ALTERNATIVE ENERGY CONSUMPTION AND ECONOMIC GROWTH IN NIGERIA

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ABSTRACT
This study analysed the disaggregated and combined effects of renewable and fossil energy consumption on economic growth in Nigeria. Results based on a bounds test cointegration analysis and the ARDL suggest that conventional energy consumption is a strong driver of growth in the long run. A 1% increase in conventional energy consumption will lead to a 0.056% increase in economic growth. This implies that fossil fuel energy consumption plays a significant role in improving economic growth, thereby confirming the existence of the growth hypothesis in Nigeria.Renewable energy consumption, on the other hand, has a negative coefficient both in the short and long run. The result shows that a 1% increase in renewable energy consumption would reduce economic growth by 0.09% in the long run. This implies that renewable energy policy should be focused on a comprehensive examination of an optimal energy portfolio that can sustainably drive economic growth.
Keywords: Energy, Alternative energy, economic growth, ARDL, cointegration, Nigeria
JEL: O13; Q42; O40; C22; N57

1 INTRODUCTION
The economic importance of energy consumption and the environmental consequences have gained much attention globally. Theoretically, energy consumption contributes positively to economic growth (Stern and Cleveland, 2004). Disaggregating energy consumption into renewable and non-renewable components may cause this contribution to vary based on the energy source in consideration (Turner and Hanley, 2011; Chien and Hu, 2007; Hisnanick and Kymn, 1992). Particularly, the case for renewable energy is centred on the premise that renewable energy helps to increase universal access to energy supply, reduce environmental degradation and enhance sustainable development (UNCTAD, 2010; Asogwa, Ugwuanyi and Anumudu, 2018). An added benefit is that access to modern, clean, affordable and reliable energy services promotes economic opportunities and driveeconomic development (OFID, 2018).
However, the effect of renewable energy in the context of sustainable growth in developing countries (particularly African countries) is not very clear. More attention needs to be given to the nature of the relationship between energy consumption and economic growth, the process through which such relationship evolves during economic development, and the implications for development and poverty alleviation policies at different levels and stages of growth across countries. Some studies appear to cast doubt on the positive effects of

renewable energy on growth, particularly in the context of developing countries which are well endowed in fossil fuel natural resources. Studies such as Resnick et al. (2012), Huberty et al. (2011), Dercon (2012) and Scott et al. (2013) have carefully examined the internalisation of environmental costs which may change patterns of growth and concluded that it is not very plausible that green growth will offer the rapid route out of poverty. The clear indication here is the need for more studies, especially on Africa.

Although fossil fuel have been proven to be major drivers of economic growth, they have also been viewed to have a negative effect on environmental quality (Newman et al., 1996). The literature on the processes through which economies can transit to renewable energy consumption is not clear, particularly for developing countries. Renewable energy consumption could be economically costly and may lead to domestic resistance among the poor. Hence, it is debatable that the process of transition can by itself produce the growth that most developing countries are seeking, as conventional energy may deliver a faster and easier route out of poverty (Resnick et al., 2012; Huberty et al., 2011; Dercon, 2012; Scott et al., 2013). Thus, economic growth is a crucial concept that depends on an adequate combination of energy resources, clean and innovative production technologies and efficiency (Tugcu, 2013). In this context, based on the relationship between energy consumption and economic growth, where energy consumption is assumed to contribute positively to economic growth, disaggregating energy input into its components may cause this contribution to vary based on the energy source in consideration (Hisnanick and Kymn, 1992; Chien and Hu, 2007; Turner and Hunley, 2011). However, empirical research has negated the unique importance that could result from the disaggregating effects of energy consumption (renewable and non-renewable) on economic growth.

Rather, most studies have focused more on the causal direction between energy and growth (Ozturk, 2010; Lee and Chang, 2007; Odhiambo, 2009; Gollagari and Rena, 2013; Tsani, 2010; Ozturk et al., 2010). Given the context of the Nigerian economy, which is highly dependent on fossil fuel energy, especially oil, consumption (Emediegwu and Okeke, 2017; Efeyana, Buzugbe, and Olele, 2019), empirical analysis that disaggregates energy input into its components may cause the contributions to vary based on the energy options in consideration. In this sense, by disaggregating energy consumption into fossil and renewable energy components, this study aims at investigating the combined and disaggregated effects of energy consumption on growth for insightful policy implications in Nigeria.

