THE IMPACT OF CONVENTIONAL FOSSIL FUEL ENERGY CONSUMPTION ON ECONOMIC GROWTH IN NIGERIA (1980-2020).

***SALISU BABA MANU; **MUBARAK USMAN SANTALI; & **MOHAMMED IBRAHIM**

**Department of Economics, School of Arts & Social Sciences. A.D. Rufa'i College of Education, Legal & General Studies Misau Bauchi State.*
***Department of Economics School of Arts & Social Sciences, Gombe State College of Education And Legal Studies, Nafada Gombe State.*

Abstract

This paper estimates the impact of conventional/fossil fuel energy consumption and its component on economic growth in Nigeria using dynamic ordinary least squares (DOLS) by employing a sample of 36 observations covering the 1980-2018 period. The results indicated that conventional/fossil fuel and its component (Crude Oil and Dry Natural Gas) energy consumption slows down economic growth in Nigeria. This is attributed to the inefficiency in the use of fossil fuel energy in the country. The conventional/fossil fuel energy are highly polluting when used (burnt). On the other hand, the use of clean energy sources like solar, wind and hydropower which does not have a side effect on human health and the environment is less in Nigeria. As such, conventional/fossil fuel energy use can slow down economic growth by lowering productivity when there is inefficiency in the energy used. The study recommends that (1) The government should intensify action in support of policies that encourage private sector participation in the provision of electricity; (2) the government should encourage and support the utilization of the abundant renewable energy sources in the country (renewable energy components such as solar, wind and geothermal) which will not only increase the revenue base of the nation but also reduce the emission of hazardous pollutants associated with the use of non-renewable energy sources; and (3) greater commitment to achieving

Keywords: *fossil fuel, dynamic OLS, energy consumption, economic growth*

Introduction

Energy is globally regarded as a propelling force behind any economic activity and indeed industrial production. Therefore, high grade energy resources will amplify the impact of technology and create tremendous economic growth. High grade resources can act as facilitator of technology while low grade resources can dampen the forcefulness of new technology (Onakoya et al. 2013).

In Nigeria, energy serves as the pillar of wealth creation evident by being the nucleus of operations and engine of growth for all sectors of the economy. The output of the energy sector (petroleum products) usually consolidate the activities of the other sectors which provide essential services to direct the production activities in agriculture, manufacturing, mining, commerce etc. Nigeria is endowed with abundant energy resources but suffers from perennial energy crisis which has defied solution. Ironically, while Nigerian energy resources, particularly oil, are exported to other countries; its people and economy suffer from severe shortages of the same product. This is manifested by the epileptic supply of electricity and perennial shortage of most petroleum products.

As a matter of fact, these studies have one way or the other proven that increase or decrease accrued to energy consumption has the potential to impact economic growth, depending on whether the country in question imports or exports the energy as put by (Evangelia, 2001, Sadorsky, 2001). Some other studies focused on the impact of a particular individual macroeconomic factor and oil price changes. For instance, a study by Vipin and Matthew (2012) has revealed that oil price upset responds speedily to short and long term U.S. and international real interest rate.

First, the Nigerian energy sector has experienced remarkable transformation since the country's independence in 1960. From nearly zero oil production in the early 1960's, Nigeria has become a major player in the international oil market by the turn of the New Millennium. While the discovery of oil and its exploration in commercial quantities has brought about unprecedented transformation in the structure of the economy. Attempts at economically utilizing the huge flared gas in the country have not been commendable.

In spite of the fluctuations in the total energy consumption, the country has continued to record some reasonable progress from the perspective of economic growth as measured by the growth rate in the real GDP which has consistently been above 6 percent in the last ten years (Conscientia 2014).

Empirical literature review

The current patterns of energy production and use, which have shaped the development process in the past, are unsustainable. The energy challenge now faced by countries around the world is to provide energy services that allow all people to achieve a decent standard of living, consistent with sustainable human development. This link between energy, growth and development remains a key factor in development policy. It will be shaped by current trends of globalization, markets and popular participation in decision-making processes, the changing roles of government and energy utilities, and the mix of sources of external funding.

The literature is beset with studies on the relationship between energy (fossil fuel/non renewable) consumption and economic growth. The results of the various test conducted by Fagge (2015), re-examine the causal relationship between energy consumption and economic growth in Nigeria in a multivariate framework by including labour and capital in the causality analysis, Using Granger causality test, impulse response and variance decomposition analysis.

The empirical result shows the absence of causality between energy consumption and economic growth suggests that the country can pursue an expansive or conservative energy policy without undermining its economic growth. Results of the variance decomposition showing labour and capital as the most important factors in output growth, implies that in order to sustain high economic growth in the long-run, the country needs to increase the efficiency of its workforce and expand its saving capacity to generate more capital. Onakoya, Olatunde, Jimi-Salami and Odedairo (2013), evaluates the causal nexus between energy consumption and Nigeria's economic growth for the period of 1975 to 2010. Secondary time-series data were analyzed using co-integration and ordinary least square techniques.

The result shows that in the long run, total energy consumption had a similar movement with economic growth except for coal consumption. The empirical results reveal that petroleum, electricity and the aggregate energy consumption have significant and positive relationship with economic growth in Nigeria. However, gas consumption although positive, does not significantly affect economic growth. The impact of coal was negative but significant. Adegboye and Babalola (2017), re-examined the causal relation between energy consumption and economic growth in Nigeria. Oyaromade, (2014), investigate the relationship between total energy consumption and economic growth in Nigeria using Granger Causality. The study finds no clear relationship between energy consumption and economic growth. Real GDP was found not to cause energy consumption while energy consumption was also found not to cause real GDP. Olusanya (2012), investigates the long run relationship between energy consumption and the economic growth in Nigeria from the period of 1985 to 2010. The results revealed that Petroleum, Electricity are positively related to Nigeria economic growth while coal and Gas shows that there is a negative relationship with Nigerian economic growth. Kabir et al. (2013), evaluate the relationship between energy consumption and national income in Nigeria for the periods 1990 to 2010. Pearson correlation coefficient was used to determine the nature of the relationship that exist between energy consumption and national income while Granger causality test was employed to identify the direction of the relationship. They found a strong positive relation between energy consumption and national income and it is energy consumption that Granger causes national income for the period (1991 to 2010) under study. Kehinde et al. (2012), determine the direction of causality between energy consumption (EC) and economic growth (EG), in Nigeria using annual data from 1981 to 2009. Their findings based on Granger causality test suggest the existence of a unidirectional causal relationship between real GDP and crude oil consumption with direction from crude oil consumption. Also, we found out the existence of a uni-directional causal relationship between real GDP and gross fixed capital formation and total labour force with direction from the gross domestic product to the two variables. Meanwhile, causality relationship is virtually inexistence between coal consumption, total electricity consumption and real GDP. Ifeakachukwu and Akinbobola (2017), examined the nexus between components of aggregate energy consumption and sectoral output in Nigeria for the period spanning 1980 to 2014. The study utilized the Vector Auto-regressive (VAR) and Vector Error Correction (VEC) techniques. Thus, the study observed that the direction of causation between components of energy consumption and output of individual sectors differed. Gbadebo and Okonkwo (2009), investigates the relationship between energy consumption

