Renewable energy consumption and economic growth in Nigeria: any causal relationship?

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Abstract

This study examined the effect of renewable energy consumption on economic growth in Nigeria for the period 1990 to 2016. It further investigated the direction of causality between renewable energy consumption and economic growth in Nigeria. This was with a view to providing information on the relationship between renewable energy consumption and economic growth in Nigeria within the period of the study. Data collected was analysed using both descriptive analysis and econometric technique, which included unit root, correlation, co-integration, regression, and granger causality tests. The result showed that although renewable energy consumption and economic growth increased between 1990 and 2016 in Nigeria, renewable energy consumption had no significant positive impact on economic growth in Nigeria. Furthermore, there was no causality between renewable energy consumption and economic growth in Nigeria during the period of study. The study concluded that renewable energy consumption exerted an insignificant negative impact on economic growth in Nigeria. We recommend that investing in renewable energy should be encouraged and enhanced as this may be a way to reduce domestic fossil fuel consumption or to meet increasing energy demand without an increase of domestic fuel consumption to increase fuel exports and thus for higher revenues.

Introduction

Modern energy services, including renewable energy, have been a prerequisite to sustained development in every advanced economy. According to United Nations Environment Program (UNEP) (2015), renewable energy defined as any energy generated from natural processes including hydropower, geothermal, solar, tides, wind, biomass, and biofuels, made up 53.6% of the total gigawatt capacity of all energy technologies installed in 2015. This excludes large hydroelectric projects. According to (International Energy Agency (IEA) (2015b), renewable energy technologies were becoming much more prevalent in both developed and developing economies as they became cheaper, more reliable, and readily available. During 2015, and for the first time ever, developing economies invested more money into renewable than developed economies (UNEP, 2015). Renewable energy technologies had more benefits to developing countries than merely being environmentally friendly. They also could provide protection against future price increases in conventional fuels by diversifying the energy portfolio, aid in the balancing of both budget and trade deficits and created new local economic opportunities which supported poverty reduction and promoted economic growth (Worldwatch, 2005; REN21, 2015).

Given the importance of renewable energy in promoting economic growth, the empirical literature studying the relationship between renewable energy and economic growth has expanded considerably in the last decade. For instance, Khobai (2017) investigates the causal relationship between renewable energy consumption and economic growth in South Africa. It incorporates carbon dioxide emissions, capital formation and trade openness as additional variables to form a multivariate framework. His study determined the direction of causality between the variables using the Vector Error Correction Model (VECM). The results indicated the existence of a unidirectional causality flowing from renewable energy consumption to economic growth in the long run while the short run results suggested a unidirectional causality flowing from economic growth to renewable energy consumption. Amri (2017) examined the relationship between economic growth and energy consumption under two categories- renewable and non-renewable energy consumption. Using the ARDL model, he found that in both the short and long run relationship, there exist a bidirectional causality between non-renewable energy consumption and economic growth while a unidirectional causality from renewable energy consumption to economic growth exist in the long run. Halkos and Tzemes (2014) investigated the link between electricity consumption from renewable sources and economic growth for 36 countries covering the period between 1990 and 2011. They analyzed the entire sample of countries and then grouped the countries into sub-samples. The results for the entire sample of countries established that the relationship increases only up to a certain level of economic growth. A highly non-linear relationship was realized for emerging and developing countries while for developed countries, an increasing non-linear relationship was observed.

Energy is an imperative enabler that affects many aspects of economic and human development. Thus, economic growth and development may be constrained without adequate energy capacity and access to affordable modern energy services. While modern energy services have been a prerequisite to sustained development in every advanced economy, energy access was often a prevalent problem in developing countries in general and specifically in Nigeria, as evidenced by the fact that over two-thirds of Africans lack access to electricity (IEA, 2015a). Encouragingly, Nigeria has huge renewable resources, which remained untapped including solar, hydroelectric, wind in coastal areas and geothermal in the northern region. In addition, past studies have been inconclusive as to what type of relationship exists between renewable energy and economic growth and there are few independent analyses of the Nigerian case as regard to growth. As such, this study sets out to answer the following the following research questions: What is the relationship between renewable energy consumption and economic growth in Nigeria? Is there a causal relationship between renewable energy consumption and economic growth in Nigeria?

Thus, given the role of renewable energy in enhancing sustainable development, and to provide answers to the above research questions, this study empirically investigated the relationship between renewable energy consumption and economic growth in Nigeria. This was done using secondary data covering the period 1990 to 2016 while the estimation included both qualitative (descriptive) analysis and quantitative analysis involving unit root test, cointegration test, regression analysis and granger causality test.

Literature Review

Several empirical studies have investigated the relationship between economic growth and renewable energy consumption or renewable electricity consumption either within country context or panel data studies.

Among these studies are Sari, Ewing, and Soytas, (2008). Using a sample period that covers 2001:1 to 2005:6, they investigated the relationship between disaggregate energy consumption and industrial production in the United States using the autoregressive distributed lag (ARDL) approach. They focused attention on the following energy consumption variables: coal, fossil fuels, conventional hydroelectric power, solar energy, wind energy, natural gas, wood, and waste. Their results indicate that real output and employment are long run forcing variables for nearly all measures of disaggregate energy consumption. Odularu and Okonkwo (2009) investigate 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 cointegration 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. The implication of the study is that increased energy consumption is a strong determinant of economic growth having an implicit effect in lagged periods and both an implicit and explicit effect on the present period in Nigeria.

