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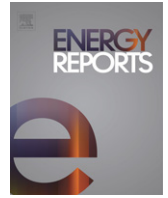
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Does clean energy contribute to economic growth? Evidence from Nigeria



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ABSTRACT

This paper examines the impact of clean energy on economic growth in Nigeria. Autoregressive distributed lag (ARDL) approach to cointegration was used to determine the existence of cointegration among the variables. The long run results suggest a significant negative relationship between two indicators of clean energy (alternative and nuclear energy and electric power consumption) and economic growth. The result further reveals a significant positive relationship between combustible renewables and waste and economic growth. Mixture of negative and positive relationships between clean energy indicators and economic growth was obtained in the short, although not significantly different from zero. We concluded that Nigeria has Potentials of clean energy to be reaped in near future.

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1. Introduction

In recent times, the importance of renewable and clean energy sources has increased significantly as climate change has become a long term threat to global ecosystems and the world economies (Simsek and Simsek, 2013). Alternative energy sources are increasingly required to respond to this threat of climate change and skyrocketing energy demand in the world. The need for a shift from the use of primary energy sources that emits toxic pollutants to the environment to greener energy source is a current issue in energy led growth literature. Most advanced countries of the world has established legal framework to encourage the use of renewable energy sources in line with the objectives of global energy organization and global climate change and environmental safety advocacy organization such as International Energy Agency (IEA) and Kyoto Protocol. Among these objectives is to advance the world's energy supply and demand structure by developing alternative sources of cleaner energy and increase the efficiency of energy use.

The objective of this paper is to examine the impact of clean energy on economic growth in Nigeria. Nigeria is one of the countries blessed with clean and renewable energy that include solar energy, wind energy, hydropower, and biomass among others. Interest in the use of clean energy has increased, since petroleum may not last

beyond 8 decades at 2010 rate of reserve and production (REMP, 2012). Despite that promotion of renewable energy sources is central to the country's National Energy Master Plan (NEMP), the development of clean energy technologies has been slow. The country also lacks a separate legal framework in charge of renewable energy. This may have led to the fall in the contribution of energy to Gross Domestic product (GDP) to 13.70% in 2013 from 15.50% in 2010 (ECN, 2013). Therefore, huge amount of clean energy will be required to achieve the nation's mission of growing the economy at the rate of 11%–13% to be part of the 20 largest economies of the world by 2020 (REMP, 2012).

The current government recently announced that it had concluded arrangement to launch a national policy on renewable energy in Nigeria. This is expected to increase the supply of clean and environmentally friendly source of energy. For instance, the 30,000 MW of electric power supply requirement for Nigeria is expected to be generated from renewable sources. Other strategies geared to enhance growth in renewable energy sector include: introduction of renewable energy legal framework, giving license to private sector to invest in clean energy related sectors in Nigeria, attractive tariff for foreign investors in renewable energy among others. Against this background, this paper investigates the impact of renewable energy resources on economic growth in Nigeria. The remainder of this paper is scheduled as follows: Section 2 is literature review, Section 3 deals with data, model and methodology, Section 4 presents results and empirical findings while Section 5 focuses on conclusion and policy implication.

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Table 1

Fossil energy resources and nuclear energy resources.

Source: NNPC (2010) and CBN (2010).

S/N	Resources	Reserves	Production (2010)	Domestic Utilization (2010)
1	Crude oil	37 billion barrels	0.896 billion barrels	0.164 billion barrels
2	Natural gas	187 Tscf	2.392 Tscf	75.7%—fuel, industries, re-injection and gas lift. 24.3%—gas flare
3	Coal	2.7 billion tonnes	0	Negligible
4	Tar sands	31 billion barrels of oil equivalent	0	0.224 million tonnes
5	Nuclear	Yet to be quantified	0	30 kW experimental nuclear reactor

2. Literature review

Energy efficiency and clean energy use has become increasingly a new area of discussion in energy–growth nexus (see for instance, Mandelli et al., 2014, Sanoh et al., 2014, Qi et al., 2014, Oyedepo, 2014 and Mediavilla et al., 2013). This led to the need to investigate clean energy relationship with economic growth in Nigeria. Recently, Olugasa et al. (2014) conducted a conceptual review on clean energy production from biogas for use in Nigeria. Having reviewed the global techniques on how to store and generate clean energy from biogas, point out its potential economic advantages and use in meeting energy demand in Nigeria and other developing countries.

