Energy consumption and economic growth in Nigeria: A revisit of the energy-growth debate

Emeka Nkoro^{a*}, Nenubari Ikue-John^b and God'sgrace I. Joshua^c

^{a,b,c}Department of Economics, Faculty of Social Sciences, University of Port Harcourt, Nigeria

ARTICLE INFO

Article history:

Received 27 July 19

Received in revised form 22 Aug 19

Accepted 12 October 19

Keywords:

Renewable-Energy

Non-renewable energy

Non-renewable-Energy

Economic-Growth

Factor-Productivity

JEL Classification:

L72, L94, Q42, Q43

ABSTRACT

This paper investigated this disparity in the literature using Nigeria data from 1980 to 2016. In doing this, energy consumption was disaggregated, and their impacts on economic growth investigated using a modified Ordinary Least Square technique which allows for time gaps in the model. It was observed that only renewable energy impacted on economic growth in the long-run whereas non-renewable energy component impacted on economic growth in the short-run. Therefore, the study sees the impact of energy consumption on economic growth to be indistinct in Nigeria within the period under review. This further buttresses the need for improvement in electricity production and distribution in Nigeria. Given the importance of energy consumption on productivity, the study, therefore, suggests policies/measures that will bring about increasing the supply or improvement of energy production in the country.

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Introduction

Energy plays a crucial role in socio-economic development, industrial breakthrough, health, education, employment and overall welfare of a country citizen. Sufficient amount of energy supply as well as its efficient utilization of the energy is needed for an economy to completely experience growth and development. Though the presence of energy is not by itself an answer to the social and economic problems facing developing economies like Nigeria, the very lack of access to affordable and reliable energy services is recognized as a major problem to the development of the country. In order to achieving the Economic Recovery and Growth Plan for 2017-2020, energy poverty (being the lack of access to modern energy services) eradication is important because energy services have significant contributions to productivity, education and communication services (UNIDO, 2011). The poverty of energy in Nigeria is such that all manufacturing firms depend on self-created electricity to power their operations and to maintain power back-up in the event of power failure, (Nkoro, Ikue-John, Okeke, Amabuike, & Ajaba, 2019). This situation is an irony, in a country where energy resources are in high abundance and serving as the prime income earner together with the fluctuating economy places the country in dire need of explanations as to the role of energy in economic life of Nigeria (Babatunde, 2016). Hence, it is pertinent to examine the role of energy in the face of fluctuating economic growth, if appropriate energy policies are to be devised.

* Corresponding author. ORCID ID: 0000-0002-1764-2283

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<http://dx.doi.org/10.36096/brss.v1i2.138>

Empirical literatures have shown conflicting evidence on the relationship between energy consumption and economic growth that has left us uncertain about the cause-and-effect nature of this nexus. An attempt by Dantama et al (2012), Adegbemi et al (2013), Jacques (2010), Mesbah (2016) and Adam et al (201) to examine the relationship between energy consumption and economic growth revealed conflicting results. The studies reported unidirectional, bidirectional, feedback and neutrality causality between energy consumption and economic growth. These conflicting results could be as a result of the choice of methodology, selectivity bias and, data quality and specification issues. It was equally observed that most of these studies treated the relationship between energy consumptions and economic growth in a feedback models. The case of Nigeria maybe little different since over the years economic growth have been increasing even in the present of higher level energy poverty as such we can argued that economic growth have not contributed to energy consumption in Nigeria, rather we suspected that it is energy consumption that will contribute to economic growth in Nigeria, (Medee, Ikue-John, & Amabuike, 2018). However, the question still remains. Does energy consumption stimulation economic growth or vice versa? This question can only be resolved by appealing to empirical evidence. Hence, the aim of the paper is to assess in a linear framework the impact of energy consumption on the economic output in Nigeria from 1980 to 2016 using the instruments of factor productivity as a check variable. To achieve this objective, the study developed a linear framework against the feedback framework to investigate the impact of disaggregated energy consumption components on economic growth in Nigeria. The study is guided by the following hypothesis, H₀₁: Energy consumption has no significant impact on economic growth in Nigeria.