A unique contribution of this essay is that it distinguishes between the growth linkages of renewable and non-renewable energy by decomposing energy components. Based on the premise that renewable energy consumption can pave the way for growth, particularly in developing economies, a decomposed analysis of energy components was employed to evaluate the separate effects of energy components on growth. Since Nigeria faces large growth and development gaps despite the large deposits of renewable and conventional energy, the study further tested for the combined effect of renewable and non-renewable energy on economic growth. Finally it showed that instead of the various alternative hypotheses around energy and growth, there may be a unique combination present for

different countries.Thus, the objective of this paper is to analyse the relationship between disaggregated energy consumption and economic growth in Nigeria.
The remainder of the paper is as follows. Section 2 presents the literature on the energy-growth linkages. The data and methodology are described in Section 3. The presentation and discussion of the results is the focus of Section 4 while Section 5 deals with the conclusion and recommendations.

2 LITERATURE REVIEW

This section presents the theories underpinning the relationship between energy consumption and economic growth. It further summarises the empirical studies on the energy-growth linkages.

2.1 Theoretical Literature

Energy development refers to the increase in the provision and use of energy services for economic productivity (Toman and Jemelkova, 2003). The production process requires some factors of production that are non-reproducible, while others can be manufactured at a cost within the economic production system (Stern, 2004). According to mainstream economists, land, labour and capital are the essential factors of production, while fuels and natural materials remain the intermediate inputs. However, the provision and consumption of energy services is directly linked to economic growth (Toman and Jemelkova, 2003). These linkages between energy use, other inputs and economic productivity varies significantly as an economy evolve, and this is described as the energy ladder (Barnes and Floor, 1996).
This variation in theory on the linkages between energy use and growth is shown in a simple model of an economy as presented below. This is known as the growth model with natural resources or simply referred to as the neoclassical literature on growth and resources and is expressed as follows:

$$Y = F(K_y, H_y, E) \qquad \dots (3.1)$$

$$E = E(K_E, H_E) \qquad \dots (3.2)$$

$$H = G(K_H, L) \qquad \dots (3.3)$$

Where Y represents the production of final goods and services, K_Y stands for physical capital and $H_Y$stands for human capital, along with another intermediate good, E is energy services. Energy services in turn depend on physical and human capital services, $K_E H_E$as shown in (3.2). Accordingly, if there is more than one input (capital and natural resources), there are many alternative paths an economy can take and these paths are determined by the institutional arrangements that are assumed to exist.
Therefore, the energy-economic growth nexus can be analysed under four hypotheses. The first theory states that energy usage plays a crucial role in economic growth. This is known as the growth hypothesis, which was advanced by ecological economists who argued that technical advancement and other physical factors could not possibly substitute for the important function of energy in production activities (Stern, 1993). This implies that a

country's economic growth depends largely on energy usage, so that any energy conservative policies may have a negative effect on economic growth. According to this hypothesis, energy consumption plays important direct and indirect roles in economic growth and acts as a complement to factors of production (labour and capital) in the production process. Thus, energy used is a restraining factor to economic growth, so that any shocks to the energy source will have a harmful influence on economic growth (Ozturk, 2010).

The second hypothesis is the feedback hypothesis, whichasserts the existence of a bi-directional causal link between energy used and growth. This theory reflects the interdependence between energy and growth, and upholds that energy used and economic growth are mutually determined and affected at the same time. Although bi-directional connection means that an energy conservation policy may still be harmful to economic growth at an aggregated level, energy policy must be judiciously thought out with careful regulations, since one-sided policy selection is detrimental for economic growth (Yildirim and Aslan, 2012).

Another view of the causality link between growth and energy is the neutrality hypothesis.The neoclassical economists argued that energy use does not influence economic growth (Stern and Cleveland, 2004). That is to say, both energy use and economic growth are neutral with respect to each other, meaning that capital and labour are the primary factors of production while energy is simply considered as an intermediate input of production which is used up in the entire production process (Tsani, 2010; Alam, Begum, Buysse and Hulenbroeck, 2012). This theory postulates that no causality exist between energy use and economic growth, implying that energy conservation policies will have no effect on growth.

Finally, the fourth hypothesis, known as the conservative hypothesis, states that a uni-directional connection runs from economic growth to energy consumption. In this regard, policies aimed at conserving energy use to reduce carbon emissions, improving energy efficiency measures and designing demand management policies to reduce energy usage and waste may have little or no negative effect on economic growth (Sharma, 2010). This theory is confirmed if a rise in real GDP leads to a rise in energy used. In the case of an energy-dependent economy, energy conservative policies that could be implemented to reduce emissions may not influence economic growth.

2.2 Empirical literature on the link between energy and growth

A group of studies supporting the conservation hypothesis on the link between energy and growth includes Kraft and Kraft (1978), who investigated the relationship between energy and growthusing the Granger Causality test for the period 1947-1974. The study provided reason to support a uni-directional long-run linkage running from GDP to energy consumption for the USA. Ewing et al. (2007) applied the ARDL bounds testing cointegration approach to test the long-run relationship between energy and growth in the United States. The results suggested the existence of unexpected shocks to coal, natural gas and fossil fuel energy sources which had the highest impacts on the variation of output.

