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POPULATION GROWTH, ENERGY USE, CRUDE OIL PRICE, AND THE NIGERIAN ECONOMY

This study examined the relationship between population growth, energy consumption and economic growth in Nigeria using the autoregressive distributed lag (ARDL) model for the period 1981 to 2015. In the study, the key role of population growth in the energy-growth link is emphasised. The result of the analysis revealed that Nigeria's population has witnessed a significant increase from 1981 up to the present period and that population growth and energy use have a positive effect on the real gross domestic product. The result showed clearly that population growth, energy consumption and oil price have positive and stable impacts on the real gross domestic product in Nigeria over the forecast period. The study, therefore, called for a reduction in electricity tariffs, improvement in government transfer spending and effective management of domestic price level to enhance the economic growth.
JEL: J10; J11; F43; O13; P48

1. Introduction

Population and energy consumption are inseparable twins. According to Barliwala and Reddy (1993), the world population increase every year, and energy resources are needed increasingly too to support numerous human activities. It thus implies that limited energy resources can inhibit human economic activities, thereby hindering economic growth in the process. It is a known fact that people consume energy for various purposes like agriculture, transportation and for industrialisation purposes. Hence, an ever-expanding population help to expand demand in energy consumption while a smaller population can probably reduce the energy demand which can have a negative on energy consumption and subsequently on economic growth too (Cheng, 1996; Soytas and Sari, 2006; Headey and Hodge, 2009). The global trend of energy consumption has shown that emerging economies

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like India and China are among the major contributors of the World's energy consumption considering their population sizes (Mazur, 1994). It thus brings to questioning as to whether it is the large population sizes that have fuelled energy consumption and subsequently economic growth in these countries.

As observed by Dyson (2010), mortality decline provided the impetus for economic growth and consequently leads to improvement in the standards of living. The main reason is that life expectancy improvement makes people live more proactive and positive life and also enables them to innovate and take risks. Empirical studies like Bloom and Canning (2001), as well as Kalemli-Ozcan (2002), affirmed that improvement in population growth rate caused by a decline in mortality help to raise the level of educational attainment and savings rates in developing countries thereby boosting investment in physical and human capital. The question then arises as to what effect population growth has on Nigeria's economy? Since the early 1970s, Nigeria's population has risen from about 56 million in 1970 to about 170 million in 2015, while the real GDP has also increased from about 19,793 billion US dollars in 1970 to 91,293 billion US dollars in 2011 with the exceptions of 2012 and 2013 where it dropped a little (World Development Indicators, 2014). Does this really suggest the reverse case for Nigeria as against the result obtained by Bloom and Canning (2001), Kalemli-Ozcan (2002), Dyson (2010) and Shaari et al. (2013), which found a positive relationship between population and economic growth?

Nigeria with an estimated population of 170 Million people and dwindling oil revenue in the last few years is faced with the challenge of diversifying its revenue base to provide for its teeming population if economic growth is to be sustained. This is boiled out of the fact that the Nigerian economy which has been solely dependent on crude oil export to cater for its ever-growing population and economic growth has now gone into recession since global crude oil price has fallen drastically from over $120 per barrel in November 2014 to around $50 per barrel in 2017. Few studies that have explored the effect of population on growth include Bloom and Canning (2001), Dao (2012) and Shaari et al. (2013). Some of these studies, especially Bloom and Canning (2001), pointed out that it is quite possible for the interaction between population dynamics and economic growth to result in a poverty trap. Similarly, considering the important role population growth and energy consumption play in an economy coupled with the fact that several economic studies have not deemed it fit to beam searchlight on the effect of demographic processes and energy use on economic growth probably due to the dearth of data on demographic features or the inability of economists to see clearly the population-energy link and economic growth, this present study becomes very crucial.

Again, the issue of crude oil price on the Nigerian economy has been very interesting lately. The country witnessed a severe drop in its growth rate due to the fall in the international crude oil price from 2015. According to data published by the National Bureau of Statistics (NBS, 2018), the country consistently remained in the doldrums of recession from the first quarter of 2015, when crude oil was sold for over 120 US dollars per barrel, to the 3rd quarter of 2016 where crude oil price was sold for less than 40 US dollars per barrel. It means that the country was in recession for five consecutive quarters. However, there appear to be some silver-lining as the country began to recover slowly from this shock starting from the 4th quarter of 2016 owing to the steady rise in the international crude oil price. However, the country's recovery from recession is still very weak because its GDP annual growth is still less than 2%. As at the 1st quarter of 2018, the annual GDP growth in Nigeria is 1.94% (NBS, 2018). For Nigeria to be able to cope with its ever-expanding population, the country's GDP should be expected to grow at nothing less than 3% per annum.