and the Nigerian economy from the period of 1970 to 2005. The energy sources used to test for this relationship were crude oil, electricity and coal. By applying the co-integration technique, the results derived infer that there exists a positive relationship between current period energy consumption and economic growth. With the exception of coal which was positive, a negative relationship was noted for lagged values of energy consumption and economic growth. Bernard and Oludare (2016), investigates the contribution energy consumption on output of industrial sector in Nigeria. Time series data from the period of 1980 to 2013 on energy consumption and industrial output was employed. The error correction mechanism was used to analyse energy consumption (oil consumption, gas consumption, electricity consumption and coal consumption) and the output of industrial sector in Nigeria. In addition to the explanatory variable is carbon dioxide emission from the use of energy in Nigeria. The ECM result provides strong evidence in support of convergent relationship between energy consumption and industrial output in Nigeria.
This survey of the literature has shown diverse results, but the consensus is that the impact of energy on social, economic and welfare development in the country is manifest (Onakoya et al. 2013).

Brief overview of fossil fuel energy in Nigeria
Nigeria is well endowed with huge reserves of various types' of non-renewable energy resources. Non-renewable energy resources (also called fossil fuels) on the other hand include fuel, gas, tar sands and coal in Nigeria.
Fossil energy are originated from remains of organic matter that are preserved in the earth's crust Byrne (2001, STS). But the energy released from burning fossil fuel is obtained from solar radiation that has been converted into biomass through photosynthesis and then store in fossil form (Byrne 2001) and Blunden and reddish (2003). During the burning of fossil fuel, light and heat is being given off as a result of the released of hydrogen gas and carbon substances which is contained in the fuel (STS). Fossil fuel energy consumption (% of total) in Nigeria was reported at 19.04 % in 2004, (according to the World Bank collection of development indicators). Fossil fuel includes the following fuels, coal, crude oil, natural gas and synthetic fuel (gas from coal).

Crude Oil

The first search for oil in Nigeria started in 1908 by a German company called the Nigerian Bitumen Corporation. Its operations were disrupted by World War 1. The second exploration was by the Shell BP Company of Nigeria in 1937, but this was again disrupted by the Second World War which ended in 1945. The company continued exploration after the war until commercial oil was discovered in 1956. Other companies later joined Shell in the search for oil. Seven oil companies popularly known as the "Seven Majors" in oil exploration were involved (Anyawuocha, 1993). Oil is the most widely use of fossil fuel. It consists of many different organic compounds which are transferred to products in a refining process.

Natural gas

Nigeria is gifted with high natural gas reserve in Africa, but has low infrastructure to expand the sector which leads to the flaring of the gas. Most of the natural gas reserves are situated in the Niger Delta. Nigeria generates about 820 billion cubic feet natural gas, consumed about 255 cubic feet mostly for electricity production where natural gas accounted for 60 percent of electricity production in 2009, because of low or inefficient equipment to produce and supply natural gas. Nigeria flared 536 billion cubic feet gas in 2010, that is about a third of gross natural gas produced in 2010 (International Energy Agency, 2011). Natural gas is use for cooking, lighting and operation of electrical appliances.

Coal

This is the first commercial fuel used in Nigeria when 24 000tons were produced. In 1959, production was close to one million tons, before reducing to the present insignificant level, due to the reduction in demand for coal to the demand for gas and petrol for thermal power generation. Coals are of different types: Lignite, Sub bituminous, and Bituminous Anthracite Lucy Davou Choji (2014).

Despite the enormous energy resources, crude oil, gas and coal are currently been processed and utilized on large scale in Nigeria. Only an all-encompassing strategic planning and effective implementation of the plans for the energy sector can overcome the challenges of sustainable energy supply in the country.

The low productivity and revenue loses to firms and government establishments. If fossil fuel are well supply, can be used as an alternative to electricity and a lot can be done.

Methodology

Empirical framework and models

The theoretical framework of this paper is the endogenous growth theory. The theory argues that economic growth can be achieved within a system as a result of internal processes and that human capital can be improved through technological advancement. Investment in human capital and innovation positively contribute to economic growth Maji and Sulaiman, (2019). The rationale of choosing this theory is that: First, the relevance of capital stock and human capital (labour) in economic growth has since been emphasized in the endogenous growth model (see Barro, 2003). Second, the theory has technological advancement and/or innovation component that enhances economic growth within a system. This second reason provides a safe ground to include fossil fuel energy (nonrenewable energy source) in a growth model as an additional input requirement. Additionally, it has recently been stressed that capital requires the use of energy, as such; energy is also an important requirement in the production process (Adewuyi and Awodumi, 2017a). Furthermore, growth model has been augmented by including energy consumption in the literature (see, Rafindadi and Ozturk, 2016; Streimikiene, 2016; Inglesi-Lotz, 2016). However, this study used conventional energy. Hence, the augmented endogenous growth model is presented as follows.

$$Y = f\,(A, L, K,) \qquad (1)$$

If $A = f$ (FC, INTR and POP), then we can safely re-write the augmented endogenous growth model as follows:

$$Y = f\,(FC, INTR, POP, L, K) \qquad (2)$$

Where Y represents economic growth, FC denotes fossil fuel energy, INTR represents interest rate, POP represents population, L represents labour, K indicates capital.