Cheng et al. (2009) focused on the linkages between renewable energy consumption and economic growth for 30 OECD countries under different economic growth regimes using a panel threshold regression model. Their results indicated that economic growth positively Granger-causes renewable energy consumption. Other studies that support the hypothesis include Cheng et al. (2014), Alaba and Dada (2013), Ahmad et al. (2012), Mehrara and Musai (2012), Mehrara (2007) and Soytas and Sari (2007).

Another group of studies which support the growth hypothesis includes Apergis and Danuletiu (2014), who employed the Canning and Pedroni (2008) long-run causality test to examine the relationship between renewable energy and economic growth for 80 countries and found evidence that supports the growth hypothesis. Apergis and Payne (2009) examined the relationship between energy consumption and economic growth for six Central American countries using a multivariate framework. Their results showed the presence of both short-run and long-run causality from energy consumption to economic growth. Odhiambo (2009) investigated the causal relationship between energy consumption and economic growth in Tanzania. The bounds test found that there is a stable long-run linkage and a unidirectional causality from total energy consumption to economic growth. Payne (2010) employed the Toda–Yamamoto causality test to examine the causal relationship between biogas energy consumption and real output in the U.S. economy over the period 1949–2007, and found a unidirectional causality running from biogas consumption to real output, also confirming the growth hypothesis. Other studies that have supported this hypothesis are Wandji (2013), Alaba and Dada (2013), Zhan-wei and Xun-gan (2012), Stern (2010), Odhiambo (2009), and Lee and Chang (2008).

There is also a fairly substantial group of empirical studies supporting the feedback theory. Mahadevan and Asafu-Adjaye (2007) employed a panel error correction model using data for 20 net energy importers and exporters from 1971 to 2002. The study found the existence of bi-directional causality between economic growth and energy consumption. Apergis and Payne (2010) conducted a study to investigate the causal relationship between renewable energy consumption and economic growth for a panel of thirteen OECD countries using panel cointegration and error correction mechanism (ECM) for the period 1985–2005. The results revealed bi-directional causality between renewable energy consumption and economic growth in both the short and long run, which confirms the feedback hypothesis. Other studies with similar findings are Gollagari and Rena (2013), Apergis and Payne (2012), Shahbaz, Zeshan and Afza (2012), and Apergis and Payne (2011).

Other empirical studies also confirm the neutrality hypothesis. Payne (2009) applied Toda–Yamamoto tests to examine the nature of the causal link between renewable energy consumption, non-renewable energy consumption and real output in the United States. The study used annual data for the period 1949–2006 and found no causality between the variables. Halicioglu (2009) studied the relationship between energy consumption and income in Turkey and found evidence to support the neutrality hypothesis of no causal relationship between energy consumption and economic growth.

Payne (2010) provided comprehensive surveys on the literature of causal relationship between energy consumption, electricity consumption and economic growth. The results show that there is no clear consensus whether particular countries or groups of countries are energy-dependent or energy-neutral. Bowden and Payne (2010) also utilised the Toda–Yamamoto long-run causality approach to test the causality between renewable energy consumption, non-renewable energy consumption and real output over the period 1949–2006. Their results indicated no causal relationship between commercial and industrial renewable energy consumption and real output.

There are also studies with mixed results in the literature. Akinlo (2008) examined the causal relationship between energy consumption and economic growth for eleven countries in sub-Saharan Africa, and found mixed results for the various countries. The Granger causality test based on the vector error correction model (VECM) showed that a bi-directional relationship exists between energy consumption and economic growth for Gambia, Ghana and Senegal. However, the Granger causality test showed that economic growth Granger-causes energy consumption in Sudan and Zimbabwe, while the neutrality hypothesis was confirmed for Cameroon, Côte d'Ivoire, Nigeria, Kenya and Togo. He further suggested the need for each country should formulate appropriate energy conservation policies taking into cognisance her peculiar condition. Sharma (2010) also employed dynamic panel data models to examine the impact of electricity and non-electricity variables on economic growth for a global panel consisting of 66 countries for the period 1986–2005. The study found the impact of electricity and non-electricity variables on growth are mixed.

One of the potential reasons for the inconsistencies in the findings on energy-growth nexus is the diverse methodological approaches adopted in the literature (Ozturk, 2010). Over the years, several methods have been adopted to investigate the link between energy and growth, including time series and panel data methods. Of the time series studies, a number of studies have focused on addressing the causality between energy and growth. For these studies, the Granger causality technique was prominent. However, the emergence of new causality tests such as Sims causality, Hsiao causality tests and Toda-Yamamoto has attracted the attention of researchers in the literature. For cointegration-based causality tests, the ARDL method has been widely used in the literature, due to the relaxation of the requirement that all the variables must be integrated of the same order as well as the robustness of the method and its suitability for small samples (Narayan and Smyth, 2005; Nkoro and Uko, 2016). Ozturk (2010) suggests that to avoid conflicting results and provide reliable findings, authors should use the ARDL method, two-regime threshold co-integration models, panel data approach and multivariate models.