Moreover, since people consume energy for several activities like agriculture, transportation, industries and for domestic purposes, it becomes expedient to determine if energy consumption significantly affect economic growth in Nigeria. As observed by Shaari *et al* (2013) as well as Eregha and Mesagan (2017), energy use can have a significant impact on the growth of an economy because limited energy resources can restrain economic activities and, in the process, hinder economic growth. In the same vein, since studies like Obas (1996), Asafu-Adjaye (2000), Levent (2007) and Little (2014) have pointed out that causal relationship exists between energy prices and economic growth, it makes sense to inquire into the effect oil price has on economic growth in an energy-dependent economy like Nigeria. Furthermore, in line with the suggestion of Dyson (2010) and Shaari *et al*. (2013), the third objective of the study is to determine if population play a significant impact on economic growth in Nigeria between 1981 and 2015. The rest of this study is divided into the literature review section, research methodology, empirical result and conclusion.

2. Literature Review

The relationship between energy consumption, energy prices, population and economic growth has been widely discussed in past studies (Mallick, 2008; Lau *et al*., 2011; Nadia, 2012; Shaari *et al*., 2013; Mantu and Hrushikesh, 2014). Birdsall (1992) researched into population and environment. The contribution of American population growth to rising energy consumption was analysed for the period 1947 to 1991. Energy consumption was disaggregated into electricity and non-electricity consumption, and by end-use sectors: residential and commercial, industrial, and transportation. Population growth was found to be relatively unimportant as a contributor to yearly fluctuations in energy price. Bretschger and Zurich (2007) looked at the channels between energy prices and economic growth. The study developed a theoretical model with different channels through which energy prices affect economic growth and the conditions for a crowding out of capital accumulation by intensive energy use were derived. Estimating a system of simultaneous equations for 37 developed countries, the study showed that rising energy prices are not a general threat to long-term economic development.

Mallick (2008) examined the linkage between energy consumption and economic growth in India. Utilizing the Granger causality test, the study suggested that economic growth fuelled the demand for both crude oil and electricity consumption. In contrast, the variance decomposition analysis suggested a bidirectional influence between electricity consumption and economic growth, other results remaining unchanged. Ighodaro (2010) used various types of energy consumption such as coal, electric, oil and gas consumption as determinants of economic growth. The results affirmed that electric consumption impacts economic growth. Yu and Choi (1985) employed various methods but found that no causal relationship exists between energy consumption and growth.

Hong (2010) examined the long-term equilibrium and short-term dynamic between GDP and energy consumption in China with a co-integration analysis. The results submitted that energy consumption and GDP have long-term equilibrium relationship. Growth was found to be connected with energy consumption. Ji *et al.* (2011) analysed the sensitivity from the energy consumption to economic growth and found that the energy consuming indexes, total consumption of coal, gasoline, diesel oil and electricity have positive effects on GDP in Beijing. Hongwei (2011) used OECD countries to analyse the relationship and discovered that energy consumption caused economic growth to increase. Mazur (1994) did a studied in OECD countries but examined causality between electricity consumption and economic growth. It was confirmed that electricity consumption has a positive effect on economic growth in Australia, Iceland, Italy, the Slovak Republic, the Czech Republic, Korea, Portugal, and the UK while growth does influence electricity consumption in Finland and Hungary.

Lau *et al.* (2011) studied energy-growth causality in seventeen selected Asian countries. The study revealed that causality runs from energy consumption to GDP in the short-run, while it runs from GDP to energy consumption in the long-run, indicating that energy is a force for economic growth in the short-run, but in the long-run, it is economic growth that drives energy consumption. Ray and Ray (2011) conducted a study on the impact of population growth on environmental degradation in India in a bid to analyse population change and its impacts on land, forest, water and energy resources. The study revealed that rapid population growth plays an important role in declining per capita agricultural land, forest and water resources. Population pressure was found to contribute to land degradation and soil erosion, thereby affecting the productive resource base of the economy. Adhikari and Chen (2012) studied energy consumption and economic growth with the aim of examining the long-run relationship between energy consumption and economic growth for 80 developing countries. The empirical results revealed a long-run cointegrating relationship between energy consumption and growth. Dao (2012) studied population and economic growth in developing countries by examining the economic effects of the demographic transition in developing countries. Based on World Bank data and using a sample of forty-three developing economies, the study found that the growth rate of per capita GDP is linearly dependent upon population growth.

For oil price, energy and population growth in the Nigerian context, studies like Dantama and Inuwa (2012) focused on the relationship between energy consumption and economic growth in Nigeria. They found a unidirectional causality running from energy consumption to economic growth without feedback. Again, Isola and Ejumedia (2012) studied the implications of population and oil production on CO_2 emissions in Nigeria within the framework of the error correction model. The study found population growth, oil production and per-capita income to be positively related to CO_2 emissions in the country. Also, Isola *et al* (2017) observed that the high pace of population growth and urbanisation are the root cause of the energy crisis in Nigeria. Aiyetan and Olomola (2017) extended the study and found that emissions, growth and energy use unidirectionally caused population growth in Nigeria. Eregha *et al.* (2015) observed that the domestic prices of petroleum products have a significant positive impact on inflation in Nigeria. In a comparative study on Nigeria, The United States, and China, Onolemhemhen *et al.* (2017) observed that urbanisation, oil price, and income significantly influenced energy consumption in the long-run in China, Nigeria, and the US. However, the study found that urbanisation has a stronger long-run impact on energy use in China than in Nigeria and US and the income did not significantly affect energy in Nigeria and in the US unlike in China.