Unit Root Test

Since the use of the VECM requires the series to be cointegrated with the same order, it is essential to first test the series for stationarity. A series is said to be non-stationary, if it has a non-constant mean, variance and auto covariance over time. If a non-stationary series has to be differenced d times to become stationary, then it is said to be integrated of order d: i.e. I(d). This first step is essential because the causality tests are very sensitive to the stationarity of the series (Stock and Watson, 1989) in Bellomi (2009), and the majority of macroeconomic series are nonstationary (Nelson and Plosser, 1982). Therefore, the augmented Dickey and Fuller (ADF) and the Phillips and Perron (PP) tests will be performed to test whether the data are difference stationary or trend stationary.

Cointegration Test

Once we found that the variables are non-stationary at their level and are in the same order of the integration i.e., integrated of order one or more, the Johansen and Juselius (1990) cointegration test can be applied. According to Koop (2005), if cointegration is present, then not only do we avoid the spurious regression problem, but we also have important economic information (e.g. that an equilibrium relationship exists or that two series are trending together). The stationary linear combination is called the cointegrating equation and may be interpreted as a long-run equilibrium relationship among the variables.

The presence of a cointegrating relation forms the basis of the VEC specification. To illustrate the VAR-based cointegration tests using the methodology developed in Johansen (1991, 1995a), we consider a VAR of order p: $y_t = A_1y_{t-1} + \ldots + A_py_{t-p} + Bx_t + E_t$ (3)

where y_t is a k-vector of non-stationary I(1) variables, x_t is a d-vector of deterministic variables, and E_t is a
vector of innovations. We may rewrite this VAR as:

$$\Delta yt = \Pi y_{t-1} + \Sigma^{p-1}_{i=1} \Gamma_i \Delta y_{t-i} + Bx_t + E_t \qquad (4)$$

Where $\Pi = \Sigma_{i=1}^{p} A_i - I$, $\Gamma_i = -\Sigma_{j=i+1}^{p} A_j$

Granger's representation theorem asserts that if the coefficient matrix Π has reduced rank $r < k$, then there exist $k \times r$ matrices ∝ and β each with rank r such that $\Pi = \alpha\beta'$ and $\beta' y_t$ is I(0). r is the number of cointegrating relations (the cointegrating rank) and each column of β is the cointegrating vector. Since the Pedroni's (1999, 2004) approach allows for cointegration test in a model containing more than one exogenous variable, the long-run model can be parameterized as follows:

$lnY_t = \gamma_t + \delta_t + \pi_1 ilnFC_t + \pi_2 lnTR_t + \pi_3 lnPOP_t + \pi_4 lnL_t + \pi_5 lnK_t + \mu_t$ .... (5)

$lnY_t = \gamma_t + \delta_t + \pi_1 ilnDNG_t + \pi_2 lnTR_t + \pi_3 lnPOP_t + \pi_4 lnL_t + \pi_5 lnK_t + \mu_t$ ....(6)

$lnY_t = \gamma_t + \delta_t + \pi_1 ilnCOC_t + \pi_2 lnTR_t + \pi_3 lnPOP_t + \pi_4 lnL_t + \pi_5 lnK_t + \mu_t$ ....(7)

The cointegration rank in this study will be carried out using maximum eigenvalue and trace statistics.

$\mu_t = \rho_t \mu_t - 1 + \varepsilon_t$ (8)

t = 1, . . . , T refers to the time period. Y represents GDP per capita, FC denotes fossil fuel/nonrenewable energy consumption, TR represents interest rate, POP represents population, L refers to
Labour, K is the level of capital while π represent the elasticities to be estimated. The parameters γt and δ respectively allow for country specific effects and deterministic trend effects. The symbol μt is error term expected to be normally and identically distributed with zero mean and constant variance. We expect that the elasticities π_1, π_2, π_3 and $\pi_4 > 0$, however, in event of inefficient utilization of production input and absence of political stability, then, π_1, π_2, π_3 and $\pi_4 < 0$.

The long-run equilibrium model in Eq. (5, 6 and 7) can be estimated using the Dynamic Ordinary Least Squares (DOLS). The DOLS has the capacity to correct endogeneity, simultaneity and serial correlation problem through the differenced leads and lags. Thus, in order to generate unbiased estimator of long-run estimates, DOLS augments the static regression with leads, lags and the contemporaneous values of Regressor in first difference (Mc- Coskey and Kao, 1998; Kao and Chiang, 2000). Besides, the use of DOLS estimator for this study was informed due to its asymptotic efficiency and robustness in a small sample. Moreover, the Fully Modified Ordinary Least Squares (FMOLS) and the Ordinary Least Squares (OLS) are further used to serve as a robustness check.

The sample period runs from1980 to 2016 based on the annual time series data availability. The data originate from the world development indicator data base; the World Bank, United State Energy Information Administration and OECD National Accounts data files. All variables are employed with their natural logarithms form to reduce heteroskedasticity and to obtain the growth rate of the relevant variables by their differenced logarithms.

The variable for fossil fuel/nonrenewable energy consumption is measured as fossil fuel energy consumption (% of total) the variable for dry natural gas is measured as Nigeria dry natural gas consumption by Year, the variable for crude oil is measured as Nigeria crude oil consumption by Year, the variable for population is measured as Population, total [SP.POP.TOTL], the variable for economic growth is measured as GDP per capita (constant 2010 US$), the variable for labour was measured as Labor force, total [SL.TLF.TOTL.IN] while that of capital was measured as Gross fixed capital formation (constant 2010 US$). The use of GDP per capita and labour in this work is consistent with recent literature (see Dogan, 2016)

The Models

The main objective of this research is to examine the impact of fossil fuel and some of its components (dry natural gas and crude oil) on economic growth in Nigeria over the period of study. The model which consists of seven variables (economic growth (GDP), fossil fuel energy consumption (FC), Interest rate (TR), population (POP), capital (KF), labour (LF), dry natural gas (DNG), and crude oil (COC)) is set as follows:

Fossil Fuel Energy

$$InGDP_t = \beta_0 + \beta_1 InFC_{t-1} + \beta_2 InTR_{t-1} + \beta_3 InPOP_{t-1} + \beta_4 InLF_{t-1} + \beta_5 InKF_{t-1} + \mu_t \quad (9)$$

Dry Natural Gas

$$InGDP_t = \beta_0 + \beta_1 InDNG_{t-1} + \beta_2 InTR_{t-1} + \beta_3 InPOP_{t-1} + \beta_4 InLF_{t-1} + \beta_5 InKF_{t-1} + \mu_t \quad (10)$$

Crude Oil

$$InGDP_t = \beta_0 + \beta_1 InCOC_{t-1} + \beta_2 InTR_{t-1} + \beta_3 InPOP_{t-1} + \beta_4 InLF_{t-1} + \beta_5 InKF_{t-1} + \mu_t \quad (11)$$

Where: GDP represents GDP per capita, FC denotes fossil fuel/nonrenewable energy consumption, DNG represents dry natural gas, COC represents crude oil, TR represents interest rate, POP represents population, L refers to labour, K is the level of capital while **β_1 to β_5** represents the slope coefficients, **β_0** is the intercept, ***U_t*** is the stochastic term or the error term at time t.