Yildirim, Sarac and Aslan, (2012) study was on energy consumption and economic growth in the USA: Evidence from renewable energy. Their study focuses on the first issue by applying Toda-Yamamoto procedure and bootstrap-corrected causality test for the US since empirical literature criticizes the Toda-Yamamoto test, which bases on asymptotic distribution. The models consist of real GDP, employment, investment, and kinds of renewable energy consumption. Only one causal relationship was found from biomass-waste-derived energy consumption to real GDP. No causal relationship was found between real GDP and all of the other renewable energy kinds-total renewable energy consumption, geothermal energy consumption, hydroelectric energy consumption, biomass energy consumption and biomass-wood-derived energy consumption. That is using of energy from waste cause not only solving the dumping problems but also it contributes to real GDP. For policy purpose, the results of this study suggest that countries should concentrate on energy producing from waste as an alternative energy resource.

Pao and Fu (2013) examined the relationship between renewable energy, non-renewable energy, and economic growth in Brazil. Their study employed data from 1980 to 2010 to explore the causal relationships between the real GDP and four types of energy consumption: non-hydroelectric renewable energy consumption (NHREC), total renewable energy consumption (TREC), non-renewable energy consumption (NREC), and the total primary energy consumption (TEC). They found a long-run equilibrium among Brazil's real GDP, labour, capital, and each of the four types of consumption. Also, the influence of NHREC/TREC on real output was positive and significant, while the impacts by NREC/TEC are insignificant. The results from the vector error correction models reveal a unidirectional causality from NHREC to economic growth, a bidirectional causality between economic growth and TREC, and a unidirectional causality from economic growth to NREC or TEC without feedback in the long run. They concluded that their findings suggest that Brazil is an energy-independent economy and that economic growth is crucial in providing the necessary resources for sustainable development. Ogundipe and Apata (2013) examined the relationship between electricity consumption and economic growth in Nigeria using the Johansen and Juselius Co-integration technique based on the Cobb-Douglas growth model covering the period 1980 to 2008. The study also conducted the Vector Error Correction Modeling and the Pair wise Granger Causality test in order to empirically ascertain the direction of causality between electricity consumption and economic growth. The study found the existence of a unique co-integrating relationship among the variables in the model with the indicator of electricity consumption have a significantly impact on growth. Also, the study shows an evidence of bi-directional causal relationship between electricity consumption and economic growth.

Leitao (2014) applied time series (OLS, GMM, VECM and Granger causality) to examine the relationship between economic growth, carbon dioxide emissions, globalization and renewable energy in Portugal, and he concluded that renewable energy, carbon dioxide emissions, globalization are correlated positively with economic growth, and causality test indicated conservation hypothesis between renewable energy and economic growth. Lin (2014) concluded that there is bidirectional long-term causality between economic growth and renewable energy consumption in China by applying Granger causality test. Apergis and Danuletiu (2014) using the Canning and Pedroni (2008) long-run causality test examined the relationship between economic growth and renewable energy consumption for 80 countries and concluded bidirectional causality between renewable energy consumption and economic growth in the long-run. Kazar and Kazar(2014) investigated the relationship between development and renewable electricity net generation values for 154countries with panel analysis and found the presence of bidirectional causality in the short-run, and that the causal relationship differs both in short run and long run depending on human development level.

Omri et al. (2015) using dynamic simultaneous-equation panel data models for 17 developed and developing countries examined the relationship between nuclear consumption and renewable energy consumption and economic growth, and concluded mixed results for different countries and unidirectional causality running from economic growth to renewable energy consumption for the global panel. Jebli and Youssef (2015) did their study on Economic growth, combustible renewables and waste consumption, and CO_2 emissions in North Africa. They used panel cointegration techniques and Granger causality tests to examine the dynamic causal link between per capita real gross domestic product (GDP), combustible renewables and waste (CRW) consumption, and CO_2 emissions for a panel of five North African countries during the period 1971 to 2008. Their Granger causality test results suggest short- and long-run unidirectional causalities running from CO_2 emissions and CRW consumption to real GDP and a short-run unidirectional causality running from CRW to CO_2 emissions. The results from panel longrun fully modified ordinary least squares (FMOLS) and dynamic ordinary least squares (DOLS) estimates show that CO2 emissions and CRW consumption have a positive and statistically significant impact on GDP. They recommended that these countries should use more CRW. This increases their output, reduces their energy dependency on fossil energy, and may decrease their CO2 emissions. Aminu and Aminu (2015) set out to re-examine the causal relationship between energy consumption and economic growth using Nigeria's data from 1980 to 2011 in a multivariate framework by including labor and capital in the causality analysis. Applying Granger causality test, impulse response and variance decomposition analysis, their results reported absence of causality and that of variance decomposition found that capital and labor are more important in affecting output growth compared to energy consumption.