Shahbaz *et al.* (2017) focused on the global economy and found that there is a feedback effect between crude oil price and growth, as well as between growth and energy consumption. Moreover, the study opined that less developed countries are still heavily reliant on energy usage for boosting economic growth despite the situation with energy prices. Onuonga (2012) investigated the causal relationship between energy consumption and economic growth in Kenya. Using the Granger-causality and Error Correction Model, the study found that economic growth influences energy consumption in Kenya. Shaari *et al*. (2013) conducted a study on the relationship between population, energy consumption and economic growth in Malaysia. The results indicated that long-term relationship exists between population, energy consumption and economic growth in Malaysia. Other previous studies such as Shahiduzzaman and Alam (2012) have also suggested some policies on energy consumption in their various studies. They suggested that a policy on energy consumption should be created because of bi-directional causality between growth and energy use in Australia. However, Lise and Montfort (2006) stated that policy on energy consumption is not necessary for Turkey. Halicioglu (2009) agreed that there is no causal relationship between energy consumption and gross national product in Turkey. Hongwei (2011) examined the causality relationship between economic growth and coal consumption in China and observed that coal consumption and production do not influence economic growth. However, economic growth influenced coal consumption. From the foregoing, it is apparent that most of the reviewed studies have only focused on the causality existing between population, energy consumption and economic growth without considering directly the impact of population growth and energy on economic growth. This study fills this noticeable gap in the literature.

3. Analytical Framework and Modelling

This study anchored on the endogenous growth model by Solow (1956). The study suggested that economic growth is driven by two important exogenous variables of labour and capital. Several empirical studies have employed the growth model of Solow to broaden our knowledge of economic growth dynamics vis-à-vis the factors that are responsible the growth differences observed between developed and less developed countries (Adebola, 2011). Several Classical, Neoclassical and Endogenous theories have been offered to explain the various variables influencing economic growth. For instance, the classical theorist placed more emphasis on the role of capital in determining economic growth, Neoclassical theorists extended the Harrod-Domar model to bring in labour and technology into the growth model (Solow, 1956). However, the major challenge with the neo-classical model is the difficulty of determining the role of technological progress within its framework and the inability of the model to provide an explanation for the huge residual differences observed across countries with similar technologies (Mohammed *et al*., 2012). This makes the Solow version of the Neo-classical model more suitable in this study owing to its dynamism.

The Solow model focuses on four variables: Output (*Y*), Capital (*K*), labour (*L*), and "knowledge" or the effectiveness of labour (*A*). At any point, the economy has some amount of capital, labour and knowledge (Solow, 1956; Romar, 2009). These are combined to produce output. The production function takes the form of:

$$Y_t = f(K_t, A_t, L_t) \tag{1}$$

Where Y_t = output at time *t*, K_t = capital at time *t*, L_t = labour at time *t*, A_t = knowledge at time *t*. A_t and L_t enter the model multiplicatively, hence A_t*L_t is effective labour. The model suggested that if the amount of knowledge (*A*) increases, there is technological progress. Hence, in an explicit form, equation (1) is written as:

$$Y_t = K_t^{\alpha}, A_t L_t^{1-\alpha} \text{ [where } 0<\alpha<1] \tag{2}$$

$$Y_t / A_t L_t = \left(K_t / A_t L_t \right)^{\alpha} \left(A_t L_t / A_t L_t \right)^{1-\alpha} \tag{3}$$

$$\text{If } Y_t / A_t L_t = y_t \text{ and } K_t / A_t L_t = k_t \tag{4}$$

$$\text{Therefore, } y_t = k_t^{\alpha} \tag{5}$$

From above, *y* is output per effective labour and *k* is capital per effective labour.

The analysis is extended to incorporate the energy resources as they affect economic growth. Thus, the production function becomes:

$$Y_t = K_t^{\alpha} OP_t^{\beta} EC_t^{\gamma} AL_t^{\theta} \tag{6}$$

Where Y_t is economic growth proxy by real GDP, A_tL_t is effective labour and will be proxy by population growth, K_t is Capital proxied by Gross Capital Formation, OP_t is oil price proxy by consumer price index (Asafu-Adjaye, 2000) and EC_t is Energy consumption (*kg* of oil equivalent).