The remaining section of this paper is divided such that section two discusses theoretical issues and review empirical literature. Section three highlights the theoretical model. Section four gives the empirical results and the discussion of findings while the last sections proffers policy recommendations and also conclude the study.

2. Literature Review

Theoretical Literature

An investigation on the link between energy consumption and economic growth is not a thing of recent studies. It dates back to the 1970s with the pioneer work of Kraft & Kraft (1978), where a unidirectional causality from GNP growth to energy consumption were observed in the united states for the period of 1947-1974. Since then numerous scholars have carried out further test to determine the relationship between energy consumption and economic growth. Renewable energy sources have begun replacing traditional energy sources in these past years due to the challenges of energy security, the risk of extinction of traditional energy sources environmental problems as well as greenhouse gas emission. It is important to understand the relationship between renewable energy consumption and economic growth in revealing its dependency on energy (Yildirim & Aslan, 2012).

Studies without qualitative distinction have provided four testable hypotheses to explain the direction of the relationship between energy consumption and economic growth (Ozturk, 2010; Wesseh & Zoumara, 2012; Tugcu et al 2012; Shahbaz et al, 2015; Kocak & Sarkgunesi 2017). They are the Growth Hypothesis, the Conservative Hypothesis, the Feedback Hypothesis and the Neutrality Hypothesis.

The Growth Hypothesis sees energy consumption as a direct influence on economic growth in presents of the control for capital and labor. The hypothesis argued unidirectional causality from energy consumption to economic growth. Here, energy policies aimed at reducing energy consumption for conservative purposes will affect economic growth negatively. *The Conservative Hypothesis* posits that economic growth pulls energy consumption. The hypothesis argued for unidirectional causality from economic growth to energy consumption. Here energy conservation policies on energy consumption would not have a negative effect on the economy. *The Feedback Hypothesis* posits bidirectional causality between energy consumption and economic growth meaning that a mutual relation exists between energy consumption and economic growth. In this situation, energy conservation policy seeks to reduce energy consumption may negatively affect economic growth and these changes are likewise reflected back to energy consumption. *The Neutrality Hypothesis* states that energy consumption has no effect on economic growth. It posits that there is no causality between energy consumption and economic growth. This hypothesis is supported when there is absence of causality between energy consumption and economic growth. In this case, energy conservation policies for the reduction of energy consumption will have no impact on economic growth.

Empirical Literature

Results regarding energy consumption and economic growth are different for countries and no inference has been drawn in literature (Bhattacharya, 2016). Most of these studies differ in the time periods, econometric methods, countries selected, energy types, and results (Ozturk, 2010). Bhattacharya et al (2016) in examining 38 countries saw that despite the various literatures on energy consumption and economic growth in the past ten years, literature on the impact of renewable energy on economic growth is not enough. To this end, Table 1 summarized some empirical evidences on the relationship between energy consumption and economic growth.

Table 1: Past Studies on the Relationship between Energy Consumption and Economic Growth