Tamba, Nsouandélé and Lélé (2017)'s study was on Gasoline consumption and economic growth in Cameroon. They analyzed the gasoline sector and examined the causal relationship between gasoline consumption and economic growth in Cameroon using annual data for the period 1975 to 2014. The utilized the unit root tests, the autoregressive vector (VAR) model, and the Wald test to test causality. Their results showed that the series are all I (1) and that there is no long-term relationship. Also, there was a bidirectional causality relationship between gasoline consumption and economic growth in Cameroon. This implies that an increase in gasoline consumption affects economic growth with feedback effect. In view of the result of causality, reducing gasoline consumption without appropriate and established energy policies is not a feasible situation to maintain Cameroon's economic growth. Khobai (2017) investigates the causal relationship between renewable energy consumption and economic growth in South Africa. It incorporates carbon dioxide emissions, capital formation and trade openness as additional variables to form a multivariate framework. Quarterly data was used for the period 1990 – 2014 and is tested for stationarity using the Augmented Dickey Fuller (ADF), Dickey Fuller Generalized Least Squares (DF-GLS), Phillips, and Perron (PP) unit root tests. The study employs the Autoregressive distributed lag (ARDL) model to examine the long run relationship among the variables. Lastly, the study determines the direction of causality between the variables using the Vector Error Correction Model (VECM). The results validated an existence of a long run relationship between the variables. Moreover, a unidirectional causality flowing from renewable energy consumption to economic growth was established in the longrun. The short run results suggested a unidirectional causality flowing from economic growth to renewable energy consumption. The findings of the study suggest that an appropriate and effective public policy is required in the longrun, while considering sustainable economic growth and development.

Amri (2017) examined the relationship between economic growth and energy consumption under two categories- renewable and non-renewable energy consumption. The findings from the ARDL model supported a long run relationship between economic growth and non-renewable energy consumption but no co-integration was found between renewable energy consumption and economic growth. The results posited bidirectional causality between non-renewable energy consumption and economic growth both in the short run and long run. Furthermore, the results revealed a unidirectional causality flowing from renewable energy consumption to economic growth in the longrun. Marinaş, Dinu, Socol and Socol (2018) tested the correlation between economic growth and renewable energy consumption for ten European Union (EU) member states from Central and Eastern Europe (CEE) in the period 1990 to 2014, using Auto-regressive and Distributed Lag (ARDL) modeling procedure, a technique that captures causal relationships both on a short run and on a long run. They found that in the short run, the Gross Domestic Product (GDP) and Renewable Energy Consumption (REC) dynamics are independent in Romania and Bulgaria, while in Hungary, Lithuania, and Slovenia an increasing renewable energy consumption improves the economic growth. The hypothesis of bi-directional causality between renewable energy consumption and economic growth is validated in the long run for both the whole group of analyzed countries as well as in the case of seven CEE states which were studied individually.

Maji, Chindo, and Rahim (2019)'s study was on Renewable energy consumption and economic growth nexus: A fresh evidence from West Africa. They estimated the impact of renewable energy on economic growth in West African countries using panel dynamic ordinary least squares (DOLS) by employing a sample of 15 West African countries covering the 1995 to 2014 period. Their results indicated that renewable energy consumption slows down economic growth in these countries. This, they attributed to the nature and source of renewable energy used in West Africa, which is majorly wood biomass. The wood biomasses used in West Africa are usually unclean and highly polluting when 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 West Africa. As such, renewable energy use can slow down economic growth by lowering productivity when unclean and inefficient sources are used. Khan, Khan, and Rehan, (2020) investigated the relationship between energy consumption, economic growth and carbon dioxide emissions in Pakistan using annual time series data from 1965 to 2015. Their estimated results of ARDL indicate that energy consumption and economic growth increase the CO2 emissions in Pakistan both in short run and long run. Based on the estimated results they recommended that policy maker in Pakistan should adopt and promote such renewable energy sources that will help to meet the increased demand for energy by replacing old traditional energy sources such as coal, gas, and oil. Renewable energy sources are reusable that can reduce the CO2 emissions and also ensure sustainable economic development of Pakistan.

Given the review above, it can be concluded that the studies for the economic growth - renewable energy consumption nexus or economic growth renewable electricity consumption nexus remains inconclusive as mixed results were found among the various studies. This variation in the results may be attributed to several characteristics as estimation techniques, model specification, data characteristics and development level of the country, Sebri (2015).

Stylized facts on Nigeria's Energy Resources

Nigeria have huge energy resources, which potentially give the country ample opportunity to transform her economy and the lives of her citizens. Nigeria sits astride of over 35 billion barrels of oil, 187trillion cubic feet of gas, 4 billion metric tons of coal and lignite, as well as huge reserves of tar sands, hydropower, and solar radiation, among others (Adenikinju, 2008). For understandable reasons, Nigeria has not devoted equal attention to her abundant energy resources. Her efforts have been concentrated on the development, exploitation and utilization of crude oil and gas for fiscal objectives.

Oil

Nigeria has an estimated 37.2 billion barrels of proven oil reserves as of the end of 2011. The majority of reserves are found along the country's Niger River Delta and offshore in the Bight of Benin, the Gulf of Guinea, and the Bight of Bonny. Current exploration activities are mostly focused in the deep and ultra-deep offshore with some activities in the Chad basin, located in the northeast of the country. The government hopes to increase proven oil reserves to 40 billion barrels in the next few years. Nigeria has four refineries with a total installed capacity of 445,000 barrels per day. However, capacity utilization is low. Consequently, annual consumption of petroleum products, which according to government figures stood at 34 million liters per day, is not fully met by internal production and has to be supplemented by imports.

Natural Gas

Nigeria's proven natural gas reserves, estimated at about 187 trillion standard cubic feet, are known to be substantially larger than its oil resources in energy terms. Gas discoveries in Nigeria are incidental to oil exploration and production activities. As of 2001, over 50% of the gas produced (mainly associated gas) was flared. In view of the increasing domestic oil consumption, an economically optimal strategy to replace oil with gas and gas derivatives will enhance the availability of more oil for export. This will also promote the conservation of the oil reserves. Apart from the economic advantage, fuel substitution from oil togas is more environmentally friendly because gas is a cleaner fuel than oil. Given the current reserves and rate of exploitation, the expected life-span of Nigerian crude oil is about 44 years, based on about 2mb/d production, while that for natural gas is about 88 years, based on the2001 production rate of 1850 bscf. It is, therefore, strategically important to undertake major investments in the gas sector in order to prepare adequately for gas as a substitute for oil both for domestic needs and foreign exchange earnings.