Similarly, Ajayi and Ajayi (2013) investigate and analyze the energy policies and legal ethics of renewable energy development in Nigeria. They focus on Nigeria legal framework of clean energy development by appraising the vision 20:2020 of the federal government of Nigeria and the clean energy master plan forwarded by joint efforts of the Energy Commission of Nigeria (ECN) and United Nations Development Programs (UNDP) among others. Some of the policy challenges revealed by the study are inadequacy of economic incentives by government, unfavorable tax and tariff system to promote clean energy technology. They further recommend the amendment of land use act, investment laws and environmental impact assessment decree by Nigerian government.

Pao and Li (2014) investigated economic growth, clean energy and unclean energy in MIST (Mexico, Indonesia, South Korea, and Turkey) economies. The method adopted was panel cointegration. Part of the result of interest suggests long run causality from clean energy use to economic growth and positive feedback causality in the short run. Renewable energy also causes fossil fuel consumption in the long run and a negative feedback effect in the short run. In the same year, Zhang et al. (2014) examine the potentiality of cooperation in renewable energy between United States of America and China. Their finding suggests that such cooperation can foster economic development, mitigate carbon emissions, improve the environmental quality, promotes green growth and mutual benefit between the two countries.

Furthermore, Sbia et al. (2014) documented the link between economic growth and indicators of foreign direct investment, trade openness, carbon emissions and clean energy for UAE. The method used was autoregressive distributed lag approach to cointegration. Their findings reveal that trade openness; carbon emissions, foreign direct investment reduce energy use while clean energy and economic growth have positive effect on energy consumption. Perobelli and Oliveira (2013) conducted a study in 27 Brazilian states by developing an indicator for energy development potentials using factor analysis. The outcome identifies three energy development potentials which include; supply of clean energy, supply of unclean energy and demand for energy.

Again, Kanellakis et al. (2013) investigate energy policies of the European Union and highlighted the union's strategy on energy related matters including the antecedence of the union's creation in 1951. Implemented policies in the union includes; clean energy, energy savings and efficiency, security of energy, energy market, nuclear energy, safety of the environment and research

and development. Pfeiffer and Mulder (2013) also investigate the diffusion of non-hydro clean energy technology for generating electricity in 180 developing countries using two stage estimation techniques. They found that the diffusion increases with the enforcement of economic and regulatory instruments. Similarly, increase aid and openness, organizational policy supports, growth of electricity use, and fossil fuel production delay diffusion of non-hydro clean energy.

Simsek and Simsek (2013) explore recent incentives and potential of clean energy sources in Turkey. The outcome suggests that recent improvement, like development in the renewable legislations, liberalization of the electricity market, has foster growth and investment opportunities on renewable energy in Turkey. Natural endowment of solar, geothermal and wind has facilitated development and attracted global attention to their market. On the other hand Brown et al. (2012) found six myths on clean electricity in the southern US that are either initiated by the public or spread among policymakers. Energy economic modeling mechanism was used to show that the myths are half-truths. Their work further identifies new energy policy improvement where clean production can save user's income and meet most demand growth in the next two decades.

Nigeria is blessed with abundant fossil, renewable and nuclear energy resources. The fossil energy resources include crude oil and natural gas, coal and tar sands while the clean and renewable energy include small hydro, large hydro, biomass, wind and solar. The renewable use of energy sources are still on the infant stage on like nonrenewable sources which have been exploited for decades and used for productive and domestic purposes in the country. Tables 1 and 2 show the nonrenewable and renewable energy potentials in Nigeria.