Results and discussion

Before estimation of the DOLS model, the stationarity property was defined employing the Augmented Dickey Fuller (ADF) and Phillip- Perron (PP) methodology. Phillip-Perron test is included to integrate residual variance that eliminates auto-correlation in the process of unit roots test, summary statistics and correlation tests were conducted. Equally, Johansen and Juselius (1990) cointegration tests were then performed to ascertain the existence of a long-run relationship between the variables.

Table A.1 reports the results of the unit root tests (in Appendix). The results from Bernard and Oludare (2016), ADF-Fisher suggest that all the variables become stationary at first difference except the coal consumption which is stationary level. Also the results from Olusanya and Olumuyiwa (2012), ADF-Fisher and PP-Fisher suggest that all the variables become stationary at first difference. For instance, the result shows that the variable of economic growth measured by per capita GDP is not stationary at level except for ADFFisher. However, economic growth is stationary at first difference for Olusanya and Olumuyiwa (2012), ADFFisher and PP-Fisher. Similarly, the variable of fossil fuel energy measured by fossil fuel energy consumption (% of total) formally becomes stationary at first difference. Furthermore, none of the considered unit root reveals stationarity of labour force at level but all methods show that labour force is stationary at first difference. Again, the variable of capital was formally stationary at first difference I(1). The fact that all the variable included in the estimation were formally stationary at I(1) also informed the use of DOLS as the estimator technique. Table A.2 (in Appendix) presents the summary of the descriptive statistics which include mean, median, standard deviation, minimum, maximum, skewness, Kurtosis and the total observation. The values of the Kurtosis indicate that the series are normally distributed. Table A.3 (in Appendix) displays the correlation matrix of all the variables. Importantly, the correlation matrix shows no high correlation between the explanatory variables. As such, we can safely conclude that our model is free from multicollinearity problem because the rule of thumb is that the persistence of the correlation

IJMSE ISSN-2041-1787 (Print)

coefficient among engaged variable should be less than 0.800 (Asongu et al., 2017b). The highest value of correlation coefficients in Table A.2 is 0.7804.

Next, we checked the existence of cointegration relationship among our modelled variables using Johansen and Juselius (1990) cointegration tests (see Table 1,2 and 3). The empirical findings of Johansen co-integration tests reveal that both the Eigen and Trace tests indicate the existence of a consistently co-integrating vector or long-run equilibrium relation among variables during the sample period of 1980-2016, as we could reject the null hypothesis of the tests. The null hypothesis of the tests suggests no cointegration among the variables. When the values of the test were estimated, linear deterministic trend was assumed. The lag interval in first differences is one (i.e. 1 to 1).

Under Olusanya and Olumuyiwa (2012), the result also reveals that there is one Co-integration equation(s) at both 1% and 5% levels, and this indicates a long run equilibrium relationship between Real Gross Domestic Product and its explanatory variables (Petroleum Consumption (PT), Electricity consumption (EC), Gas Consumption, and Coal Consumption. Bernard and Oludare (2016), they employed Johansen multivariate cointegration approach. The result shows that Trace test and Maximum Eigenvalue provided support for long-run equilibrium relationship between variables. Hence both suggest the existence of a long-run relationship between the variables.

Equally, in this study the Johansen and Juselius (1990) cointegration test statistic for all models is significant; the trace test indicates that there are six (6) co-integrating equations at the 5 per cent level. Moreover, the maximum Eigen value test indicates three (3) co-integrating equations at 5 per cent level which suggests the existence of a long-run relationship between the same variables. Therefore, rejecting the null hypothesis of no cointegration confirms the existence of a long-run relationship among the variables, as suggested by results.

Having confirmed the existence of a long-run relationship between the variables, the long-run model is estimated using DOLS. Table 4, 5 and 6 reports the estimated long-run results. Firstly, the fossil fuel consumption is estimated. Secondly, the components of fossil fuel (Crude Oil and Dry Natural Gas) energy consumption are estimated in two different models, respectively. The results for all the estimation indicate that fossil fuel energy consumption, crude oil consumption and the dry natural gas consumption has a significant negative effect on economic growth. The results of robustness checks from FMOLS.

Table 1
Unrestricted Co-Integration Rank Test
Fossil Fuel

Null Hypothesis (H_0)	Alternative Hypothesis (H_1)	Max-Eigen Statistics	Trace Statistics	0.05 Critical Value (Eigen)	0.05 Critical Value (Trace)
r = 0	r = 1	60.39191	160.0285	40.07757	95.75366
r = 1	r = 2	43.65703	99.63661	33.87687	69.81889
r = 2	r = 3	21.69516	55.97958	27.58434	47.85613
r = 3	r = 4	16.87040	34.28442	21.13162	29.79707
r = 4	r = 5	9.575085	17.41402	14.26460	15.49471
r = 5	r = 6	7.838936	7.838936	3.841466	3.841466

Source: Extract from estimation output using E-views9

Table 2 Unrestricted Co-Integration Rank Test
Oil

Null Hypothesis (H_0)	Alternative Hypothesis (H_1)	Max-Eigen Statistics	Trace Statistics	0.05 Critical Value (Eigen)	0.05 Critical Value (Trace)
r = 0	r = 1	60.39191	160.0285	40.07757	95.75366
r = 1	r = 2	43.65703	99.63661	33.87687	69.81889
r = 2	r = 3	21.69516	55.97958	27.58434	47.85613
r = 3	r = 4	16.87040	34.28442	21.13162	29.79707
r = 4	r = 5	9.575085	17.41402	14.26460	15.49471
r = 5	r = 6	7.838936	7.838936	3.841466	3.841466

