54.656	53.262	54.134	54.820	54.176	53.825
SBC	50.991	49.60	50.470	51.156	50.51	50.161
CUSUM	Stable	Stable	Stable	Stable	Stable	Stable
CUSUM2	Stable	Stable	Stable	Stable	Stable	Stable

Note: Numbers inside the () are the probability of t-statistic

4.3 Causality Pattern in Energy Consumption-Growth Nexus in Nigeria

Following the existence of long run equilibrium between energy consumption and sectoral GDP in Nigeria, the causal link is examined, using the null hypotheses of no causality between energy and growth. The hypothesis is tested using pair wise Granger-causality approach. When the F-statistic is significant (i.e. $p<0.05$), we reject the null hypothesis of non-Granger causality. Hence, we accept the alternative hypothesis that causality exists between the variables of interest. With emphasis on causal pattern between total primary energy consumption (TPE) and aggregate or sector outputs only, the results of the causality test are shown in Table 6. Results on capital are not reported to save space. The pair wise test utilized 32 observations and 1 lag throughout. The values in parenthesis () are probability values.

The null hypotheses of non-Granger causality from energy use to building & construction and service sectors are rejected at 5% significance level while that of wholesale & retail trade is rejected at 10%. The evidence suggests unidirectional causality from energy consumption to building & construction, service and wholesale & retail trade sectors. These results simply suggest that an increase in energy demand leads to an increase in the output of the three sectors listed. In other words, the growth hypothesis is applicable in the service, building & construction and trade sectors of Nigeria. Thus, energy conservation policies may have adverse consequences for the

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growth of these sectors if the economic or commercial activities in the sectors are not sufficiently considered.

Table 6: Causal Pattern between Energy Consumption and Economic Growth

Null Hypothesis (Ho)	*F-Stat (Prob.)*	*Decision*
Growth does not Granger-cause energy	0.260 (0.614)	Accept Ho
Energy does not Granger-cause growth	1.758 (0.195)	Accept Ho
Energy does not Granger-cause building	8.864 (0.006)	Reject Ho
Energy does not Granger-cause wholesale trade	2.997 (0.090)*	Reject Ho
Energy does not Granger-cause service	10.153 (0.003)	Reject Ho

* means the decision is based on 10% level of significance.

5. Discussion

This evidence of one-way causation corroborates Dantama (2012) who submits that unidirectional causality runs from energy use to economic growth in Nigeria. However, it contradicts Akinlo's (2008) and Wolde-Rufael's (2009) support for neutral causality.

More specifically, while Nwosa & Akinbobola (2012) find unidirectional causality from the service sector to energy consumption (i.e. the conservation hypothesis), this study shows that the direction of causality between service sector and energy moves from the latter to the former (i.e. the growth hypothesis). Moreover, this study shows that there is a neutral relationship between agricultural output and energy consumption. This is contrary to Nwosa and Akinbobola who find bidirectional causal relationship. Finally, the evidence of no causal relationship between energy use, building & construction by Nwosa and Akinbobola is invalidated by this study which finds that unidirectional causality running from energy consumption to building & construction exists.

It is noteworthy that the study applied exogenous selection of break - change from military to civilian government in May 1999. Meanwhile, the endogenous search by Esso (2010) and Eggoh et al. (2011) for structural breaks suggests year 2001as significant threshold period in Nigeria.

6. Conclusions

This study examines the relationship between energy consumption and economic growth measured by total real GDP in Nigeria and finds existence of long and short-run co-integration. Also, there is evidence in support of the growth hypothesis in Nigeria in the service, building & construction sectors while no causal pattern is found between energy consumption and growth in agriculture, industry, wholesale & retail trade sectors.

Our fixed period of year 2000 is close to 2001, and it is assumed reasonable since it marked the commencement of a full-civilian fiscal year after May 29, 1999. We employ this choice and search for possible co-integration and causal relation in energy-growth relation over two sub-samples: 1981-1999 and 2000-2013, in order to further establish the role of governance in our analysis. The results show that the null of no co-integration could not be rejected in both sub-samples, and causal pattern could not be ascertained. Various explanations exist for the absence of valid results in the sub-samples' analysis and such examination is off our focus. Hence, we conclude that the findings in this study are robust and suitable for policy designs.

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Furthermore, capital is vital in explaining the relationship between energy consumption and economic growth whereas the index of regime type of government is not, but has positive impact on energy consumption. Therefore, energy demand policies in Nigeria could be made flexible and sector-specific. Since the growth hypothesis dominates in the service and building & construction sector, energy conservation policies or high energy price may have adverse consequences on economic activities in these sectors. The current scarcity or inefficiency in energy supply may also have greater effect on the growth of the sectors compared to other sectors in Nigeria. Therefore, the study recommends that government gives priority to the provision of adequate and efficient energy supply, especially in the non-agricultural sector. The government may also step-up its efforts in creating a more even distribution in the supply of energy resources for both rural and urban areas. This can be achieved via appropriate investment towards the discovery of new or additional sources of energy supply, among others.

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