3. Data, model and methodology

This paper tests the empirical impact of clean energy on economic growth in Nigeria. To achieve this, annual data were collected from World Bank development indicator in 2014. The data collected covers the period from 1971 to 2011. Gross Domestic Product (GDP) per capita (constant LCU) was used as a proxy for economic growth while three separate indicators were used to represent clean energy. These include; alternative and nuclear energy (% of total energy use), combustible renewables and waste (metric tons of oil equivalent) and electric power consumption (kWh). These indicators were used to ascertain the influence of renewable energy on economic growth in Nigeria. The trend of the series and descriptive statistics are presented in Fig. 1 and Table 3.

In the series, economic growth, alternative and nuclear energy, and electric power consumption show fluctuations while combustible renewables and waste indicates continuous increase. The descriptive statistics result of Jarque–Bera test shows that all variables fulfil the requirement for normal distribution.

In order to model the relationship between economic growth and clean energy, a functional form model is constructed below.

$$Y_t = f(AN_t, CR_t, EP_t) . \quad (1)$$

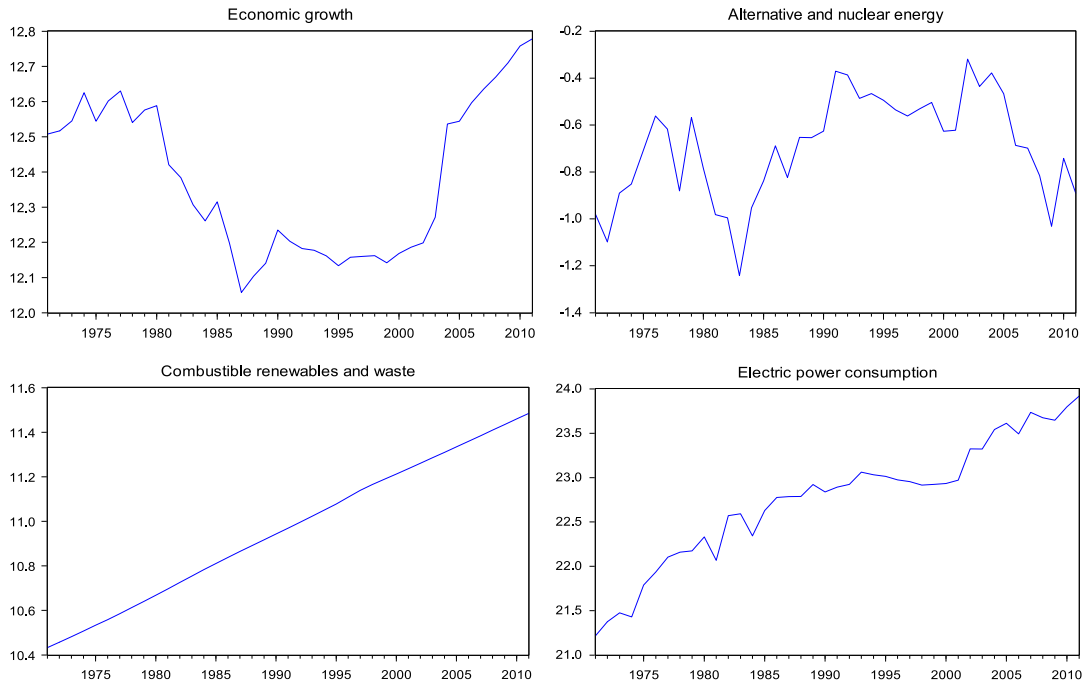


Fig. 1. Trend of the variables.

Table 2
Renewable energy resource potentials.
Source: REMF (2012).