Logging both sides of equation (6), we have:

$$\ln Y_t = \alpha \ln K_t + \beta \ln OP_t + \gamma \ln EC_t + \theta(\ln A_t + \ln L_t) \tag{7}$$

Differentiating both sides with respect to time, we obtain the following:

$$gy = \alpha gk + \beta gOP + \gamma gEC + \theta(n + g) \tag{8}$$

At the Balanced Growth Path (BGP), the rate of growth of output and growth of capital are the same (i.e. *gy* = *gk*). Reworking equation (8), we have

$$gy - \alpha gy = \beta gOP + \gamma gEC + \theta(n + g) \tag{9}$$

$$gy(1 - \alpha) = \beta gOP + \gamma gEC + \theta(n + g) \tag{10}$$

Therefore, the extended version of the Solow growth model indicates that growth rate of energy consumption, oil price and population are determinants of output. Therefore, for the purpose of this empirical study, the model to be estimated is presented as follows:

$$GDP = f(GCF, P, EC, OP) \tag{11}$$

$$GDP_t = \alpha_0 + \alpha_1 GCF_t + \alpha_2 OP_t + \alpha_3 EC_t + \alpha_4 P_t + \mu_t \tag{12}$$

In equation (12), gross capital formation serves as a control variable, while μ is the stochastic residual term. Data employed in the study are mainly secondary and they are collected from the World Development Indicators of the World Bank (WDI, 2016) for the first quarter over the period of 1981 to 2015. The periods of dataset were considered due to data availability. The dependent variable is economic growth captured by gross domestic product (*GDP*). For the explanatory variables, they include investment proxied with gross fixed capital formation (*GFCF*), oil price measured by consumer price index (*OP*), energy consumption measured by total energy use in *kg* of oil equivalent, and population growth (*P*). It is expected that all the indicators (gross fixed capital formation, energy consumption and population) are expected to enhance economic growth except oil price which is expected to negatively impact on output growth.

4. Data Description and Estimation Methods

The study used annual time series data spanning from 1981 to 2015, capturing the structural periods and the global financial crisis in Nigeria. Table 1 presents the descriptive statistics of the variables. The average growth rate of real gross domestic product (GDP) was 4.17% within the period considered, depicting a substantial level of output growth. The mean of oil price measures by consumer price index growth depicts a double-digit value with 19.68% indicating that output growth is inflation driven. The growth rate of the gross fixed capital formation with 2.98% is low compared to the average growth level of real GDP. The mean value of energy consumption was 2.92% whereas population grew at an average value of 2.61%.

Table 1

List of variables and descriptive statistics

Variables	Variable description	Measurement Unit	Mean	Std. Dev.	Max.	Min.
GDP	Gross domestic product (%)	Constant 2010 US$	4.1652	7.1997	33.736	-10.752
GCF	Gross fixed capital formation (%)	Constant 2010 US$	2.9754	23.264	59.388	-35.997
P	Population (%)	Total numbers	2.6088	0.0681	2.7138	2.5194
EC	Energy consumption (%)	kg of oil equivalent	2.9173	2.1840	7.6211	-2.4523
OP	Oil price (%)	Consumer price index	19.682	18.205	72.836	5.3822

Source: Authors' computation (2017).

Table 2 presents the correlation analysis of the indicators to check the problem of multicollinearity for the results of ARDL. The results of the correlation coefficients of the indicators of real GDP were low and also maintain signs which are in line a'priori expectations.

Table 2

Correlation matrix

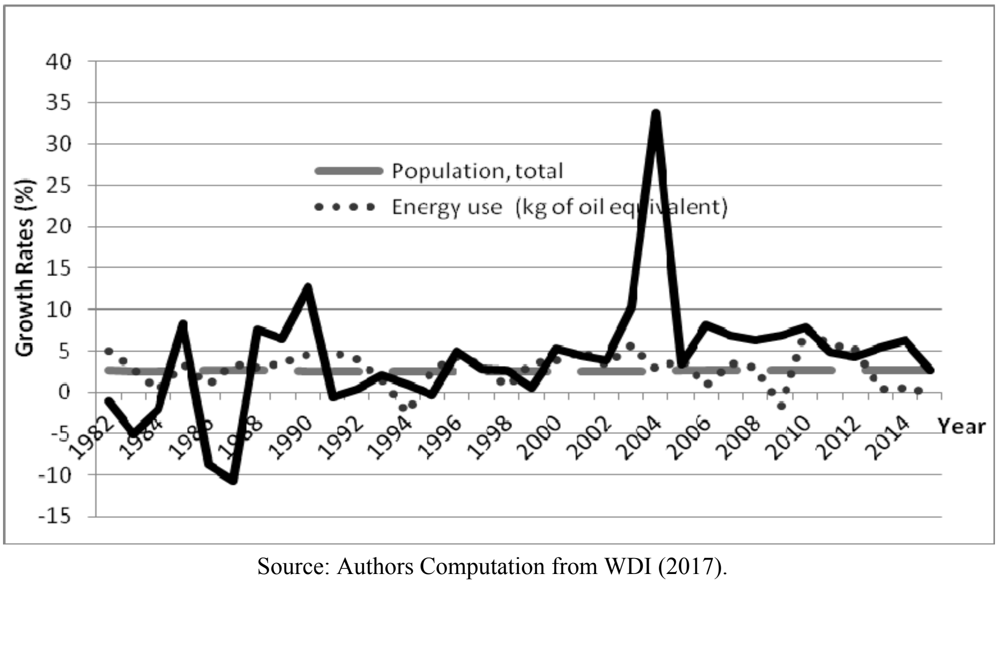
	GDP	GCF	EC	OP	P
GDP	1.0000				
GCF	0.3276	1.0000			
EC	0.1200	0.0340	1.0000		
OP	-0.0911	-0.2137	-0.1464	1.0000	
P	0.1126	0.1822	0.0400	-0.3352	1.0000

Source: Authors' computation (2017).