Coal

Recent technical and economic studies have identified coal energy as a cost effective solution for power generation; it comes at a cost that is about 20% that of fuel oil and with the cost of crude oil heading towards US$100 per barrel, the gap will continue to widen. Furthermore, with over two billion tons reserves in Nigeria, coal is an abundant domestic resource that can support the mining and energy industries and provide numerous jobs with potentially high multiplier effects on the local economy. Current technologies allow for clean burning of coal, which takes care of its negative environmental impact; indeed over 50% of the US electrical power supply is from coal resources. Nigerian coal can be utilized for power generation, steam production, in cement production and for brick making; as a heat source and reducing agent for steel production; as a domestic fuel; and as feedstock for the production of chemicals, liquid fuels, gaseous fuels, batteries, carbon electrodes etc. Nwasike and Gregory, (2003). These potentials of coal need to be effectively harnessed into the country's energy delivery system and export commodity mix through the development of a vibrant coal industry. Coal is an alternative energy medium that could be used with oil and gas to give the nation the desired mix that will ensure a reliable, affordable, and environmentally friendly energy medium.

Electricity

Commercial electricity is generated mainly from hydropower, steam plants and gas turbines in Nigeria. Between 1985 and 2000, electricity generation capacity grew by a mere 10 per centin Nigeria compared to 332 per cent in Vietnam, 142 per cent in Iran, 237 per cent in Indonesia, 243 per cent in Malaysia and 205 per cent in South Korea (Maigida, 2008). Electricity generation capacity is also far below compared countries. Nigeria, with a population of over 170 million people, has an installed generation capacity of 6000MW compared to UAE 4740MW to a population of 4 million or South Africa that has 46000MW to44million people.

Biomass

Organic, non-fossil material of biological origin is called biomass. The biomass resources of Nigeria can be identified as wood, forage grasses and shrubs, animal wastes and wastes arising from forestry, agricultural, municipal, and industrial activities, as well as aquatic biomass. The biomass energy resources of the nation have been estimated to be significant. Plant biomass can be used as fuel in thermal power plants or converted to produce solid briquettes, which can then be utilized as fuel for small-scale industries. Biogas digesters of various designs are capable of sustaining household, industrial and institutional energy needs. It has indeed been shown that the remaining biomass material after digestion is a better fertilizer than the original waste. The intensive application of this will reduce the existing heavy reliance on chemical fertilizers. The abundant energy available from biomass can be meaningfully introduced into the nation's energy mix through the development of a comprehensive programme. The programme should encompass fully supported research, development, demonstration, and manpower training components.

Methodology and Data Source

Model Specification

This study aimed at establishing the dynamics properties of the relationship between Renewable Energy Consumption (REC), and Economic Growth proxy by Real Gross Domestic Product (RGDP) in Nigeria over the years (1990 to 2016). The functional form, on which the model is based, employed simple regression equation in the analysis of this work. In an attempt to capture the crux of this study, the model is represented in a functional form as shown below:

$$RGDP_t = f(REC_t), \quad \ldots\ldots\ldots 1$$

Stating equation (3.1) in the linear explicit form yields:

$$LNRGDP_t = \beta_0 + \beta_1 \; LNREC_t + \varepsilon_t \quad \ldots\ldots\ldots 2$$

Expressing equation (3.2) in log linear form yields

$$LNRGDP_t = \beta_0 + \beta_1 LNREC_t + \varepsilon_t \quad \ldots\ldots\ldots 3$$

Where:

$RGDP_t$ is Real Gross Domestic Product at time t

REC_t is Renewable Energy Consumption at time t

$LNRGDP_t$ is Log of Real Gross Domestic Product at time t

$LNREC_t$ is Log of Renewable Energy Consumption at time t

ε_t is the stochastic error term
it is Time trend (1990-2016)
β_0, and β_1, is are intercept and slope coefficients to be estimated.

The 'a *Priori*' Expectation

The a-priori expectation regarding the relationship among the independent variables and the dependent variable is that; $\beta_0 > 0$ indicating that at zero renewable energy consumption RGDP is greater than zero. $\beta_1 > 0$ a positive relationship between renewable energy consumption and economic growth, that is, increase/decrease in renewable energy consumption leads to increase or decrease in economic growth *ceteris paribus*.

Causality Model Specification
The pair-wise bivariate causality model is as present below:

$$LnRGDP_t = \sum_{i-1}^{n} \alpha_i LnRGDP_t + \sum_{i=1}^{n} \beta_i LnREC_t + \varepsilon_t \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 4$$

$$LnREC_t = \sum_{i-1}^{n} \alpha_i LnREC_t + \sum_{i=1}^{n} \beta_i LnRGDP_t + \varepsilon_t \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 5$$

In Equation 4 current LNRGDP was related to its past values as well as past values of LNREC. On the other hand, equations 5 postulated that LNREC was related to its past values as well as past values of LNRGDP. If $\beta_1, \beta_2, \ldots, \beta_k = 0$ in equation 4 implied LNREC does not Granger Cause LNRGDP. Similarly, if $\beta_1, \beta_2, \ldots, \beta_k = 0$ in equation 5 implied LNRGDP does not Granger Cause LNREC.