Resources	Potentials	Remark
Large hydropower	11,250 MW	1900 MW exploited
Small hydropower	3500 MW	64.2 MW exploited
Solar	4.0 kWh/m ² day–6.5 kWh/m ² /day	15 MW dispersed solar PV installation (estimated)
Wind	2–4 m/s @ 10 m height mainland	Electronic wind information system (WIS) available; 10 MW wind farm in Katsina in progress
Biomass (non-fossil organic matter)	– Municipal waste – Fuel wood Animal waste – Agric residuals – Energy crops	– 18.5 million tonnes produced in 2005 and now estimated at 0.5 kg/capita/day – 43.4 million tones/yr fuel wood consumption 245 million assorted animals in 2001 – 91.4 million tonnes/yr produced – 28.2 million hectares of arable land; 8.5% cultivated

Table 3
Descriptive statistics.

Variables	ln Y _t	ln AN _t	ln CR _t	ln EP _t
Mean	12.38133	−0.693568	10.96568	22.75518
Median	12.31532	−0.653933	10.96951	22.91525
Maximum	12.77802	−0.318678	11.48509	23.92002
Minimum	12.05759	−1.241711	10.43280	21.21613
Std. Dev.	0.217555	0.221103	0.319154	0.696497
Skewness	0.208646	−0.391468	−0.043954	−0.462727
Kurtosis	1.540102	2.451358	1.770634	2.588115
Jarque–Bera	3.938453	1.561413	2.595075	1.752942
Probability	0.139565	0.458082	0.273204	0.416249
Sum	507.6345	−28.43629	449.5930	932.9624
Sum Sq. Dev.	1.893209	1.955465	4.074369	19.40433
Observations	41	41	41	41

The functional Eq. (1) was converted to an econometric model by introducing a drift parameter, slope of each explanatory variable and stochastic error term. We have further converted Eq. (1) into natural log to enable efficient estimation as shown below:

$$\ln Y_t = \pi_0 + \pi_1 \ln AN_t + \pi_2 \ln CR_t + \pi_3 \ln EP_t + \mu_t \quad (2)$$

where Y_t represents economic growth, AN_t denotes alternative and nuclear energy, CR_t for combustible renewables and waste and EP_t represents electric power consumption indicator. π₀ is the

intercept or drift parameter while μ_t is the random error term that is expected to be normally distributed with zero mean and constant variance.

Following Pao and Li (2014), Shahbaz et al. (2014), Sbia et al. (2014) and Saboori et al. (2012) with modifications, the study adopts the Autoregressive distributed lag (ARDL) approach to cointegration introduced by Pesaran et al. (2001) to test the long run equilibrium relationship between economic growth and clean energy indicators. Some of the merit of using the ARDL cointegration approach over other methods include: derivation of the error correction model via a simple linear transformation which combines short run adjustment from shocks with long run without compromising long run information; it can be used irrespective of the fact that variables are stationary at I(0), I(1) or combination of both; ARDL cointegration has a good property for small sample size. On the bases of these justifications we construct the unrestricted error correction model of ARDL cointegration approach as follows:

$$\begin{aligned} \Delta \ln Y_t = & \gamma_0 + \sum_{i=1}^n \gamma_{1i} \Delta \ln Y_{t-i} + \sum_{i=0}^n \gamma_{2i} \Delta \ln AN_{t-i} \\ & + \sum_{i=0}^n \gamma_{3i} \Delta \ln CR_{t-i} + \sum_{i=0}^n \gamma_{4i} \Delta \ln EP_{t-i} \end{aligned}$$

Table 4
Result of unit root test.

Variables	ADF		PP	
	Level	First difference	Level	First difference
$\ln Y_t$	-0.298(0.916)	-5.212(0.000) ^{***}	-0.738(0.825)	-5.315(0.000) ^{***}
$\ln AN_t$	-2.528(0.117)	-7.858(0.000) ^{***}	-2.535(0.115)	-7.836(0.000) ^{***}
$\ln CR_t$	-2.082(0.253)	-2.393(0.151)	-1.317(0.587)	-2.171(0.220)
$\ln EP_t$	-1.715(0.416)	-6.036(0.000) ^{***}	-1.651(0.448)	-8.750(0.000) ^{***}