Figures 1 and 2 depicted the graphical illustrations of our variables. In Figure 1, it shows the trend review of growth rates of energy consumption, population and real GDP. The trend movement of growth rates of gross fixed capital formation, oil price measured by consumer price index and real GDP are shown in Figure 2. It is important t note that the trend reviews of the figures do not show clear direction (whether positive or negative) of all the explanatory indicators on real output growth. Thus, the inconclusiveness of their direction necessitates the need for an empirical analysis.

Figure 1

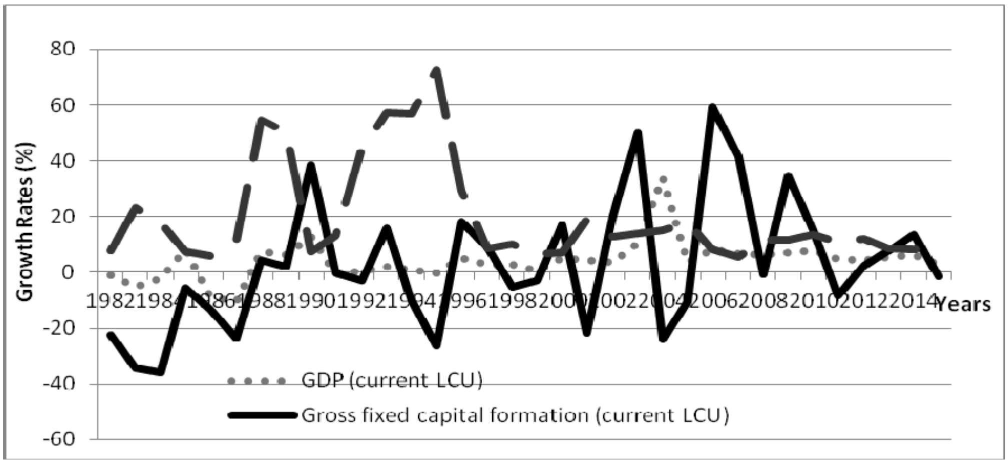
Growth Rates of Energy Consumption, Population and Real GDP



Source: Authors Computation from WDI (2017).

Figure 2

Growth Rates of Investment, Consumer Price Index and Real GDP



Source: Authors' Computation from WDI (2017).

This study employs the autoregressive distributed lag (ARDL) test developed by Pesaran *et al*. (1999, 2001) to evaluate the population growth, energy consumption and economic growth nexus. The technique was chosen owing to its superior small sample performance. According to Pesaran *et al*. (1999, 2001), the procedure of the ARDL bound test was "built on the F-statistic or Wald test in a generalized Dickey-Fuller type of regression normally used to test the significance of lagged levels of those variables that are under consideration in a conditional unrestricted equilibrium error correction model". The estimation technique also helps to analyse the long-run relationships and short-run dynamic interactions among variables. It tests the significance of the lagged levels of the variables in a first difference regression based on the standard F- and t- statistics. The method is applicable irrespective of whether the underlying regressors are *I(0), I(1)* or mutually integrated. The result from the integration test presented in Table 3 using Augmented Dickey-Fuller (ADF) test by Dickey and Fuller (1979) to establish the existence of unit roots suggest that real GDP, energy consumption and oil price are integrated at order one while gross fixed capital formation and population are found to be integrated at order zero.

Table 3

ADF unit root tests for the variables at levels and first differences

Variables	Levels		First Difference		Results
	No Trend	Trend	No Trend	Trend	
GDP	-2.428 (0) -2.957	-2.947 (1) -3.553	-8.342 (0) -3.653*	-8.238 (1) -4.273*	I(1)
GCF	-4.479 (1) -3.654*	-5.312 (1) -4.263*	-	-	I(0)
P	-4.574 (8) -3.724*	-3.962 (8) -3.603**	-	-	I(0)
EC	-2.862 (0) -2.954	-2893 (0) -3.553	-8.435 (0) -3.654*	-8.314 (0) -4.273*	I(1)
OP	-2.723 (0) -2.954	-3.012 (1) -4.273	-5.156 (0) -3.654*	-5.063 (0) -4.273*	I(1)

Note: ** and * denotes significance level at 5% and 1% respectively.
Source: Authors' computation (2017).