Data Source

This study made use of secondary annual data for Nigeria for the period 1990 to 2016. The data for the study was sourced from the Central Bank of Nigeria (CBN) 2016 Statistical Bulletin (for RGDP) as well as the U.S. Energy Information Administration for renewable energy consumption for (REC).

Data Analysis

Descriptive Statistics

The results for the Mean, a measure of central tendency, Standard Deviation, a measure of dispersion or variability, maximum or peak value and minimum or lowest value is as presented in table below:

Table 4.1 Descriptive Statistics

	RGDP	REC
Mean	37274.79	3098868.
Median	31709.45	2997940.
Maximum	69023.93	4206286.
Minimum	19199.06	2145327.
Std. Dev.	17796.49	676437.8
Skewness	0.563305	0.278251
Kurtosis	1.814241	1.754103
Jarque-Bera	3.009684	2.094699
Probability	0.222052	0.350866
Sum	1006419.	83669448
Sum Sq. Dev.	8.23E+09	1.19E+13
Observations	27	27

Source: Computed by the Authors using E-views 9

From the table, the average real gross domestic product (RGDP) from 1990 to 2016 is 37,274.79 billion naira. This is as shown by the mean value for real gross domestic product for the 27-year period of the study. The average value for renewable energy consumption (REC) is 3,098,868 Gigawatt hours. It is also clearly showed that the peak value for real gross domestic product (RGDP) is 69,023.93 billion naira. This occurred in year 2015. In addition, peak value for renewable energy consumption (REC) is 4,206,286 Gigawatt hours. This also occurred in year 2016. These values are as shown by their respective maximum values. However, the lowest value for real gross domestic product (RGDP) and renewable energy consumption (REC) is 19,199.06 billion naira and 2,145,327 as shown by their minimum values respectively. These values both occurred in year 1990, which is the early year of the study. The standard deviation indicates the spread of the variable around it means. It is a measure of spread and variability. The standard deviation for RGDP and REC is 17,796.46 and 676,437.8, respectively. The normality distribution of the data sets was tested using Jarque-Bera statistics, the test showed that are not normally distributed at 10% and 1% respectively. This implies that REC has high level of volatility when compared to the RGDP.

Correlation Analysis

In this section we discuss correlation analysis, which is used to quantify the association between two continuous variables (e.g., between an independent and a dependent variable or between two independent variables). In correlation analysis, we estimate a sample correlation coefficient, more specifically the Pearson Product Moment correlation coefficient. The sample correlation coefficient, denoted r, ranges between -1 and +1 and quantifies the direction and strength of the linear association between the two variables. The correlation between two variables can be positive (i.e., higher levels of one variable are associated with higher levels of the other) or negative (i.e., higher levels of one variable are associated with lower levels of the other). The analysis continues in this section in determining the degree of linear association between RGDP and the independent variable, REC. The result of the correlation analysis is presented in table below.

Table 4.2: Correlation Matrix between the Variables

	LNRGDP	LNREC
LOGRGDP	1.000000	0.759589
LOGREC	0.759589	1.000000

Source: Computed by the Authors using E-Views 9

It is evident from table 4.2 above that there is a strong positive relationship between real gross domestic product (RGDP) and renewable energy consumption (REC) during the period of the study. This is indicated by the high Pearson Correlation Coefficient of 0.759589, implying that with increase renewable consumption energy there is more opportunity for increased economic activities and hence an increase in real gross domestic product (RGDP) and growth.

Empirical Analysis

Unit root Test or Test of Stationarity

This section presents the unit root test result. The unit root test was conducted to help avoid "spurious" or "nonsense" regression results. Most time series variables are usually non-stationary and using non-stationary variables in the model might lead to spurious regressions (Granger and New bold, 1977 and in

Yule 1926). Hence the variables were tested at levels, first and second difference for stationarity using the Augmented Dickey-Fuller (ADF) test. The result is presented below:

Table 4.3: Results of Augmented Dickey-Fuller Unit Root Tests

	ADF Test Statistics and Mackinnon (1996) one-sided P-values for the Variables in brackets		Makinnon Critical Values at 5%	
Test in:	LNRGDP	LNREC	LNRGDP	LNREC
Level	-1.122466 (0.6904)	1.227719 (0.9973)	-2.986225	-3.004861
1st Difference	-1.929053 (0.3144)	-2.998064* (0.0020)	-2.986225	-3.020686
2nd Differnce	-5.226688* (0.0003)	-2.245140 (0.1975)	-2.991878	-3.004861
Order of Integration	I (2)	I (1)		

* Significant at 5 per cent Level of Significance (LOS). ADF is calculated with intercept using Lag Length: 1 (Automatic - based on SIC, maxlag=5)

Source: Computed by the Authors using E-Views 9

The unit root was done using the Augmented Dickey-Fuller (ADF) test, (including test with intercept and a one period lag). The summary of results for the unit root test as tabulated in table 4.3 above have shown that both variables have unit root, that is, they are non-stationary, at levels, This is because their ADF statistic values are all less than the Mackinnon critical table values in absolute term at the 5 per cent level of significance (LOS). Alternatively, the Mackinnon p-value in the bracket is more than 5 percent. Thus, the null hypothesis of non-stationarity could not be rejected when the test is done at level for the two variables. Consequently, the ADF test strongly support the hypothesis that both variables are non-stationary at level and that they exhibit a random walk.