Source: Extract from estimation output using E-views9

Table 3 Unrestricted Co-Integration Rank Test
Gas

Null Hypothesis	Alternative	Max-Eigen	Trace	0.05 Critical	0.05 Critical

(H_0)	Hypothesis (H_1)	Statistics	Statistics	Value (Eigen)	Value (Trace)
r = 0	r = 1	60.39191	160.0285	40.07757	95.75366
r = 1	r = 2	43.65703	99.63661	33.87687	69.81889
r = 2	r = 3	21.69516	55.97958	27.58434	47.85613
r = 3	r = 4	16.87040	34.28442	21.13162	29.79707
r = 4	r = 5	9.575085	17.41402	14.26460	15.49471
r = 5	r = 6	7.838936	7.838936	3.841466	3.841466

Source: Extract from estimation output using E-views9

OLS equally yield the same negative and significant coefficients. It suggests that an increase in fossil fuel energy consumption, crude oil consumption and dry natural gas consumption in Nigeria marginally reduces economic growth. The finding is consistent with the findings of other researchers in Nigeria.
Gbadebo et al. (2009) reported that, a negative relationship was noted for lagged values of energy consumption and economic growth. Oyaromade, Matthew and Abalaba (2014) He also reported that, no clear relationship between energy consumption and economic growth. Real GDP was found not to cause energy consumption while energy consumption was also found not to cause real GDP. These findings does not come as a surprise, as there is inefficiency in the use of fossil fuel energy in the country, and also the Burning fossil fuels contribute to global warming and greenhouse effect by upsetting the natural balance of carbon dioxide (Co2) and it is detrimental to the human's health which affect the productivity of the labour force and indirectly their purchasing power as they go to hospital for medical attention. The conventional/fossil fuel energy is resources which can run out sooner or later and cannot be replaced (Chibueze, Jude and Nnaji (2013)).

Table 4 Impact of fossil fuel consumption on economic growth,

Variables	GDP= *f*(FC, KF, LFT, TR, POP)		
	DOLS Coefficient	FMOLS Coefficient	OLS Coefficient
lnFC	-0.6822***	-0.2798	-0.3082*
	(-4.5296)	(-0.8870)	(-1.1043)

lnKF	0.2975*** (5.7683)	0.3359*** (5.0339)	0.3209*** (5.6272)
lnLFT	-1.8495*** (-6.7197)	0.5543* (1.2489)	0.5352* (1.2914)
lnTR	-0.4284*** (-7.5901)	-0.2873*** (-2.9345)	-0.2519*** (-2.7575)
lnPOP	1.4385*** (7.5720)	-0.0147* (-0.0450)	0.0841*** (-0.2910)

Note: ***, ** and * indicate significance at 1%, 5% and 10% levels, respectively. While figures in parentheses are t-statistic. lnKF , is the natural logarithm of capital formation, lnLFT is the natural logarithm of labour force total, InTR is the natural logarithm of interest rate, InPOP is the natural logarithm of population and InFC is the natural logarithm of fossil fuel consumption.

Table 5
Impact of crude oil consumption on economic growth,

Variables	GDP= *f*(COC, KF, LFT, TR, POP)		
	DOLS Coefficient	FMOLS Coefficient	OLS Coefficient
lnCOC	-0.7946** (-2.5827)	-0.8290*** (-2.8338)	-0.7400*** (-2.9960)
lnKF	-1.7763*** (3.5056)	0.2756*** (5.1253)	0.2598*** (5.3392)
lnLFT	-1.7763*** (-4.8552)	0.2359 (0.5713)	0.2192 (0.5701)
lnTR	-0.3792*** (-6.6829)	-0.1625** (-2.2920)	-0.1735*** (-2.6398)
lnPOP	1.9770*** (5.4728)	0.5276* (1.4899)	0.4893* (1.4843)

Note: ***, ** and * indicate significance at 1%, 5% and 10% levels, respectively. While figures in parentheses are t-statistic. lnKF , is the natural logarithm of capital formation, lnLFT is the natural logarithm of labour force total, InTR is the natural logarithm of interest rate, InPOP is the natural logarithm of population and InCOC is the natural logarithm of crude oil consumption.

Table 6 Impact of dry natural gas consumption on economic growth,

Variables	GDP= *f*(NDC, KF, LFT, TR, POP)		
	DOLS Coefficient	FMOLS Coefficient	OLS Coefficient
InNDC	-0.1142 (-0.9705)	-0.0601 (-0.6461)	-0.0993* (-1.2941)
InKF	0.1020* (1.1525)	0.3058*** (4.6691)	0.2694*** (4.8165)
InLFT	-1.5751*** (-3.2782)	0.7597* (1.7138)	0.6450* (1.6702)
InTR	-0.2612*** (-3.6130)	-0.1966** (-2.3596)	-0.1887** (-2.6003)
InPOP	1.7884*** (3.3081)	-0.0300 (-0.0743)	0.1079 (0.3065)

Note: ***, ** and * indicate significance at 1%, 5% and 10% levels, respectively. While figures in parentheses are t-statistic. lnKF , is the natural logarithm of capital formation, lnLFT is the natural logarithm of labour force total, InTR is the natural logarithm of interest rate, InPOP is the natural logarithm of population and InNDC is the natural logarithm of dry natural gas consumption.