A review of the different strands of literature show that there exist well-documented studies in the energy-growth nexus literature. However, these studies have mainly focused on the causal direction between energy resources and economic growth, and not disaggregated and aggregated energy sources and economic growth, particularly in Nigeria. To the best of my knowledge, while studies that have disaggregated energy sources exist (Tugcu et al., 2012; Tugcu, 2013; Terzi and Pata, 2016; Destek and Okumus, 2017; Bhat, 2018), few or no studies such as this have been found in Nigeria, which is a net exporter of fossil fuel. Few studies on the impact of disaggregated energy sources (renewable and non-renewable) on growth have employed ARDL in developing countries such as Nigeria. Thus, this current study seeks to fill this identified gap by focusing on Nigeria.

3 METHODOLOGY

The long-run economic growth impacts of energy consumption were established within an ARDL bounds testing approach by Pesaran et al. (2001) and Narayan and Narayan (2010) and is based on the following validations. First, the order of integration of the series does not matter as the ARDL does not enforce a restraining assumption that all the variables under study must be integrated of the same order (Kur, Ogbonna and Eze, 2020), unlike other conventional cointegration techniques. Second, while other cointegration techniques are sensitive to the sample size, the ARDL approach is more suitable and appropriate for a small sample. Appropriate modification of the order of the ARDL technique can correct and provide unprejudiced estimates of the long-run model and valid t-statistics even when some of the regressors are endogenous.

Following the specific objective of this study, the study adopts a log-linear functional form of the Cobb–Douglas production function to explore the effect of energy consumption on economic growth. First the study estimated the standard growth model of the growth-energy nexus, which includes capital and labour, and compared this with a second growth model that disaggregated energy sources into renewable and non-renewable energy sources. The aggregated and disaggregated models are to show the combined effects of energy consumption on economic growth as well as the relative effects of the different components of energy consumption (conventional and renewable). From the literature, the standard growth model is specified as follows:

$$LNGDP_t = \alpha_0 + \alpha_1 LNEC_t + \alpha_2 LNK_t + \alpha_3 LNL_t + \varepsilon_t \quad \dots (1)$$

$$LNGDP_t = \alpha_0 + \alpha_1 LNREC_t + \alpha_2 LNFEC_t + \alpha_3 LNK_t + \alpha_4 LNL_t + \varepsilon_t + \quad \dots (2)$$

Where GDP stands for gross domestic product, RCE denotes the share of renewable energy consumption in total energy consumption, FEC denotes the share of fossil fuel energy consumption in total energy consumption, K represents physical capital and is proxied by gross fixed capital formation, and L is human capital measured by secondary school enrolment. GDP, K and L are logarithmically processed while REC and FEC are percentage values (K and L are control variables in the model). The long-run impact of energy consumption on economic growth is established within an ARDL bounds testing approach, popularised in Pesaran et al. (2001).

The ARDL representation of (3) and (4) below indicates that economic growth tends to be influenced and explained by its past values, the past values of all the explanatory variables as well as the change in the past values of all the variables in the model. Therefore, two models were specified, with one capturing the interaction between renewable and non-renewable energy and the other combining fossil and renewable energy.

$$\Delta LNGDP_t = \alpha_0 + \alpha_1 LNGDP_{t-1} + \alpha_2 LNREC_{t-1} + \alpha_3 LNFEC_{t-1} + \alpha_4 LNK_{t-1} + \alpha_5 LNL_{t-1} + \sum_{t-1}^{n} \emptyset_1 \Delta LNGDP_{t-1} + \sum_{t-1}^{n} \emptyset_2 \Delta LNREC_{t-1} + \sum_{t-1}^{n} \emptyset_3 \Delta LNFEC_{t-1} + \sum_{t-1}^{n} \emptyset_4 \Delta LNK_{t-1} + \sum_{t-1}^{n} \emptyset_5 \Delta LNL_{t-1} + ECT_{t-1} + \varepsilon_t \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots.3$$

$$\Delta LNGDP_t = \alpha_0 + \alpha_1 LNGDP_{t-1} + \alpha_2 LNEC_{t-1} + \alpha_3 LNK_{t-1} + \alpha_4 LNL_{t-1} + \sum_{t-1}^{n} \emptyset_1 \Delta LNGDP_{t-1} + \sum_{t-1}^{n} \emptyset_2 \Delta LNEC_{t-1} + \sum_{t-1}^{n} \emptyset_3 \Delta LNK_{t-1} + \sum_{t-1}^{n} \emptyset_4 \Delta LNL_{t-1} + ECT_{t-1} + \varepsilon_t \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots.4$$