This suggested the need to difference the series to obtain stationarity. The immediate conclusion is that any dynamic specification of the model in the levels of the series is likely to be inappropriate and may be affected by problems of “nonsense” regression or “spurious” regression. After the 2nd difference, LNRGDP become stationary as shown by the bold asterisk values in the table. Hence, it is integrated of order two I (2). LNREC on the other hand is stationary at first difference meaning it is integrated of order one I (1). So, the unit root test was re-tested by differencing the LNRGDP so as to derive I (1) of REC and I (1) in order to test further for co-integration. The result of the unit root after differencing RGDP(LNDRGDP) and logging it to derive integrated of order I(1) and logging of REC (LNREC) now remain at integrated of order I(1) was significant at first difference where LNDRGDP at first difference is 0.0001 and LNREC is 0.0020. The result showed that the unit test was stationary at first difference and has no unit root so null hypothesis is rejected.

Co-integration Test

The result of the co-integration test in table 4.4 below at 5% level was set that the series are not co-integrated, so we rejected the null hypothesis.

Table 4.4: Result of Cointegration Test

Dependent	tau-statistic	Prob.*	z-statistic	Prob.*
LOGDRGDP	-3.126603	0.1202	-15.04498	0.0705
LOGREC	-2.130230	0.4750	-9.176176	0.3333

*MacKinnon (1996) p-values.

Intermediate Results:

	LOGDRGDP	LOGREC
Rho – 1	-0.654129	-0.398964
Rho S.E.	0.209214	0.187287

Residual variance	0.571765	4.92E-05
Long-run residual variance	0.571765	4.92E-05
Number of lags	0	0
Number of observations	23	23
Number of stochastic trends**	2	2

**Number of stochastic trends in asymptotic distribution

Regression Analysis

One of the objectives of this study is to determine the relationship between renewable energy consumption and economic growth in Nigeria. To carry out this objective a simple regression analysis using ordinary least squares (OLS) was conducted and the result is as presented in table 4.6.1 below for scale effect and a more robust regression result the natural logarithms of the data presented in appendix II were employed for the regression analysis.

Table 4.5: Regression Results

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.392074	0.660154	0.593913	0.5596
D(LOGREC)	-155.3216	348.1863	-0.446088	0.6606
D (LOGDRGDP (-1))	-0.293674	0.222822	-1.317974	0.2032

R-squared	0.089317	Mean dependent var	0.082039
Adjusted R-squared	-0.006545	S.D. dependent var	0.920345
S.E. of regression	0.923352	Akaike info criterion	2.804512
Sum squared resid	16.19900	Schwarz criterion	2.953290
Log likelihood	-27.84963	Hannan-Quinn criter.	2.839559
F-statistic	0.931727	Durbin-Watson stat	1.887898
Prob(F-statistic)	0.411140		

Source: Computed by the Authors using E-Views 9

The estimated regression result can be represented as below:

LNDRGDP = 0.392074 – (155.3216) LNREC --- 6

The regression result shows that the coefficient of LNREC is negative, this means that $\beta_1 < 0$ and this conforms to the a priori expectation of the model for the study. This result can be interpreted as a decrease (increase) in LNREC leads to decrease (increase) in real gross domestic product. This is as the same as the correlation and Granger causality results. The coefficient of LNREC is -155.3216 meaning a percentage decrease (increase) in LNREC leads to about -155 percent decrease (increase) in LNDRGDP; this is because the variables are already in logarithm form. In addition, the t-statistic of -0.446088 is low enough and the probability value of 0.6606 is high enough, indicating that the coefficient of LNREC is not statistically significant at 5 percent level of significance (LOS). The R_2 of 0.089317 shows that 8.93 percent variation in the dependent variable (LNDRGDP) is explained by the independent variable (LNREC), leaving the remaining 91.07 percent to other variables not captured by the model. In addition, the F-statistics and F-statistical probability of 0.931727 and 0.411140 respectively are highly plausible indicate that overall, the model is not statistically significant at one percent level of significance. However, the Durbin-Watson statistic of 1.887898 is not desirable as it indicates that there is no serial correlation in the series because; Durbin Watson is in the neigbourhood of 2.

Granger Causality Test

The analysis continues in this section with a test of causality between the variables. Employing E-views 9 statistical package, from the data in Appendix I, the pair-wise Granger causality test were examined. The result is as presented in table 4.8.1 below.

Table 4.6: Granger Causality Test Results

Null Hypothesis:	Obs	F-Statistic	Prob.
LOGREC does not Granger Cause LOGDRGDP	22	1.70822	0.2109
LOGRGDP does not Granger Cause LOGREC		0.92443	0.4158

Source: Computed by the Authors using E-Views 9

From the above result, there was no causality between the two variable RGDP and REC. The null hypothesis REC does not Granger cause RGDP was accepted while the second null hypothesis, RGDP does not Granger Cause REC was also accepted for the two Lag period considered at 5% level of the set probability 0.2109 and 0.4158 are not significant.