Table A. 1 Unit root tests results

Variables	Form	Method	T-stat & (p-value)	Conclusion
InGDP	Level	ADF	-0.165992 (0.9340)	Non Stationary
		PP	-0.523929 (0.8748)	Non Stationary
	1st difference			
		ADF	-4.850555 (0.0004)	Stationary
		PP	-4.847161 (0.0004)	Stationary
InFC				
	Level	ADF	-2.725929 (0.0801)	Non Stationary

		PP	-2.884008 (0.0577)	Stationary
	1st difference			
		ADF	-5.913799 (0.0000)	Stationary
		PP	-7.600713 (0.0000)	Stationary
lnKF				
	Level	ADF	-1.423977 (0.5598)	Non Stationary
		PP	-1.520479 (0.5120)	Non Stationary
	1st difference			
		ADF	-4.643919 (0.0007)	Stationary
		PP	-4.532060 (0.0009)	Stationary
lnLFT				
	Level	ADF	0.368751 (0.9787)	Non Stationary
		PP	0.487744 (0.9839)	Non Stationary
	1st difference			
		ADF	-5.901790 (0.0000)	Stationary
		PP	-5.901781 (0.0000)	Stationary
lnTR				
	Level	ADF	-1.373444 (0.5843)	Non Stationary
		PP	-1.387331 (0.5776)	Non Stationary
	1st difference			
		ADF	-7.561656 (0.0000)	Stationary
		PP	-7.407466 (0.0000)	Stationary
lnPOP				
	Level	ADF	1.501799 (0.9989)	Non Stationary
		PP	1.110309 (0.9968)	Non Stationary
	1st difference			
		ADF	-5.911770 (0.0000)	Stationary
		PP	-2.331937 (0.1681)	Non Stationary
	2nd difference			
		PP	-4.364650 (0.0015)	Stationary
lnCOC				
	Level	ADF	-3.259947 (0.0245)	Stationary
		PP	-3.355192 (0.0195)	Stationary
	1st difference			

		ADF	-7.096257 (0.0000)	Stationary
		PP	-8.923326 (0.0000)	Stationary
lnNDC				
	Level	ADF	-2.025565 (0.2751)	Non Stationary
		PP	-1.956671 (0.3038)	Non Stationary
	1st difference			
		ADF	-7.207929 (0.0000)	Stationary
		PP	-10.17984 (0.0000)	Stationary

Note: lnGDP is the natural logarithm of gross domestic product, lnFC is the natural logarithm of fossil fuel consumption, lnKF , is the natural logarithm of capital formation, lnLFT is the natural logarithm of labour force total, InTR is the natural logarithm of interest rate, InPOP is the natural logarithm of population, InCOC is the natural logarithm of crude oil consumption and InNDC is the natural logarithm of dry natural gas consumption.

A. 2 Descriptive Statistics

	lnGDP	lnFC	lnKF	lnLFT	lnTR	lnPOP	lnCOC	lnNDC
Mean	7.3888	2.9736	10.7944	17.4893	3.8508	18.5744	5.5409	5.2685
Median	7.2633	2.9712	10.7302	17.4276	3.9664	18.5724	5.5722	5.2627
Maximum	7.8490	3.1287	11.8068	17.8924	4.4044	19.0412	5.7430	6.4998
Minimum	7.0485	2.7654	9.7864	17.2030	3.0312	18.1123	5.1358	3.6376
Std. Dev.	0.2678	0.0837	0.5135	0.205	0.3870	0.2779	0.1391	0.6290
Skewness	0.5196	-0.1017	-0.2205	0.4589	-0.7302	0.0153	-0.9180	-0.3916
Kurtosis	1.6783	2.6157	2.1403	1.9763	2.4115	1.8219	3.3296	3.2584
Observations	37	35	37	37	37	37	37	37

Note: lnGDP is the natural logarithm of gross domestic product, lnFC is the natural logarithm of fossil fuel consumption, lnKF , is the natural logarithm of capital formation, lnLFT is the natural logarithm of labour force total, InTR is the natural logarithm of interest rate, InPOP is the natural logarithm of population, InCOC is the natural logarithm of crude oil consumption and InNDC is the natural logarithm of dry natural gas consumption.

From table 6 above, the control variables, denoted by labour and interest rate reveal negative insignificant coefficients, population growth reveal positive significant coefficient, but capital shows positive, negative, significant and insignificant coefficient respectively, as suggested by DOLS estimates for Nigeria. It suggests that population growth is more effective in facilitating economic growth than labour and interest rate in Nigeria. While capital is more effective in fossil fuel and dry natural gas consumption but less effective in crude oil consumption. The robustness checks by FMOLS shows the same pattern of results regarding the coefficient of interest rate in Nigeria. Labour and capital results reveal positive pattern regarding their coefficients. While the result of population growth reveal negative pattern in fossil fuel and dry natural gas consumption but positive in crude oil consumption regarding their coefficients. Equally, the robustness checks by OLS shows the same pattern of results regarding the coefficient of interest rate in Nigeria. While labour, capital and population growth results reveal positive pattern regarding their coefficients. The DOLS result indicates that fossil fuel, crude oil and dry natural gas consumption has a significant negative impact on economic growth in Nigeria. This finding substantiates the earlier result of the impact of fossil fuel consumption and its component (crude oil and dry natural gas) energy on economic growth. Equally, FMOLS and OLS show similar results. The finding further justifies the negative impact of fossil fuel, crude oil and dry natural gas consumption on economic growth.

Conclusion, recommendations and policy implications

This study estimated the relationship between economic growth, fossil fuel energy consumption and its component (Crude Oil and Dry Natural Gas energy consumption) in Nigeria using DOLS by employing a sample of 36 covering the 1980–2016 periods. The estimation was categorized into three models. The first model comprises fossil fuel consumption and four control variables (gross fix capital formation, labour force, interest rate and population growth), which were captured in the main model. The second model consists of crude oil consumption and the same four control variables were used, which were captured in the second model to serve as robustness. Last, the third model also consists of dry natural gas consumption and the same four control variables were used, which also serve as robustness. The results indicate that fossil fuel, crude oil and dry natural gas energy consumption is negatively related to the economic growth of Nigeria. The results for first, second, and third models show a similar pattern, which reveal that the estimates were robust. The finding shows that the conventional/fossil fuel energy and its component (Crude Oil and Dry Natural Gas) used in Nigeria rather slow down economic growth than facilitating it. This could be attributed to the fact that, the participation of private sector in energy (electricity) supply is low and there is inefficiency in the use of conventional/fossil fuel energy in the country and its cost (adverse effects) outweighs its benefits. Therefore, marginally, the use of conventional/fossil fuel energy in Nigeria reduces growth as shown by this study. To validate the outcome of this study from DOLS, the same model was estimated using FMOLS and OLS. The results of both FMOLS and OLS corroborate the finding of DOLS. Thus, the finding can be considered robust and reliable for statistical inference.