Whereα_0 is a constant term, $\alpha_1$to α_5 are long-run coefficients, $\emptyset_1$ to $\emptyset_5$ stand for the short-run coefficients, Δ is the lag operator, and EC stands for primary energy consumption. All other variables are as defined above. The ECT is the error correction term, derived from residuals generated from the original functions. It shows the adjustment process of the short-to long-run equilibrium relationship between economic growth, energy consumption and other specified independent variables. As is standard, the coefficient of the ECM term is expected to be negative and also statistically significant for there to be short-run adjustment to long-run equilibrium. The error term, ε_t, is expected to be normally distributed (Gujarati, 2003). The model adopts the general to specific approach such that only variables with the best econometric properties and economic intuition are presented and discussed.

The paper utilised yearly time series data over the period 1980–2016, sourced from the World Development Indicators (WDI) of the World Bank and U.S. Energy Information Administration (EIA). The choice of time frame was guided by data availability. For the purpose of this study, Gross Domestic Product (GDP) in constant 2010 U.S. dollars is used as a proxy for economic growth. Data on energy consumption is decomposed into renewable and non-renewable energy sources, and is sourced from the EIA. Capital and labour are included in the model as control variables and are treated as separate inputs (Wang et al., 2011; Kasperowicz, 2014). Capital is measured by Gross Fixed Capital Formation, while labour is measured by secondary school enrolment (UCAN et al., 2014 and Zhao et al., 2016).

4 RESULTS AND DISCUSSION OF FINDINGS

This section presents the results of the various tests and analysis conducted to examine the relationship between aggregated and disaggregated energy consumption and economic growth in Nigeria.

4.1 Stationarity test

One of the pre-conditions for cointegration analysis is the test for unit root (Mobosi and Madueme, 2016). For the purpose of the study, the test for stationarity in all the variables is done with two popular tests: the Augmented Dickey-Fuller (ADF) test and the Phillips-Perron (PP) test, and the results are presented in Table 1 and 2 below.

Table 1: Augmented Dickey-Fuller unit root tests

Variables	ADF				Decision
	Levels		1st difference		
	Constant	Intercept & trend	Constant	Intercept & trend	
LNGDP	-0.4029	-2.1649	-4.9042**	-5.2221***	I(1)
LNEPROD	-1.4796	-2.3348	-5.4709***	-5.4001***	I(1)
LNK	-0.7399	-1.9784	-4.5776	-9.4313***	I(1)
LNL	-1.1754	-3.6428**			I(0)
REC	-2.7236	-2.6978	-5.4004***	-5.2931***	I(1)
LNFEC	-2.4268	-2.5244	-5.1316***	-5.0688***	I(1)

Source: Author's computation; Note: ***=1% sig. level; **=5% sig. level; *=10% sig. level

Table 2: Phillips-Perron unit root tests

Variables	PP				Decision
	Levels		1st difference		
	Constant	Intercept & trend	Constant	Intercept & trend	
LNGDP	-0.7989	-2.1269	-4.9519**	-5.2732***	I(1)
LNEPROD	-1.4847	-2.4154	-5.4970***	-5.4822***	I(1)
LNK	-0.8980	-1.9240	-5.3816***	-6.0685***	I(1)
LNL	-3.0440**	-3.6731**			I(0)
REC	-2.7236	-2.6978	-5.5711***	-5.4362***	I(1)
LNFEC	-2.4268	-2.5244	-5.1316***	-5.0689***	I(1)

Source: Author's computation; Note: ***=1% sig. level; **=5% sig. level; *=10% sig. level

As shown in the results, both tests show mixed results of the stationarity of the variables. Only labour is stationary at levels in both tests. However, all the other variables become stationary after first differencing. The differences in the order of integration among the variables provide strong justification for the bounds testing approach to cointegration.

However, it is expected that the presence of structural breaks could affect the relationship between energy consumption and economic growth (Kheraief et al., 2016). Structural changes that occurred in the economy are likely to subject macroeconomic variables to structural breaks which can lead to huge forecasting errors and unreliability of the model in general (Gujarati, 2007). Therefore, because structural breaks in time series are of great importance for the stationary analysis, the study employed two of the commonly used structural break unit root methods – the Bai-Perron multiple breakpoint tests and ADF breakpoint tests – to determine the presence of structural breaks.