Summary and Conclusion

This study empirically examined the relationship between renewable energy consumption and economic growth in Nigeria (1990-2016). The major objective of this study is to determine the impact of renewable energy consumption on economic growth in Nigeria. The data used in this study are secondary data. The variables that were used include the dependent variable; RGDP in constant 2010 basic prices, (RGDP) as proxy for economic growth and the independent variable is renewable energy consumption defined in billions of kilowatt hours (REC). Unit root was conducted using the Augmented Dickey-Fuller (ADF) test. The results for the unit root test have shown that both variables have unit root, that is, they are non-stationary, at levels, and that they exhibit a random walk. This suggests the need to difference the series to obtain stationarity. RGDP become stationary at 1st difference hence, it is integrated of order one I (1). REC on the other hand is stationary at first difference meaning it is integrated of order one I (1). From the correlation analysis, it is evident that there is a strong and significant positive relationship between economic growth and renewable energy consumption (REC) during the period of the study. From the Granger causality result, there is no causality between real gross domestic product and renewable energy consumption. The granger causality test negates *apriori* expectation positive relationship between the renewable energy consumption and economic growth in Nigeria. As a result, renewable energy consumption leads to economic growth in the long-un. The regression result shows that the coefficient of renewable energy consumption (REC) negate to the *a priori* expectation of positive relationship between renewable energy consumption and economic growth in Nigeria. The result showed a negative but not significant relationship.

It is believed that the greater the renewable energy consumption, the more the economic activity in the nation and as a result a greater economy emerges. But, based on the empirical results, this study concludes that there is no significant and positive long-run relationship exists between renewable energy consumption and economic growth in Nigeria. This might be attributed to the fact that Nigeria though, heavily reliant on energy, the use of these renewable resources tends to be negligible and this might be a major factor in the result gotten by the study. Thus, we recommend that policies should focus more on increasing the use and efficiency of this renewable energy. Investing in renewable energy should be encouraged and enhanced as this may be a way to reduce domestic fossil fuel consumption or to meet increasing energy demand without an increase of domestic fuel consumption to increase fuel exports and thus for higher revenues as well as enhance economic growth.

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Appendix: Unit Root Test Results

LNRGDP Unit Root Test Result at Level

Null Hypothesis: LOGRGDP has a unit root
Exogenous: Constant
Lag Length: 1 (Automatic - based on SIC, maxlag=6)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-1.122466	0.6904
Test critical values:	1% level	-3.724070	
	5% level	-2.986225	
	10% level	-2.632604	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(LOGRGDP)
Method: Least Squares
Date: 08/05/18 Time: 10:06
Sample (adjusted): 1992 2016
Included observations: 25 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LOGRGDP (-1)	-0.014520	0.012936	-1.122466	0.2738
D (LOGRGDP (-1))	0.786178	0.172513	4.557208	0.0002
C	0.161659	0.131118	1.232924	0.2306

R-squared	0.497502	Mean dependent var	0.050545
Adjusted R-squared	0.451820	S.D. dependent var	0.034892
S.E. of regression	0.025834	Akaike info criterion	-4.362087
Sum squared resid	0.014683	Schwarz criterion	-4.215822
Log likelihood	57.52609	Hannan-Quinn criter.	-4.321520
F-statistic	10.89064	Durbin-Watson stat	2.079293
Prob(F-statistic)	0.000516		

LNDRGDP Unit Root Test Result at First Difference

Null Hypothesis: LOGRGDP has a unit root
Exogenous: Constant
Lag Length: 1 (Automatic - based on SIC, maxlag=6)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-1.122466	0.6904
Test critical values:	1% level	-3.724070	
	5% level	-2.986225	
	10% level	-2.632604	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(LOGRGDP)
Method: Least Squares
Date: 08/05/18 Time: 10:06
Sample (adjusted): 1992 2016
Included observations: 25 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LOGRGDP (-1)	-0.014520	0.012936	-1.122466	0.2738
D (LOGRGDP (-1))	0.786178	0.172513	4.557208	0.0002
C	0.161659	0.131118	1.232924	0.2306

R-squared	0.497502	Mean dependent var	0.050545
Adjusted R-squared	0.451820	S.D. dependent var	0.034892
S.E. of regression	0.025834	Akaike info criterion	-4.362087
Sum squared resid	0.014683	Schwarz criterion	-4.215822
Log likelihood	57.52609	Hannan-Quinn criter.	-4.321520
F-statistic	10.89064	Durbin-Watson stat	2.079293
Prob(F-statistic)	0.000516		

LNRGDP Unit Root Test Result at Second Difference

Null Hypothesis: D(LOGRGDP) has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on SIC, maxlag=5)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-1.929053	0.3144
Test critical values:	1% level	-3.724070	
	5% level	-2.986225	
	10% level	-2.632604	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(LOGRGDP,2)
Method: Least Squares
Date: 08/05/18 Time: 10:14
Sample (adjusted): 1992 2016
Included observations: 25 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D (LOGRGDP (-1))	-0.299835	0.155431	-1.929053	0.0662
C	0.014863	0.009473	1.568993	0.1303

R-squared	0.139262	Mean dependent var	-0.000417
Adjusted R-squared	0.101838	S.D. dependent var	0.027413
S.E. of regression	0.025980	Akaike info criterion	-4.386398
Sum squared resid	0.015524	Schwarz criterion	-4.288888
Log likelihood	56.82997	Hannan-Quinn criter.	-4.359353
F-statistic	3.721247	Durbin-Watson stat	1.835265
Prob(F-statistic)	0.066153		

LNDRGDP Unit Root Test Result at Level

Null Hypothesis: LOGDRGDP has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on SIC, maxlag=5)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-1.949016	0.3056
Test critical values:	1% level	-3.752946	
	5% level	-2.998064	
	10% level	-2.638752	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(LOGDRGDP)
Method: Least Squares
Date: 07/31/18 Time: 10:01
Sample (adjusted): 1993 2015
Included observations: 23 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LOGDRGDP (-1)	-0.286348	0.146919	-1.949016	0.0648
C	2.119815	1.069174	1.982666	0.0606