The policy recommendations from this study are as follows. The research recommends that government should intensify action in support of policies that encourage private sector participation in the provision of electricity. Also, the research recommends that government should encourage and support the utilization of the abundant renewable energy sources in the country (renewable energy components such as solar, wind and geothermal) which will not only increase the revenue base of the nation but also reduce the emission of hazardous pollutants associated with the use of non-renewable energy sources. Results of the DOLS showing labour and capital as the most important factors in output growth, implies that in order to sustain high economic growth in the long-run, the country needs to increase the efficiency of its workforce and expand its saving capacity to generate more capital. This survey of the literature has shown diverse results, but the consensus is that the impact of energy on social, economic and welfare development in the country is manifest. Last, greater commitment toward achieving sustainable renewable energy is needed in the country.

References

Abiodun A.A (2017). *Energy Consumption and Economic Growth Nexus: A Re-Examination of Causal Evidence in Nigeria.* Journal of Applied Economics and Business Research JAEBR, 7(1): 19-37 (2017).

Adeyemi and Ogundipe (2013). *Electricity Consumption and Economic Growth in Nigeria.* Scientific Papers (www.scientificpapers.org) Journal of Business Management and Applied Economics 1 Vol. II, Vol. II, Issue 4 July 2013.

Agbede M. O. (2018). Disaggregate Energy Supply and Industrial Output in Nigeria. *International Journal of Economics, Business and Management Research Vol. 2, No. 02; 2018 ISSN: 2456-7760. www.ijebmr.com.*

Ahmed A. (2015). *Independence of Domestic Gas Consumption on Nigerian Economy.* Proceedings of The IRES 12th International Conference, Barcelona, Spain, 13th October 2015, ISBN: 978-93-85832-09-3.

Akinbola O.A., Zekeri A., Idowu H.A.O. (2017). The Power Sector and its Impacts on Industrialization of Businesses in Nigeria. *Archives of Business Research – Vol.5, No.12 Publication Date: Dec. 25, 2017 DOI: 10.14738/abr.512.4018.*

Akomolafe A.K.J., Danladi J. (2014). *Electricity Consumption and Economic Growth in Nigeria: A Multivariate Investigation.* International Journal of Economics, Finance and Management VOL. 3, NO. 4, June 2014 ISSN 2307-2466 ©2014.

Alam, M. S (2006). *Economic growth with energy*. Retrieved on the 20th November 2013.

Alege P.O., Oluwasogo S., Adediran, Adeyemi A. Ogundipe (2016). Pollutant Emissions, Energy Consumption and Economic Growth in Nigeria. *International Journal of Energy Economics and Policy, 2016, 6(2), 202-207 ISSN: 2146-4553.*

Anyanwuocha, R.A.I. (1993).*Fundamentals of economics for senior secondary schools*. Onitsha: African-Feb. publishers.

Auty, R. M. (1993). Sustaining Development in Mineral Economies: The Resource Curse Thesis. London: Routledge.

Bernard O.A., and Oludare A. (2016). Is Energy Consumption Relevant to Industrial Output in Nigeria? *European Journal of Research in Social Sciences* Vol. 4 No. 4, 2016 *ISSN 2056-5429, Progressive Academic Publishing, UK.* www.idpublications.org.

Blunden, J. and Reddish, A. (2003). Energy Resources and Environment. London Hodder and Stoughton. Pp.

Bright O. (2013). *Electricity Consumption and Economic Growth in Nigeria.* JORIND 11(2) December, 2013. ISSN 1596-8303. www.transcampus.org/journals; www.ajol.info/journals/jorind.

Byrne Kevin (2001) Environmental Science 2nd Edition, Bath Advanced Science Series, University of Bath.

California Energy Commission (2012).The Energy story. California. Retrieved from http//www.Internationalenergycentre.com/

Central Bank of Nigeria (2010). Statistical Bulletin Retrieved from www. cenbank.org/OUT/2011/PUBLICATIONS/STATISTICS/2010/PartB/PartB.html

Cox, A. & Healey, J. (1999).Promises to the poor.The record of European Development Agencies. London: oversees development institute

Cox,A.(2004).DefinepovertyRetrievedfromhttp//www2.uese.edu/atlas/glossary/html

Emmanuel, R.I. (2005).Cause of Underdevelopment in Nigeria. Unpublished B.Sc. Project, University of Ibadan

Energy Commission of Nigeria (2003).National Energy policy of Nigeria. Abuja: Energy commission of Nigeria

Energy Commission of Nigeria (2006).National Energy policy of Nigeria. Abuja: Energy commission of Nigeria

Energy Information Administration (2010). *International Petroleum Monthly*. February Retrieved from http//www.eia.doe.gov/emeu/ipsr/appc.html

FGN (2011). The Energy commission act. Abuja: Energy commission of Nigeria. P.I.

Gbadebo (2009). Does energy consumption contribute to economic performance? Empirical evidence from Nigeria. Journal of Economics and International Finance Vol. 1(2), pp. 044-058, July 2009 Available online at http://www.academicjournals.org/JEIF

Hall, J.H (2004).Energy and Environmental policies.Minna: Trumpet Book House. From https//www.rseeb.org/

http://www.economicsdiscussion.net/economic-growth/solow-model-of-economic-growth-economics/26284

https://ballotpedia.org/Fossil_fuels

https://comfortasokoroogaji.wordpress.com/2011/09/19/importance-of-energy-to-the-nigerian-economy-by-comfort-asokoro-ogaji/

https://en.m.wikipedia.org/wiki/Energy_in_Nigeria

https://link.springer.com/article/10.1186/2192-0567-2-15

https://link.springer.com/article/10.1186/2192-0567-2-15

https://m.guardian.ng/business-services/demand-for-gas-in-nigeria-outstrips-supply/

https://www.dailytrust.com.ng/news/business/energy-demand-to-rise-in-nigeria-others-in-next-25-years/123163.html

https://www.naija.ng/1120356-importance-crude-oil-nigeria-economy.html

https://www.vanguardngr.com/2014/08/brazil-now-highest-buyer-nigerias-crude/

I.K Maji and Sulaiman (2019). Renewable energy consumption and economic growth nexus: A fresh evidence from West Africa. Energy Reports 5 (2019) 384–392

Ifeakachukwu N.P. (2017). Disaggregate Energy Consumption and Sectoral Output in Nigeria. *Science Journal of Energy Engineering*. Vol. 5, No. 6, 2017, pp. 136-145. doi: 10.11648/j.sjee.20170506.12.