Authors	Subject	Periods	Sample variables	Method	Major findings
Medee, Ikue- John, & Amabuike, (2018)	Granger causality of Energy Consumption and Economic Growth in the Organization of Petroleum Exporting Countries: Evidence from the Toda–Yamamoto approach	1970-2014	Economic Growth, renew and non-renew energy consumption	Augmented Granger Causality model (AGCM) by Toda-Yamamoto	Dominants of feedback hypotheses among the major oil exporting countries.
Mesbah (2016)	Energy consumption and economic growth in Egypt	1980 - 2012	Oil, electricity, coal, natural gas and economic growth	Toda Yamamoto causality test	Neutrality hypothesis
Adam et al.,(2016)	Energy consumption, political regime and Economic growth in Sub-Sahara Africa	1971-2013	Energy consumption, energy price, GDP, and degree of openness	Panel Vector Autoregressive Model (PVAM)	Feedback Hypothesis
Fuinhas&Margues (2012)	Nexus between primary energy consumption and economic growth in five European countries	1965-2009	Oil, electricity, natural gas and GDP	Autoregressive Distributed Lag (ARDL) approach	Feedback Hypothesis
Menegaki (2011)	Causal relationship between renewable energy consumption and economic growth in selected 27 European countries	1980-2007	Renewable energy resources and economic growth	Multivariate panel analysis	Neutrality Hypothesis
Yildirim et al.,(2014)	causality between energy consumption and economic growth in selected 11 countries	1980-2011	Oil, electricity, and GDP	Trivariate model and bootstrapped auto-regressive metric causality approach	Neutrality Hypothesis
Apergis& Payne (2012)	Examine the link between renewable, non- renewable energy consumption in selected 80 countries	1990-2007	Renewable, non-renewable resources and GDP	Panel Error Correction Model (PECM)	Feedback Hypothesis
Mohammadi&Parvaresh (2014)	Short and long dynamics between energy consumption and economic output in 14 selected oil exporting economies	1980-2007	Oil, natural gas and GDP	Panel estimation techniques-dynamic fixed effect, pooled, and mean-group estimators	Feedback Hypothesis
Shahbaz et al, (2012)	the link between renewable, non-renewable energy usage and economic growth in Pakistan	1972-2012	Renewable, non-renewable resources and GDP	Autoregressive Distributed Lag (ARDL) bound test approach	Feedback Hypothesis
Bloch et al., (2015)	Relationship between GDP Oil, Coal and Renewable energy resources in china	1977-2013	GDP, Oil Coal and Renewable Energy resources	ARDL techniques and Vector Error Correction Model	Feedback Hypothesis
Omri&Mabrou (2014)	The effect economic growth on energy consumption in 65 selected countries	1990-2011	GDP, oil Natural gas and electricity	GMM estimator techniques	Conservative Hypothesis
Odhiambo (2010)	Examines the link between Energy-Growth Nexus in Kenya, Congo and South Africa		Energy consumption, price and GDP	Panel Error Correction Model	Growth Hypothesis in Kenya and South Africa, Conservative Hypothesis in Congo
Menyah&Wolde-Rufael (2010)	The relationship between energy consumption and economic growth in South Africa	1965-2006	Energy consumption, pollutant emission, GDP	Autoregressive Distributed Lag (ARDL)	Growth Hypothesis
Jacques (2010)	Examines the link between energy consumption and economic performance in seven Africa Countries	1970-2007	Energy consumption and economic growth (GDP)	Bound test approach	Conservative Hypothesis
Karanfil& Li (2015)	Energy-Growth Nexus In 160 Countries	1980-2010	Electricity consumption and level of economic performance	Exploring Panel-Specific Difference	Conservative, Feedback and Neutrality Hypotheses
Khalid (2015)	Dynamic linkages among energy consumption, environment, health and wealth in BRICS Countries	1975-2013	Energy consumption, health,	Panel co-integration	Growth Hypothesis

			environment impact and GDP		
Dantama et al (2012)	The impact of energy consumption on economic growth in Nigeria	1980-2010	Oil, Electricity, Coal and GDP	ARDL approach to co-integration analysis	Growth Hypothesis
Adegbemi et al., (2013)	The Nexus between energy consumption and Nigeria's economic growth	1975-2010	Coal, Oil, Gas, Economic Growth and Electricity	Co-integration and OLS techniques	Growth Hypothesis
Fang, Y. (2011).	Assessment of the role of both the amount and share of renewable energy consumption in economic welfare in China.	1978 - 2008	Renewable energy consumption, real GDP, GDP per capita, per capita annual income of rural households and per capita annual income of urban households	Multivariate OLS technique	Growth Hypothesis
Ogundipe & Apata (2013)	Examined the relationship between electricity consumption and economic growth in Nigeria	1980 - 2008	Electricity consumption and gross domestic product	Vector Error Correction Modeling and the Pairwise Granger Causality test	Feedback Hypothesis

Source: Authors' Computations

The growth hypothesis = where causality runs from energy consumption to economic growth; The conservation hypothesis = where causality runs from economic growth to energy consumption; The neutrality hypothesis = both economic growth and energy consumption has no effect to each other; The feedback hypothesis = both economic growth and energy consumption granger cause each other

Research and Methodology

Analytical Framework

This paper follows the works of Fang (2011) and Ogundipe and Apata (2013) in an attempt to evaluate the impact of energy consumption on economic growth in China and Nigeria respectively. They used the Cobb-Douglas functional form to show the relationship between inputs and outputs in production. In its general form the production function appears as;

$$Q = AL^{\alpha}K^{\beta}$$

Where;

Q = production in monetary value

L =labor input

K =capital input

A = total factor productivity

α & β = Elasticity of labor and capital respectively.