^{***} Indicates significance at 1% level.

$$\begin{aligned}
 & + \alpha_1 \ln Y_{t-1} + \alpha_2 \ln AN_{t-1} + \alpha_3 \ln CR_{t-1} \\
 & + \alpha_4 \ln EP_{t-1} + \vartheta_t. \quad (3)
 \end{aligned}$$

Having developed the unrestricted error correction model, we proceed to test the joint null hypothesis of the variables in order to establish the long run equilibrium relationship among them. Our null hypothesis is given as $H_0 : \alpha_1 = \alpha_2 = \alpha_3 = \alpha_4 = 0$ while the alternative hypothesis is $H_a : \alpha_1 \neq \alpha_2 \neq \alpha_3 \neq \alpha_4 \neq 0$. The null hypothesis suggests the absence of cointegration while the alternative indicates the existence of cointegration among variables. In order to establish the existence of cointegration between economic growth and clean energy indicators in Nigeria, we estimate the value of F-statistics of the ARDL approach to cointegration through the OLS and compare with critical bounds table of Narayan (2005). Cointegration exists if the value of the F-statistics is greater than the value of upper bounds of the Narayan critical bounds table. On the other hand cointegration does not exist if the estimated F-statistics is smaller than the lower bounds value of the Narayan critical table and the outcome is inconclusive if the F-statistics falls between the upper and the lower bounds value. Before estimating Eq. (3), we first construct the long run model of the ARDL approach to cointegration as follows:

$$\begin{aligned}
 \ln Y_t = & \rho_0 + \sum_{i=1}^n \rho_{1i} \ln Y_{t-i} + \sum_{i=0}^n \rho_{2i} \ln AN_{t-i} \\
 & + \sum_{i=0}^n \rho_{3i} \ln CR_{t-i} + \sum_{i=0}^n \rho_{4i} \ln EP_{t-i} + \vartheta_t. \quad (4)
 \end{aligned}$$

The long run model is followed by the error correction model presented in Eq. (5):

$$\begin{aligned}
 \Delta \ln Y_t = & \varphi_0 + \sum_{i=1}^n \varphi_{1i} \Delta \ln Y_{t-i} + \sum_{i=0}^n \varphi_{2i} \Delta \ln AN_{t-i} \\
 & + \sum_{i=0}^n \varphi_{3i} \Delta \ln CR_{t-i} + \sum_{i=0}^n \varphi_{4i} \Delta \ln EP_{t-i} \\
 & + \tau ECM_{t-1} + \vartheta_t. \quad (5)
 \end{aligned}$$

In view of Eqs. (1)–(5), we first conducted a unit root test on economic growth and renewable energy indicators to avoid spurious result. The unit root test was conducted and presented in the next section.

4. Results and empirical findings

The stationarity property of economic growth and indicators of renewable energy were tested using the Augmented Dickey Fuller (ADF) and Phillips Perron (PP). The result suggested that the variables were stationary at $I(1)$. Although unit root test is not a necessary requirement in ARDL approach to cointegration, we do not fail to conduct it in order to be sure that all variables do not exceed $I(1)$. The result of the unit root test is presented in Table 4 and we can then safely proceed to test the cointegration relationship among our variables.

Using ARDL approach to cointegration test, we estimated the F-statistic through the OLS variable addition test in Eq. (3). The

Table 5
Result of ARDL cointegration.

$Y_t = f(AN_t, CR_t, EP_t)$	Sig. level	Critical values for bound test: Case III	
		Lower bounds	Upper bounds
F-statistics			
(14.7603) ^{***}	1% level	5.018	6.610
Lag length	5% level	3.548	4.803
(4, 5, 6, 6)	10% level	2.933	4.020

Cointegration exists since F-statistics is greater than the upper bounds value at 1% level of significance.