The ARDL bound technique entails the estimation of the unrestricted error correction model (UECM) specified in equation (13) following Pesaran *et al.* (1999).

$$\nabla Y_t = \alpha_0 + \sum_{i=1}^{p} \alpha_1 \nabla Y_{t-i} + \sum_{i=1}^{p} \alpha_2 \nabla Z_{t-i} + \beta_1 Y_{t-1} + \beta_2 Z_{t-1} + \varepsilon_{1t} \tag{13}$$

Where Y_t is the vector of dependent variables, Z_t is the vector of explanatory variables, ∇ is the difference operator, P is the lag structure, α_1 and α_2 are the short run coefficients, β_1 and β_2 are the long run coefficients, while ε_{1t} are the residual terms. Hence, following Pesaran *et al*. (1999, 2001), the models estimated is specified in equations (14) as follows:

$$\Delta GDP_t = \phi_0 + \phi_1 GDP_{t-1} + \phi_2 GCF_{t-1} + \phi_3 EC_{t-1} + \sum_{i=1}^{p} \varphi_1 \Delta GDP_{t-i} + \sum_{i=1}^{p} \varphi_2 \Delta GCF_{t-i} + \sum_{i=1}^{p} \varphi_3 \Delta EC_{t-i} + e_{1t} \tag{14}$$

$$\Delta GDP_t = \gamma_0 + \gamma_1 GDP_{t-1} + \gamma_2 GCF_{t-1} + \gamma_3 P_{t-1} + \sum_{i=1}^{p} \eta_1 \Delta GDP_{t-i} + \sum_{i=1}^{p} \eta_2 \Delta GCF_{t-i} + \sum_{i=1}^{p} \eta_3 \Delta P_{t-i} + e_{2t} \tag{15}$$

$$\Delta GDP_t = \lambda_0 + \lambda_1 GDP_{t-1} + \lambda_2 GCF_{t-1} + \lambda_3 OP_{t-1} + \sum_{i=1}^{p} \pi_1 \Delta GDP_{t-i} + \sum_{i=1}^{p} \pi_2 \Delta GCF_{t-i} + \sum_{i=1}^{p} \pi_3 \Delta OP_{t-i} + e_{3t} \tag{16}$$

$$\Delta GDP_t = \vartheta_0 + \vartheta_1 GDP_{t-1} + \vartheta_2 GCF_{t-1} + \vartheta_3 OP_{t-1} + \vartheta_4 EC_{t-1} + \vartheta_5 P_{t-1} + \sum_{i=1}^{p} \varpi_1 \Delta GDP_{t-i} + \sum_{i=1}^{p} \varpi_2 \Delta GCF_{t-i} + \sum_{i=1}^{p} \varpi_3 \Delta OP_{t-i} + \sum_{i=1}^{p} \varpi_4 \Delta EC_{t-i} + \sum_{i=1}^{p} \varpi_5 \Delta P_{t-i} + e_{4t} \tag{17}$$

Where; Δ is the first difference operator; $\phi_{1-3}, \gamma_{1-3}, \lambda_{1-3}, \vartheta_{1-5}$ are long-run multipliers corresponding to long-run relationships; $\phi_0, \gamma_0, \lambda_0, \vartheta_0$ are drifts; $\varphi_{1-3}, \eta_{1-3}, \pi_{1-3}, \varpi_{1-5}$ are the short-run dynamic coefficients of the underlying ARDL model in the equation; *t* is a time or trend variable; and e_{1t-4t} are white noise errors.

The null hypothesis $[H_0 = \phi_{1-3} = \gamma_{1-3} = \lambda_{1-3} = \vartheta_{1-5} = 0]$ of no long-run equilibrium relationship will be tested against the alternative hypothesis of the existence of long-run relationships $[H_1 \neq \phi_{1-3} \neq \gamma_{1-3} \neq \lambda_{1-3} \neq \vartheta_{1-5} \neq 0]$ using the *F*-test as suggested in Pesaran *et al*. (1999, 2001). However, this test has non-standard distributions depending on the sample size, the inclusion of intercept and trend variable in the equation, as well as the number of regressors. The estimated ARDL test statistics will be compared with two asymptotic critical values reported in Pesaran *et al.* (2001) as against the conventional critical values. If the test statistic is above an upper critical value, it implies that the null hypothesis of no long-run relationship is rejected, but if it is below a lower critical value, the null hypothesis will be accepted. If it however falls between these two bounds or critical values, the result is declared inconclusive. Table 4 shows the results of ARDL bound tests for cointegration.

Table 4

Result of ARDL bounds test for cointegration relationship

Dependent variable: GDP	Functions				F-statistics	
Model I ARDL (1,1,1)	$F_{GDP}(GDP \vert GCG, EC)$				9.6074*	
Model II ARDL (1,1,3)	$F_{GDP}(GDP \vert GCG, P)$				10.7117*	
Model III ARDL (1,1,0)	$F_{GDP}(GDP \vert GCG, OP)$				9.6746*	
Model IV ARDL (4,1,4,4,1)	$F_{GDP}(GDP \vert GCG, EC, P, OP)$				5.2258*	
	1%		5%		10%	
	I(0)	I(1)	I(0)	I(1)	I(0)	I(1)
Critical bound values for models I, II & III	5.15	6.36	3.79	4.85	3.17	4.14
Critical bound values for models IV	3.74	5.06	2.86	4.01	2.45	3.52

Note: ***, ** and * denote rejection of null hypothesis at 10, 5 and 1% significance levels respectively.
Source: Authors' computation (2017).