In this paper, labor and capital are captured easily as number of the employed persons in the country and gross fixed capital formation respectively, technological changes are not so easily quantifiable and data for it in Nigeria is scarce hence its omission here. The model for this paper is premised on Fang (2011) and Ogundipe and Apata (2013) but with little modification in terms of variable and method of analysis. The paper uses total consumption of renewable energy (TCR) in kiloton of oil equivalent as proxy for renewable energy consumption obtained by the sum of solar, hydro, biofuel, biomass, wind and geothermal and CO₂ emission to account the present of non-renewable energy which is treated as strictly exogenous in the model whereas Fang (2011) and Ogundipe and Apata (2013) used renewable energy consumption and electricity consumption respectively. Analytically, this paper adopts the modified ordinary least square as in Ogundipe and Apata (2013) but contrary to Fang (2011) who adopted the multivariate OLS. Also, Ogundipe and Apata (2013) examined the relationship between energy consumption and economic growth from 1980-2008 while this paper extended to 2016 as a result of policy changes that have taken place in the country.

Data Analysis

Analytically, this paper adopts the modified ordinary least square. The estimation starts with examining the time series characteristics of the variables included in the model, then proceed to estimating the Engel & Granger co-integration analysis in order to test for the existence of a co-integrating relationship among the variables. Next is the examination of the relationship between energy consumption and economic growth is conducted using Parsimonious Error Correction Model and finally, the diagnostic tests of the model.

All the data employed in this study are obtained from the Central Bank of Nigeria (CBN) Statistical Bulletin, International Energy Agency, and World Development Indicators Annual Reports.

Model

The functional relationship between economic growth and energy consumption in the present of control for some selected macroeconomic fundamentals can be express as follows:

$$GDP = f(TCR, CO, EMP, GFCE)$$

Where;

GDP = Gross domestic product proxy for economic growth

CO= Carbon Dioxide Emissions (Co₂ Emission Per Capita) proxy for non-renewable Energy Consumption

RENER = Total Consumption of Renewable proxy for Renewable Energy Consumption

EMP= Employment proxy for labor force

GFCE= Gross Fixed Capital Formation proxy for physical capital

The general specification of a linear static model is cast as follows;

$$Y_t = \alpha_0 + \sum_{i=1}^n \alpha_1 Y_{t-i} + \sum_{j=0}^m \alpha_2 X_{t-j} + \varepsilon_t \quad 1$$

Whereas, the general expression of linear dynamic model with Error Correction is cast as follows:

$$\Delta Y_t = \beta_0 + \sum \beta_1 Y_{t-i} + \sum \beta_2 X_{t-j} + \psi ECM_{t-1} + \varepsilon_t \quad 2$$

In equation 2 the speed of adjustment parameter (ψ) in the dynamic model must be negative and statistically significant. The Error Correction Term specifies that any divergence from the long-run equilibrium between variables is corrected in each period and how much time it will take to restore the long-run equilibrium position.

Where:

ECM_{t-1} = Residuals acquired from cointegration model

The model is estimated with the modified Ordinary Least Square (OLS) technique. The interpretation of the model follows econometrics, statistics and economic criteria. The Econometric criteria includes the examination of second order test (that is, diagnostic and robustness check in the spirits of conducting linearity test, homoscedasticity test, serial correlation, residual normality test and cumulative sum (CUSUM) and cumulative sum squared (CUSUM square) among others). The statistical test includes the test for the explanatory power of the models, the statistical significance of the overall model and the significance of the individual parameters. Whereas the economic criteria includes the interpretations of the theoretical relationship (signs of the parameters), elasticity's of the parameters (size or magnitude of the parameters) and finally, the economic implication of the sign and magnitudes of the parameter estimated.

Hypothesis

H_0 = Energy consumption has no significant impact on economic growth in Nigeria.