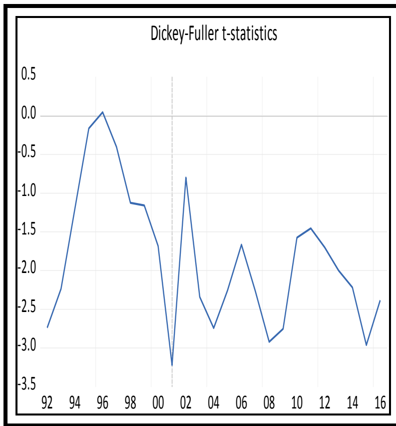
The results are shown in Table 3 and Figures 1 to 3. Based on the results of the Bai-Perron test in Table 3, the null hypothesis that there are at least three structural breaks is accepted as the scaled F-statistics is higher than the critical values at the 1% significance level. The test further shows the break dates to be 2002, 2008 and 2014. The results of the ADF breakpoint test are shown in Figures 1 to 3. From the results, structural breaks were found in years 2001 and 2002.

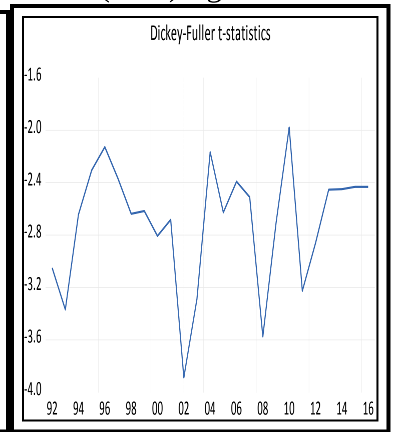
Table 3: Bai-Perron multiple breakpoint (BP) test

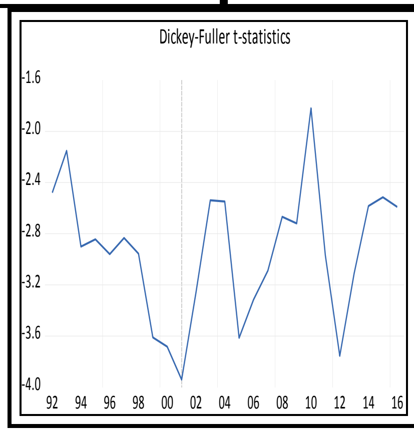
Break test	F-stats.	Scaled-F-stats	Critical Values
0 vs. 1 *	77.56294	232.6888	13.98
1 vs. 2 *	29.90979	89.72936	15.72
2 vs. 3 *	7.175640	21.52692	16.83
3 vs. 4	2.168193	6.504578	17.61
	Break dates	Sequential	Repartition
	1	2002	2002
	2	2008	2008
	3	2014	2014

Source: Author's computation

Fig. 1: ADF BP test (GDP)Fig.2: ADF BP test (FEC)Fig. 3: ADF BP test REC







Source: Author's computation

4.2 Cointegration analysis (bounds testing approach)

To determine the long-run co-integration relationship between growth and energy use in Nigeria, after observing the existence of structural changes, dummy variables were included in the regression and the unrestricted ECM was estimated with constant and no trend. The bound testing requires a test of the combined significance of the variables in the model or an F- (Wald test) under the null hypothesis that all variables in the model are jointly insignificant. Consequently, a statistically significant F-statistic is compared with the upper bounds of the critical values provided in Pesaran, Shin, and Smith (2001) for establishing a long-run relationship among stationary variables in the model. Thus, an F-statistic of 13.08 as shown in Table 4 for the disaggregated model and 11.12 for the aggregated model are sufficient for the strong rejection of the null of no long-run relationship between economic growth and the specified determinants in Nigeria as this exceeds even the 1% critical value for the upper bounds test critical values in the disaggregated and aggregated models.

By including three dummy variables (dummy 1=2002, dummy 2=2008 and dummy 3=2014) to capture the structural breaks, the unrestricted constant and no trend model was estimated. Results for the disaggregated model showed that the dummies are weakly significant, implying that the transition to civilian regime partially affected economic growth. However, in the aggregated model, dummy 1 is highly significant and positive while dummies 2 and 3 are insignificant. From this result, particularly in the aggregated model, one can infer the possible effect of the transition to the civilian regime on economic growth. This is possible as government implemented significant policies during that period.

Table 4: ARDL bounds test

	Disaggregated Model		Aggregated Model	
Test Statistic	Value	K	Value	K
F-statistic	13. 08	7	11.12	6
Critical Value Bounds				
Significance	I(0) Bound	1(1) Bound	I(0) Bound	1(1) Bound
10%	2.03	3.13	2.12	3.23
5%	2.32	3.5	2.45	3.61
2.50%	2.6	3.84	2.75	3.99
1%	2.96	4.26	3.15	4.43

Source: Author's computation

Table 5 presents the long-run elasticity estimates and shows that labour is a significant driver of growth in the long run in both the aggregated and disaggregated models. Capital is only significant in the aggregated model. In the disaggregated model, an increase in the share of fossil fuel energy increases economic growth significantly with a long-run elasticity coefficient of 0.056. This means that 1% increase in the share of fossil fuel energy leads to a 0.056% increase in economic growth, ceteris paribus.