R-squared	0.153180	Mean dependent var	0.064842
Adjusted R-squared	0.112855	S.D. dependent var	0.902959
S.E. of regression	0.850483	Akaike info criterion	2.596916
Sum squared resid	15.18974	Schwarz criterion	2.695655
Log likelihood	-27.86453	Hannan-Quinn criter.	2.621748
F-statistic	3.798662	Durbin-Watson stat	2.214683
Prob(F-statistic)	0.064777		

LNDRGDP Unit Root Test Result at First Difference

Null Hypothesis: D(LOGDRGDP) has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on SIC, maxlag=5)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-5.908384	0.0001
Test critical values:	1% level	-3.769597	
	5% level	-3.004861	
	10% level	-2.642242	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(LOGDRGDP,2)
Method: Least Squares
Date: 08/05/18 Time: 10:26
Sample (adjusted): 1994 2015

Included observations: 22 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D (LOGDRGDP (-1))	-1.286779	0.217789	-5.908384	0.0000
C	0.111166	0.194141	0.572605	0.5733

R-squared	0.635761	Mean dependent var	-0.019529
Adjusted R-squared	0.617549	S.D. dependent var	1.462863
S.E. of regression	0.904673	Akaike info criterion	2.724021
Sum squared resid	16.36866	Schwarz criterion	2.823207
Log likelihood	-27.96424	Hannan-Quinn criter.	2.747387
F-statistic	34.90900	Durbin-Watson stat	1.920661
Prob(F-statistic)	0.000009		

LNREC Unit Root Test Result at Level

Null Hypothesis: LOGREC has a unit root
Exogenous: Constant
Lag Length: 2 (Automatic - based on SIC, maxlag=5)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		1.227719	0.9973
Test critical values:	1% level	-3.752946	
	5% level	-2.998064	
	10% level	-2.638752	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(LOGREC)
Method: Least Squares
Date: 07/31/18 Time: 10:04
Sample (adjusted): 1993 2015
Included observations: 23 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LOGREC (-1)	0.011363	0.009255	1.227719	0.2345
D (LOGREC (-1))	0.639409	0.209136	3.057382	0.0065
D (LOGREC (-2))	-1.074996	0.362014	-2.969491	0.0079
C	-0.028041	0.024769	-1.132111	0.2717

R-squared	0.389194	Mean dependent var	0.001799
Adjusted R-squared	0.292751	S.D. dependent var	0.000567
S.E. of regression	0.000477	Akaike info criterion	-12.30128
Sum squared resid	4.32E-06	Schwarz criterion	-12.10380
Log likelihood	145.4647	Hannan-Quinn criter.	-12.25161
F-statistic	4.035480	Durbin-Watson stat	2.198280
Prob(F-statistic)	0.022315		

LNREC Unit Root Test Result at First Difference

Null Hypothesis: D(LOGREC) has a unit root
Exogenous: Constant
Lag Length: 1 (Automatic - based on SIC, maxlag=5)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-4.464511	0.0020
Test critical values:	1% level	-3.752946	
	5% level	-2.998064	
	10% level	-2.638752	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(LOGREC,2)
Method: Least Squares
Date: 07/31/18 Time: 10:09
Sample (adjusted): 1993 2015
Included observations: 23 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D (LOGREC (-1))	-1.273721	0.285299	-4.464511	0.0002
D (LOGREC (-1),2)	0.846448	0.314396	2.692301	0.0140
C	0.002361	0.000543	4.351472	0.0003

R-squared	0.516102	Mean dependent var	1.36E-06
Adjusted R-squared	0.467713	S.D. dependent var	0.000662
S.E. of regression	0.000483	Akaike info criterion	-12.31189
Sum squared resid	4.67E-06	Schwarz criterion	-12.16378
Log likelihood	144.5867	Hannan-Quinn criter.	-12.27464
F-statistic	10.66553	Durbin-Watson stat	1.900869
Prob(F-statistic)	0.000704		

LNREC Unit Root Test Result at Second Difference

Null Hypothesis: D(LOGREC,2) has a unit root
Exogenous: Constant
Lag Length: 3 (Automatic - based on SIC, maxlag=6)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-2.245140	0.1975
Test critical values:	1% level	-3.788030	
	5% level	-3.012363	
	10% level	-2.646119	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(LOGREC,3)
Method: Least Squares
Date: 08/05/18 Time: 10:52
Sample (adjusted): 1996 2016
Included observations: 21 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D (LOGREC (-1),2)	-5.680511	2.530137	-2.245140	0.0392
D (LOGREC (-1),3)	4.330199	2.416667	1.791807	0.0921
D (LOGREC (-2),3)	3.763999	2.420763	1.554881	0.1395
D (LOGREC (-3),3)	3.305585	1.772017	1.865437	0.0806
C	0.001254	0.002397	0.523216	0.6080

R-squared	0.818292	Mean dependent var	-0.000988
Adjusted R-squared	0.772865	S.D. dependent var	0.018323
S.E. of regression	0.008732	Akaike info criterion	-6.439329
Sum squared resid	0.001220	Schwarz criterion	-6.190633
Log likelihood	72.61295	Hannan-Quinn criter.	-6.385355
F-statistic	18.01338	Durbin-Watson stat	1.954562
Prob(F-statistic)	0.000009		