Result and Discussion

Unit Root Test

The unit root result is conducted by using Dickey & Fuller (1979) technique is summarized in Table 2. It reveals that the variables are not stationary at level but are at first difference. Hence, all the variables in the model are integrated at order one (I(1)). Since the variables are not integrated at I(0), there is need to test for possible long-run relationship among them.

Table 2: Unit Root Test

Variables	Test Methods: Augmented Dickey-fuller (1979)			
	Calculated Values		Critical values	Order of Integration
	Level	1 st diff.	5%	I(d)
logGDP _t	-2.4987	-144.44***	-3.5443	I(1)
LogCO _t	-2.1218	-5.6742***	-3.5403	I(1)
LogRENER _t	-2.7224	-5.3602***	-3.5403	I(1)
LogGFCF _t	-1.8838	-5.0414***	-3.5403	I(1)
LogUMP _t	-2.6419	-4.4641***	-3.5403	I(1)

Source: Authors Computations from E-Views 9.0 Results

Cointegration Test

The result in Table 3 shows that the study fails to accept the null hypotheses of cointegration since the unit root results of the error term is stationary at level of order I(0). Since the error term extracted from the static model is integrated at I(0) or stationary at

levels. Then the combinations of the non-stationary variables in the model are cointegrated. The significance of the tau-statistics and z-statistics show that the critical values are greater than the calculated values in real terms.

Table 3: Cointegration Result/ Engel-Granger Two Step

Cointegration Test - Engle-Granger		
Specification: LOG(GDP) LOG(CO) LOG(RENER) LOG(GFCF) LOG(UMP) C		
Null hypothesis: Series are not cointegrated		
	Value	Prob.*
Engle-Granger tau-statistic	-8.7458***	0.0000
Engle-Granger z-statistic	-38.925***	0.0012
*MacKinnon (1996) p-values		

Source: Authors Computations from E-Views 9.0 Results

Since the variables in the model are non-stationary but cointegrated by Engel-Granger technique, the study therefore estimated both the static and dynamic model. The dynamic model shows similar behavior as the static model both models are reported below.

Table 4: Results from the Static Model

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-56.587**	26.168	-2.1625	0.0382
LOG(CO)	0.5548	0.5573	0.9954	0.3270
LOG(RENER)	10.973**	4.4486	2.4665	0.0192
LOG(GFCF)	0.2921	0.1827	1.5989	0.1197
LOG(UMP)	-1.9061***	0.4746	-4.0167	0.0003
R-squared	0.6420	Adjusted R-squared		0.5973
F-statistic	14.34 (0.0000)	Durbin-Watson stat		1.5421 $\approx$ 2

Source: Authors Computations from E-Views 9.0 Results

The static model reported on table 4 is estimated with the Ordinary Least Square estimator. The model is not spurious since the R² is less than the Durbin-Watson statistics (0.6420<1.5421). The model is free from first order Markov because the Durbin-Watson value is approximately 2. The model is strong as about 64.20 percent of the explanatory variables predicted the outcome of energy consumption on economic growth within the study periods whereas the remaining 35.80 percent were explained by other variables which are not included in the model but are accounted for by the error term. The analysis of the entire model (Analysis of the Variance) shows that the model is statistically significant at the 5 percent shown by the value Analysis of the Variance of F-statistics.

The Dynamic Model Result Presentation

Table 5: Dynamic Model

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.0319**	0.0112	2.8477	0.0116
DLOG(GDP(-1))	0.2746	0.2000	1.3731	0.1886
DLOG(GDP(-2))	-0.0409**	0.1789	-2.2286	0.0221
DLOG(GDP(-3))	0.0052***	0.0058	5.9077	0.0000
DLOG(CO)	0.0305	0.0304	1.0032	0.3307
DLOG(CO(-1))	0.0339	0.0308	1.1003	0.2875
DLOG(CO(-2))	0.0749***	0.0242	3.1022	0.0068
DLOG(RENER)	0.5058	0.2915	1.7352	0.1019
DLOG(RENER(-1))	0.1803	0.2660	0.6778	0.5076
DLOG(RENER(-2))	-0.0905	0.2468	-0.3666	0.7187
DLOG(GFCF)	0.0559	0.0196	2.8530	0.0115
DLOG(GFCF(-1))	-0.0142	0.0226	-0.6276	0.5391
DLOG(GFCF(-2))	0.0239	0.0226	1.0615	0.3042
DLOG(UMP)	-0.0716***	0.0236	-3.0321	0.0079
DLOG(UMP(-1))	-0.0555	0.0358	-1.5513	0.1404
DLOG(UMP(-2))	-0.0364	0.0341	-1.0692	0.3008
ECM(-1)	-0.4621***	0.0204	-2.9877	0.0028
R-squared	0.8103	Adjusted R-squared		0.8007
F-statistic	4.2727 (0.0030)	Durbin-Watson stat		2.274132