^{***} Indicates significance at 1%.

value of the F-statistics (14.7603) is greater than the upper bounds value (6.610) of the Narayan (2005) table at 1% level of significance, indicating a strong cointegration relationship between economic growth and proxies of clean energy in Nigeria. On this ground, we accepted our alternative hypothesis of the existence of cointegration and do not fail to reject the null hypothesis that postulates absence of cointegration. The result of the cointegration test is presented in Table 5:

Since we have achieved the existence of cointegration among our variables using ARDL approach advanced by Pesaran et al. (2001) in Table 5, we move further to estimate the long run model of Eq. (4). The model was estimated and presented in Table 6. The long run result suggests that the coefficient of alternative and nuclear energy (% of total energy use) is significant and inversely related to economic growth. An increase in alternative and nuclear energy by 1% reduces economic growth by 0.7131% other factor influencing economic growth held constant. The result seems counter intuitive; however, it is in line with the findings of Wesseh and Zoumara (2012) that investigated similar study for Liberia. It suggests that promoting alternative and nuclear energy may hinder economic growth in Nigeria. This result may not be unconnected with the fact that the country has not fully developed renewable energy sources as government is currently working on the legal framework frame for clean energy in Nigeria.

Furthermore, the estimate of combustible renewables and waste is positively related to economic growth in Nigeria and significant at 1% level, meaning that an increase in combustible renewables and waste by 1% will lead to more than proportionate increase in economic growth. This result apart from being in line with expectation shows a very strong influence on economic growth in Nigeria. The finding corroborates recent literature of Pao and Li (2014) for MIST economies, Olugasa et al. (2014) for a study in Nigeria, Pfeiffer and Mulder (2013) for developing countries and Brown et al. (2012) for United State. This further shows that combustible renewables and waste is among clean energy endowment that facilitates economic growth in Nigeria. Therefore government should pay attention to it in the development of national policy on clean energy sources.

Similarly, the coefficient of electric power consumption of clean energy is also significant and inversely related to economic growth in the long run. If other factors influencing economic growth are held constant, an increase in electric power consumption in Nigeria by 1% will lead to a reduction in economic growth by 0.5524%. The negative result could be attributed to absence of sound institutional framework of electricity generation in the

Table 6
Estimated long and short run coefficients.

Dependent variable = $\ln Y_t$		
Variables	Coefficient	T-ratio (<i>p</i> values)
Long run results		
$\ln AN_t$	−0.7131	−3.4787 (0.006)***
$\ln CR_t$	1.2623	3.2192 (0.009)***
$\ln EP_t$	−0.5524	−3.4885 (0.006)***
Constant	16.1270	9.7862 (0.000)***
Short run results		
$\Delta \ln AN_t$	0.0530	0.6322 (0.538)
$\Delta \ln AN_{t+4}$	0.1845	2.2289 (0.044)**
$\Delta \ln CR_t$	−18.9316	−1.5635 (0.142)
$\Delta \ln EP_t$	−0.0657	−0.5711 (0.578)
Constant	8.9126	3.4260 (0.005)***
ecm (−1)	−0.5527	−4.0326 (0.001)***
Diagnostic tests		
	F-statistics	<i>P</i> values
χ^2_{sc}	1.7400	(0.220)
χ^2_{het}	0.1538	(0.697)
<i>Cus & cus sq</i>	Stable	Stable
χ^2_{ff}	None	None
χ^2_{nor}	Not applicable	Not applicable

Note: *sc*, *het*, *ff*, *nor* stand for serial correlation, heteroscedasticity, functional form and normality respectively.

** Indicates significance at 5%.

*** Indicates significance at 1%.

country. This result provides support to the findings of Wesseh and Zoumara (2012). It may also suggest that much resource is invested to generate electric power in Nigeria, to the extent that it hinders economic growth. This is coupled with the fact that recent privatization of the electricity generating company to private investors has not yield reasonable outcome.