The orders of the ARDL models are selected by Akaike Info Criterion (AIC) for the cointegration results reported in Table 4. The results of our computed F-statistics are greater than the upper bound critical values implying that the null hypotheses of no cointegration are rejected at 5% significance level. It therefore means that there is adequate evidence in support of a unique and stable long-run relationship between energy consumption, population growth and real income growth. The long-run relationship of energy consumption, population and growth were in tandem with the findings of Shaari *et al*. (2013) in Malaysia; and also, with Hong (2010) in China and Adhikari and Chen (2012) for 80 developing countries reported for a long-run relationship between energy consumption and growth.

5. Empirical Results and Discussion

The long-run estimates and the diagnostic & stability tests are presented in Tables 5 and 6 respectively. Models I-IV revealed the ARDL models for output growth with respects to the parameter coefficients of energy consumption, population growth and oil price measured by consumer price index and gross fixed capital formation as the control variable. Table 5 shows that energy consumption has positive and significant impact on economic growth in Nigeria at 5% and 10% in Model I and Model IV respectively. Likewise, the coefficient of gross fixed capital formation has positive association with output growth which is also significant at 0.1 and 0.05 critical levels correspondingly all through the four models. In magnitude terms, a 10% change in energy consumption would positively increase output growth by 0.74%. The parameter coefficient of energy consumption increases to 1.67% when all the macroeconomic variables are included as reported in Model IV. The results were in tandem with the findings of Mallick (2008) in India, Ighodaro (2010), Mazur (1994)[4] and Hongwei (2011) in OECD countries, Ji *et al.* (2011) in Beijing, and Dantama and Inuwa (2012) in Nigeria among others, that energy consumption improves output growth while negating the findings of Yu and Choi (1985), Halicioglu (2009) and Hongwei (2011) of no causal relations in Turkey and China respectively.

Table 5

Results of the estimated ARDL long-run coefficients

Independent variables	Dependent variables (Real GDP)			
	I	II	III	IV
Constant	1.5003 (2.7230)	-3.2115 (1.4434)**	3.2521 (2.1636)	-25.507 (12.859)**
GCF	0.1874 (0.0750)**	0.07996 (0.04106)***	0.2013 (0.0815)**	0.0394 (0.0234)***
EC	0.0741 (0.0423)***			0.1671 (0.0839)**
P		1.4158 (2.0944)		0.8922 (1.2888)
OP			0.0202 (0.0796)	0.0731 (0.0476)

*Note: ***, ** and * denote rejection of null hypothesis at 10%, 5% and 1% significance levels respectively.*

Source: Authors' computation (2017).

However, the direct relationships reported by population growth and oil price measured by consumer price index with output growth were found to be insignificant at the conventional level. This implies that population growth was relatively unimportant as a factor contributor to inflation driven output growth in Nigeria. Thus, a 10% increase in population growth leads to a higher increase in real output growth by 14.2% in Model II and 8.9% in Model IV. The implication is that the Nigerian economy requires a very large market to expand.

[4] The positive effect energy consumption on economic growth was found in Australia, Iceland, Italy, the Slovak Republic, the Czech Republic, Korea, Portugal, and United Kingdom (UK).

Population increases propels the Nigerian economy to growth, hence, the need to cater appropriately for the growing population to ensure a high pace of growth for the economy. This is in tune with the findings of Dao (2012) as well as Shahbaz *et al.* (2017). Also, an increase in oil price proxy by CPI by 10% enhance real output growth by 0.2% in Model III and 0.73% in Model IV. The intuition is that Nigeria's economic growth is determined significantly by oil price increases. This is why it is an inflation driven output growth. The situation in the country reflects this as the trend of crude oil price increases often determine the direction of economic growth. Recently, the fall in the international crude oil price plunged the country into recession as economic growth records a negative growth for about five quarters, between 2015 and 2016. Recently, the country starts climbing out of recession gradually owing to the same rise in the international oil prices. Again, the positive and insignificant relationship between oil price and real output growth implies that the price of oil measured by consumer price index is a threat to long-term inflation driven output growth. The result is similar to the finding of Bretschger and Zurich (2007) for 37 developed countries. Thus, the output growth has its economic costs in terms of high cost of business and inflation. The outcomes of the population-output nexus confirm the findings of Dao (2012) that real income growth is linearly dependent upon population growth. Moreover, the empirical result of this study confirmed that energy consumption positively and significantly enhanced economic growth in model I and model IV. The intuition is that the Nigerian economy is heavily dependent on energy. The result is not surprising as Nigeria is a major producer of crude oil and a major net oil-exporting nation. Also, the result is in line with the study of Shahbaz *et al.* (2017), which observed that less developed countries are heavily reliant on energy usage for boosting economic growth despite the situation with energy prices. That is, whether or not oil prices rise or fall in Nigeria, energy usage is still a key driver of its economic growth.

The dynamics short-run estimates reported both positive and negative relationship between the lags of real income, gross fixed capital formation, energy use and population, which are all presented in Appendix. The coefficients of the error correction term (ECT) for the models were found to be negative and significant at 5% significance level ranging within the magnitude of 8.9% and 20.9%. It implies that approximately 8.9% and 20.9% disequilibrium of shock in the previous year's shock on real output growth indicators performance converges to long-run equilibrium in the current year. Thus, this supports the existence of a long-run relationship between energy use, population and real income growths in Nigeria.