Source: Authors Computations from E-Views 9.0 Results

The result in Table 5 shows that the non-renewable component of energy consumption impacted significant on economic growth in Nigeria while the relationship between renewable energy consumption and economic growth is insignificant. This is contrary with

the static model which reveals that only renewable component of energy consumption significantly impacted on economic growth. With respect to the dynamic model, the significant impact of non-renewable energy on growth is only observed in the second period lag. The result indicates that economic growth will respond effectively to energy consumption after two years of consumption non-renewable energy. Therefore, the study reveals that renewable energy component significantly impacted on economic growth in the long-run and exhibited insignificant impact on growth in the short-run while the non-renewable energy component significantly impacted on growth in the short-run and exhibited insignificant impact on growth in the long-run within the study period.

The finding agrees with the works of Apergis et al. (2010) and Ouedraogo (2013). The three studies show a positive relationship between economic growth and energy consumption among various developing nations of Africa. The results show that the third period lags of GDP in the model show a 5% significant cluster effects reflecting the strength of the effect. This means that economic growth can internally stimulate itself to ensure more growth in the future periods; also the first period lag of GDP shows an insignificant positive effect implying that it perpetuates itself relatively in the early period. The Error Correction Mechanism is negative and statistically significant. This shows that the adjustment procedure from the disequilibrium in short-run towards the long-run equilibrium is 46.21%. The rate of adjustment procedure in the model is slow indicating that shocks on the model tend to be permanent. Thus, policy option on the relationship between energy consumption and economic growth in Nigeria should be viewed from the short-run perspective.

Diagnostic Test

Table 6: Summary of Diagnostic Test

Hypothesis	Test-statistic	Empirical Statistic	Decision
Residual Normality	Jarque-Bera (JB)	1.7349 (0.4200)	Accept
Serial correlation	Breusch-Godfrey (BG)	0.7778 (0.4783)	Accept
Homoscedasticity	Breusch-Pagan-Godfrey	0.7513 (0.7130)	Accept
Model specification	Ramsey RESET	0.2088 (0.8374)	Accept

Source: Researcher's computation. All tests were carried out at 0.05 level of significance, figures in parenthesis are the p-values and the hypothesis are stated in the null form

The result in Table 6 shows the acceptance of the null hypothesis of the four assumptions diagnosed. That is the residuals from the model are normally distributed with a constant mean and variance and are not autocorrelated since the probability values of the test statistics are not significant at the 5 percent level. Also, it was revealed that the model was correctly specified which indicates that there is no specification bias. Figure 1 and 2 are aimed at examining whether any of the estimated coefficients falls outside the cycles. If any of the coefficients falls outside the circle then, the coefficient estimated is not stable. The results from figure 1 and 2 show that none of the coefficient falls outside the CUSUM and CUSUM square circle at 5% level, hence the parameters estimated are stable.

Figure 1: Coefficient Stability Test

Figure 2: Coefficient Stability Test

Conclusions

This study examines the relationship between energy consumption and economic growth in Nigeria. The findings from the study reveal that economic growth is only affected by renewable energy in the long-run whereas non-renewable energy component affected economic growth in the short-run (i.e after two years of consumption activity). Therefore the study sees the impact of energy consumption on economic growth to be indistinct in Nigeria within the period under review. Based on the findings, the following suggestions were made:

- i) There is need to advocate for policies/measure that will bring about increase the supply or improve on renewable energy production in the country; as this could improve productivity and economic growth in the long run.
- ii) There is need for short term measures in the area of improving on the non-renewable energy supply as this could serve as an intervention measure when there is a disturbance in the supply of renewable energy in the country.

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