The share of renewable energy consumption appears to have a negative effect on economic growth in the long run. According to the results in Table 5, a 1% increase in renewable energy consumption leads to a 0.093% decrease in economic growth, ceteris paribus. This result corroborates existing findings by Venkatraja (2020). According to Venkaktraja (2020), increasing share of renewable in total energy consumption in Brazil, Russia, India and China (BRIC) is associated with lower economic growth. On the contrary, the results contradict that of Ntanos, et al. (2018), which finds renewable energy to be associated with growth in higher GDP countries, than lower GDP countries. The negative effects of renewable energy on economic growth in Nigeria is not puzzling given the hypothesis that for a developing country with large development gaps and slow growth in the midst of abundant non-renewable energy (which is already being utilised), the path to increased growth and rapid development cannot be by renewable energy alone. The findings are consistent with Hisnanick and Kymn (1992) and Tugcu (2013) and imply that policies that support and encourage the inclusion of the share of renewable energy consumption in the national grid of the country should be carefully implemented, if it is intended to benefit not only as a factor of production but also as a positive externality that strengthens the growth performance of the economy by its positive effects on sustainability.

Analysis of the aggregated model in Table 5 shows that combined energy consumption, capital and labour are significant drivers of growth in Nigeria. A 1% increase in aggregate energy consumption will lead to a 1.34% increase in growth in the long run. Correspondingly, a 1% increase in energy consumption will lead to a 1.34% increase in economic growth, other factors being constant. This result is in line with the growth hypothesis and supports the findings of Gozgor, Lau and Lu (2018) for OECD countries, Lu (2017) for Taiwan, Ogundipe and Apata (2013) and Muse (2014) for Nigeria. It implies that energy consumption is a significant driver of economic growth.

Table 5: Long-run model

Disaggregated Model					Aggregated Model				
Var.	Coef.	Std.	T-stat	Prob.	Var.	Coef.	Std.	T-	Prob.
FEC	0.056	0.018	3.056	0.007	LNEC	1.341	0.214	6.272	0.000
REC	-	0.027	-	0.003	LNK	0.158	0.066	2.373	0.031
LNK	0.109	0.169	0.645	0.527	LNL	0.7434	0.223	3.336	0.005
LNL	1.996	0.551	3.622	0.002	DUMM	0.2059	0.066	3.115	0.007
DUMM	0.172	0.092	1.879	0.077	DUMM	0.0827	0.057	1.440	0.170
DUMM	0.044	0.064	0.678	0.507	DUMM	0.091	0.048	1.891	0.078
DUMM Y3	0.141	0.076	1.859	0.080					
C	1.984	0.358	5.544	0.000 0	C	- 0.1128	0.331	- 0.341	0.737

Source: Author's computation

Tables 6 and 7 present the parsimonious short-run error correction model estimates in the aggregated and disaggregated models. The error correction term indicates the speed of adjustment from the short-run disequilibrium to long-run equilibrium relation of output and energy consumption in Nigeria. The ECM coefficients in both the aggregated and disaggregated models are negative, less than 1, and statistically significant at the 5% level. For the disaggregated model, convergence to equilibrium state will occur at 12% per year, while for the aggregated model, convergence to equilibrium state will occur at 29% per year.

Table 6: Parsimonious short-run error correction model (disaggregated model)

Variables	Coef.	Std. Error	T-Stat	Prob.
ΔLNGDP(-1)	0.879732	0.040686	21.62266	0.0000
ΔREC	-0.011199	0.001953	-5.735039	0.0000
ΔFEC	-0.006789	0.001483	-4.577548	0.0003
ΔLNK	0.063186	0.022046	2.866052	0.0107
ΔLNK(-1)	-0.050051	0.019752	-2.534033	0.0214
ΔLNL	0.240038	0.046696	5.140437	0.0001
DUMMY1	0.020678	0.007958	2.598460	0.0187
DUMMY2	0.005232	0.007347	0.712072	0.4861

Variables	Coef.	Std. Error	T-Stat	Prob.
DUMMY3	0.016975	0.007670	2.213174	0.0409
C	1.984191	0.357871	5.544427	0.0000
ECM(-1)	-0.120268	0.009893	-12.15623	0.0000
R-squared = 0.99 F-Statistics = 21.013(0.0001) Adjusted R-squared = 0.99 S.E. of regression = 0.007 Sum of squared resid= 0.0008				

* p-value incompatible with t-Bounds distribution.