The result of the short run model was estimated from Eq. (5) and presented along with the long run in Table 6. The coefficient of alternative and nuclear energy is positive but seems not to be significantly different from zero at current period. This is similar to the result obtain by Cowan et al. (2014). However, the coefficient is positive and significant in period ($t + 4$). It implies that given current situation it will take up to 4 year before this indicator impacts positively on economic growth. Furthermore, the estimates of combustible renewables and waste and electric power consumption are both negative and also seem not to be statistically significant. The coefficient of the error correction model (ecm) is negative, less than one and significant. The 0.5527 coefficient of error correction model is the speed of adjustment of economic growth in event of any short term shock in the model. It is a moderate speed of adjustment during a period of one year.

The results of the diagnostic tests were also presented in Table 6. The result suggests that the model passes the two main diagnostic tests of serial correlation and heteroscedasticity test. The stochastic error term is white noise and normally distributed with zero mean and constant variance. Therefore we fail to reject the null hypothesis.

The model was further diagnosed for stability test using cumulative sum of recursive residuals and cumulative sum of squares of recursive residuals. The results are within the critical bounds at 5% level of significant indicating that the model is stable, consistent and reliable. The diagrammatic representations of stability test are presented in Figs. 2 and 3.

5. Conclusion and policy implication

The objective of this paper is to examine the impact of clean energy on economic growth in Nigeria. ARDL approach to cointegration forwarded by Pesaran et al. (2001) was adopted to

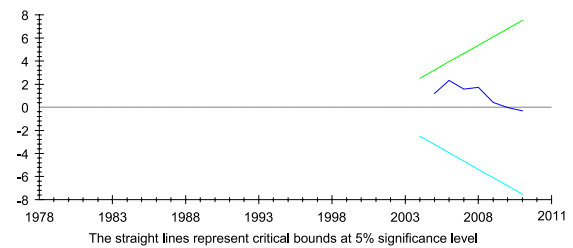


Fig. 2. Plot of cumulative sum of recursive residuals.

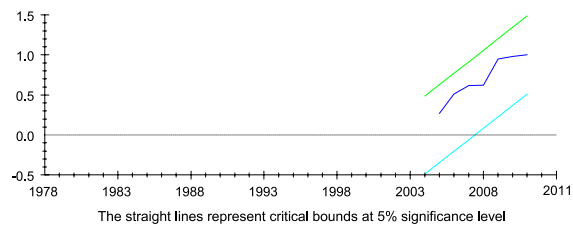


Fig. 3. Plot of cumulative sum of squares of recursive residuals.

test the long run relationship between clean energy indicators and economic growth. The result suggests the existence of cointegration among the variables at 1% level of significance. The long run estimate of alternative and nuclear energy is significant and negatively related to economic growth. The policy implication is that any current policy of government to increase clean energy through alternative and nuclear energy may retard economic growth over some period in Nigeria. This may have resulted from the fact that the economy has not fully developed its renewable energy sources. There is also the absence of separate legal and institutional framework for clean energy in the country.

The coefficient of combustible renewables and waste provides a positive and significance relationship with economic growth in the long run. An increase in combustible renewables and waste will not be at the expense of growth since 1% increase results to increase in economic growth by 1.262. This suggests that combustible renewables and waste will contribute even more, to economic growth when the institutional framework is improved. It is therefore a potential source of renewable energy which should be properly incorporated in the current strategy of government for renewable energy sector. More so, the coefficient of electric power consumption is also negative and significant at 1% level. This may suggest that electric power consumption has a crowding out effect on other macroeconomic variables that contribute to economic growth.

An interesting part of the short run result is that alternative and nuclear energy projected a positive and significant impact on economic growth in period ($t + 4$). This portrays a future potential contribution to economic growth by this indicator. Therefore government need to pay more attention to renewable energy resources to fully reap its benefit in the future. Despite the challenges faced by government to develop the country's renewable energy resources as emphasis in its Renewable Energy master Plan (REMP), the clean energy sources if developed and efficiently utilized will go a long way in providing energy security, green jobs and contribute to sustainable growth and development in Nigeria.

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