Ifeanyi U.T. and Chioma U.A, (2016). *Empirical Analysis of Electricity Supply on Economic Growth, Evidence from Nigeria1980-2013. Global Journal of Applied, Management and Social Sciences (GOJAMSS); Vol.12 September 2016; P.157 – 165 (ISSN: 2276 – 9013).*

Ikhide and Adjasi (2015). The Causal Relationship between Renewable and Non-Renewable Energy Consumption and Economic Growth: The Case Study of Nigeria. *Paper presented at the Economic Society of South Africa at UCT on the 2nd-4th September 2015.*

International Energy Agency (2007). Renewables in Global Energy supply: An IEA Facts sheet. www.iea.org

International Energy Agency (2011).www.iea.org

Johansen, S. &Juselius, K. (1990). Maximum Likelihood Estimation and Inference on Cointegration – with Applications to the Demand for Money, *Oxford Bulletin of Economics and Statistics*, 52, 2, 169–210.

Kabir A., Zaku S.G., Tukur A.A., Aikhuele J.G. (2013). *The relationship between energy consumption and national income of Nigeria. Journal of Economics and international Finance.* Vol. 5(2), pp. 53-57, May, 2013, DOI: 10.5897/JEIF12.078 ISSN 2006-9812 ©2013 Journals Academic http://www.academicjournals.org/JEIF.

Kehinde A.O., Felix A.O, Kayode K.I., Musibau O.O. (2012). The Causality Between Energy Consumption and Economic Growth in Nigeria (1981 – 2009). *IOSR Journal of Applied Physics (IOSR-JAP) ISSN: 2278-4861. Volume 2, Issue 3 (Nov. - Dec. 2012), PP 01-07 www.iosrjournals.org.*

Lucy D.C. (2014). Energy Demand and Economic Growth in Nigeria. *Eastern Mediterranean University July 2014 Gazimağusa, North Cyprus.*

McConnell, C.R. (2011). Economics: principles, problems and policies, 19thed. New York: McGraw-Hill/Irwin

McCracken, M. (2005).Definition of energy demand.www.teachmefinance.com

Mustapha and Muhammad F. (2015). *Energy Consumption and Economic Growth in Nigeria: A Causality Analysis*. Journal of Economics and Sustainable Development www.iiste.org ISSN 2222-1700 (Paper) ISSN 2222-2855 (Online) Vol.6, No.13, 2015.

National Bureau of Statistics (2010). Retrieved from http//www.nigerianstat.gov.ng /index.php//sectorStatistics

Nurkes, A. (2004).Sustainable Energy Supply in Sweden.www.greenpeace.org

Nwosa and Ifeakachukwu (2012). Aggregate Energy Consumption and Sectoral Output in Nigeria. An International *Multidisciplinary Journal, Ethiopia Vol. 6 (4), Serial No. 27, October, 2012* ISSN 1994-9057 (Print) ISSN 2070--0083 (Online) DOI: http://dx.doi.org/10.4314/afrrev.v6i4.14.

Ohwofasa B.O., Obeh H.O., Arakpoweri .J. (2015). The Impact of Electricity Supply on Economic Growth, 1980-2010: An Error Correction Method. *Research Journal of Finance and Accounting www.iiste.org ISSN 2222-1697 (Paper) ISSN 2222-2847 (Online) Vol.6, No.5, 2015.*

Ojinnaka, I. J. (2008). Energy Crisis in Nigeria, The role of Natural Gas. *The Bullion*, The Publication of Central Bank of Nigeria, 22 (4), 78-97.

Okoligwe N.E. and Ihugba O.A (2014). Relationship between Electricity Consumption and Economic Growth: Evidence From Nigeria (1971-2012). *Academic Journal of Interdisciplinary Studies MCSER Publishing, Rome-Italy Vol 3 No 5 July 2014, E-ISSN 2281-4612 ISSN 2281-3993.*

Olusanya and Olumuyiwa (2012). Longrun Relationship Between Energy Consumption And Economic Growth: *Evidence From Nigeria. IOSR Journal of Humanities and Social Science (JHSS) ISSN: 2279-0837, ISBN: 2279-0845. Volume 3, Issue 3 (Sep-Oct. 2012), PP 40-51 www.iosrjournals.org.*

Onakoya A.B, Onakoya A.O, Jimi-Salami O.A, Odedairo B.O (2013). Energy Consumption and Nigerian Economic Growth: An Empirical Analysis. *European Scientific Journal February 2013 edition vol.9, No.4 ISSN: 1857 – 7881 (Print) e - ISSN 1857- 7431.*

Oyaromade R. Mathew A. Abalaba B.P. (2014). *Energy Consumption and Economic Growth in Nigeria: A Causality Analysis.* International Journal of Sustainable Energy and Environmental Research, *2014 Vol. 3, No. 1, pp. 53-61 ISSN(e): 2306-6253 ISSN(p): 2312-5764© 2014 Conscientia Beam.*

Sambo, A.S. (2008), Renewable Energy options for the environment and sustainable development in Nigeria. Paper presented at the National Workshop on Energy investment and private sector participation at the petroleum training institute, warri.

Sambo, A.S. (2009).Strategic Developments in Renewable Energy in Nigeria. In: IAEE Energy forum, 3rd Quarter Edition. USA: International Association for Energy Economics

Sinclair, J. (1992).*BBC English dictionary*. Hammersmith, London: Harper Collins publishers ltd

Sylvester A.A., Benedict U.A., Kingsley I.I. (2015). *A Var Analysis of the Relationship between Energy Consumption and Economic Growth in Nigeria.* Journal of Economics and Sustainable Development www.iiste.org ISSN 2222-1700 (Paper) ISSN 2222-2855 (Online) Vol.6, No.12, 2015.

The World Fact book - CIA.(2008). Retrieved from https://www.cia.gov/library/ publications/the-world-factbook/rankorder/ 2042rank.html

Ujah, E. (2004), Poverty in Nigeria. In: Vanguard News paper. Lagos: Vanguard Media ltd, April 15,p.4

World Bank (2011). List of economies.World Development Indicators. Washington DC, 11. Retrieved from: http://siteresources.worldbank.org/DATASTATISTICS/ Resources /CLA