Source: Author's computation

Table 7: Parsimonious short-run error correction model (aggregated model)

Variables	Coef.	Std. Error	T-Stat	Prob.
ΔLNGDP(-1)	0.709445	0.067353	10.53331	0.0000
ΔLNEPROD	0.247412	0.116192	2.129335	0.0502
ΔLNEPROD(-	0.142351	0.107098	1.329160	0.2037
ΔLNK	0.045799	0.027017	1.695180	0.1107
ΔLNL	0.215994	0.066766	3.235092	0.0056
DUMMY1	0.038551	0.009759	3.950168	0.0013
DUMMY1(-1)	0.021279	0.010424	2.041310	0.0592
DUMMY2	0.009445	0.009321	1.013233	0.3270
DUMMY2(-1)	0.014587	0.009761	1.494413	0.1558
DUMMY3	0.014371	0.009045	1.588919	0.1329
DUMMY3(-1)	0.011915	0.009737	1.223699	0.2399
C	-0.112835	0.330782	-0.341115	0.07377
ECM(-1)	-0.29056	0.0278	-10.4402	0.0000
R-squared = 0.99 F-Statistics = 129.544(0.000) Adjusted R-squared = 0.99 S.E. of regression = 0.008 Sum of squared resid=0.009				

Source: Author's computation

Several diagnostic tests are conducted to verify the stability and validity of the results. The results of the diagnostic tests are presented in Table 8.The models contain some good econometric properties in terms of being stable, given the recursive estimates with the cumulative sum (CUSUM) and cumulative sum of squares (CUSUMsQ) plots. Both lie within the 5% level of significance. The Durbin Watson (DW) statistic is a first order test for autocorrelation in the residuals of a statistical regression analysis, and results mostly lie between 0 and 4. A value of 2 means that there is no autocorrelation in the regression. Hence, the values of DW in the aggregated model (2.12) and disaggregated model (2.4) show the existence of no autocorrelation. The Breusch-Godfrey LM test statistics is a higher order serial correlation test and superior to the DW test. The errors are serially independent with the Breusch-Godfrey LM test statistic of 0.97 and a probability value of 0.99, leading to the acceptance of the null hypothesis of serial independence of errors. The probabilities of the ARCH test shows that the null hypothesis of heteroscedasticity is rejected. In effect, the diagnostics tests confirm the reliability and validity of the estimation results.

Table 8: Diagnostic statistics

	Disaggregated Model	Aggregated Model
Breusch-Godfrey LM test	0.97(0.35)	4.55(0.10)
Heteroscedasticity (Breusch-Pagan)	6.33(0.71)	13.96(0.24)
ARCH test	1.26(0.26)	0.46(0.52)
Normality (Jarque–Bera)	0.61(0.73)	0.05(0.98)
Durbin-Watson	2.4	2.12
CUSUM at 5%	Stable	Stable
CUSUM Squared at 5%	Stable	Stable

Source: Author’s computation; Note: Probability values are in parenthesis.

5 CONCLUSION AND POLICY IMPLICATIONS

The paper evaluated the effects of energy consumption (renewable and non-renewable energy) on economic growth in Nigeria, using the ARDL bounds testing approach to cointegration by Pesaran et al.(2001). Two models were specified to determine the different growth effects of disaggregated (renewable and non-renewable) and aggregated energy consumption energy on growth.

In the disaggregated model, the analysis showed that there seems to be a statistically significant negative effect of renewable energy on economic growth in the long run. Although the case for renewable energy is centered on the premise that renewable energy helps to increase access to clean energy, for a developing country such as Nigeria with large fossil energy resources, renewable energy utilisation is still very low due to the limited development of renewable energy resources in the country. The results also showed that GDP responds positively to fossil fuel energy consumption in the short and long run. Thus, a 1% increase in fossil fuel energy use willincrease economic growth by 0.056%. But a 1% increase in renewable energy consumption results in a decline in growth by 0.093%. In the aggregated model, the results appear to be statistically significant, implying that energy consumption drives growth in Nigeria. Hence, a unit increase in aggregate energy consumption will increase growth by 1.34 units in the long run. The error correction models (disaggregated and aggregated) indicate the speed or rate of adjustment from the short-run disequilibrium to long-run equilibrium relationship between energy consumption and economic growth in Nigeria. The coefficient of ECT in both models is negative and significant.

The result of this paper has implications for energy policy, especially as it relates to ensuring an adequate mix of conventional and renewable energy. The National Renewable Energy and Energy Efficiency Policy of the Federal Government should be re-orientated in the light of the impacts of renewable energy on economic growth in a fossil-fuel reliant economy like Nigeria. While renewable energy is desirable due to its environmental effects, its impacts on economic growth need to be carefully examined before transitioning.

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