The diagnostic and stability tests results were presented in Table 6. The estimated models passed all diagnostic tests indicating that the error terms have the same variance, are normally distributed and uncorrelated. The functional form test revealed that the models are well specified. The results of cumulative sum and cumulative sum of square fall within the critical bounds at 5% significance level indicating that the parameters are stable over the sample periods.

Table 6

Model diagnostic and stability tests

Test statistics	Dependent variables			
	I	II	III	IV
Normality	0.503 (0.935)	1.328 (0.317)	0.473 (0.934)	1.373 (0.289)
Serial correlation	0.6463 (0.533)	0.7455 (0.487)	0.3302 (0.722)	2.3917 (0.147)
Heteroskerdasticity	1.7501 (0.157)	1.0750 (0.410)	1.9712 (0.126)	2.7148 (0.047)
Functional form	0.2937 (0.771)	0.0176 (0.986)	0.4637 (0.647)	1.373 (0.289)
CUSUM	Stable	Stable	Stable	Stable
CUSUMQ	Stable	Stable	Stable	Stable
ECT(-1)	-0.0921 (0.0176)*	-0.1032 (0.019)*	-0.0888 (0.0178)*	-0.2086 (0.0491)*

Note: The values in brackets are the probability values for the diagnostic and stability tests.
****, **, * denote rejection of null hypothesis at 10%, 5% and 1% significance levels respectively.*
Source: Authors' computation (2017).

6. Conclusion

The analysis of the effect of energy consumption and population on economic growth in Nigeria between 1970 and 2015 revealed that for the Nigerian economy to be plunged on the path of growth i.e. to witness substantial growth in real gross domestic product, population dynamism, energy consumption, gross capital formation, as well as consumer price index should be rising significantly. This means that Nigeria has benefited immensely from population increase since independence. It is a known fact that Nigeria's population rose significantly from about 30.4 million in 1953 to 140 million in 2006, which was the last census figure reported by the National Population Commission (NPC) and recently projected to over 186 million in 2016 (World Development Indicators, 2016). In view of the fact that the ARDL result asserts a positive relationship between population and economic growth in Nigeria, it is clear that the strength of Nigeria's GDP lies in a very strong market where effective demand from a big population provides an impetus. Similarly, the vector error correction test revealed that the first period (lag 1) of population growth and energy use positively impact economic growth, while that of second and third periods (lags 2 & 3) negatively impact economic growth in Nigeria. The reason for this is not far-fetched as recent values of energy consumption, population or even consumer prices are expected to contribute more to the growth of the present period than older values of the explanatory variables would do. According to Koyck (1954), given a distributed lag model, coefficients of the lagged values decline geometrically as we increase lags. Therefore, the second lag of population growth and energy use in the study has a lesser effect on economic growth compared to the first lags and the study safely conclude that energy consumption and population growth have a significant effect on the Nigeria's real economic growth.

To this end, policies that can enhance the capacity of the populace to be able to afford and increase energy consumption must be put in place. Such policies include reduction of electricity tariffs and cushioning of the current harsh economic condition through increases in government transfer spending. Health improvement facilities that can improve the living standards of the citizenry should also be made available and domestic price level should be well managed to enhance the growth of the economy and bring the country out of recession currently being experienced. To do this, the government should put necessary structures in place to enhance the productive base of all sectors in the economy such as the agriculture and manufacturing industries through input subsidization.

References

Adebola, S. S. (2011), Electricity Consumption and Economic Growth: Trivariate investigation in Botswana with real capital formation. – International Journal of Energy Economics and Policy.

Adhikari, D., Chen, Y. (2012). Energy Consumption and Economic Growth: A Panel Cointegration Analysis for Developing Countries. – Review of Economics and Finance. Article ID: 1923-7529-2013-02-68-13, p. 68-80.

Aiyetan, I. R., Olomola, P. A. (2017). Environmental degradation, energy consumption, population growth and economic growth: Does Environmental Kuznets curve matter for Nigeria?. – Economic and Policy Review, 16(2), p. 1-14.

Asafu-Adjaye, J. (2000). The relationship between energy consumption, energy prices, and economic growth: time series evidence from Asian developing countries. – Energy Economics, 22, p. 615-625.

Batliwala, S., Reddy, A. K. N. (1993). Energy Consumption and Population. Population Summit of the World's Scientific Academies. October 24-27, New Delhi (India).

Birdsall, N. (1992). Another Look at Population and Global Warming. – Working Paper WPS 1020. Washington DC: The World Bank.

Bloom, D., Canning, D. (2001). Cumulative causality, economic growth, and the demographic transition. – In: Birdsall, N., Kelley, A. C., Sinding, S. (eds.). Population Matters: Demographic Change, Economic Growth, and Poverty in the Developing World, Oxford: Oxford University Press.

Bretschger, L., Zurich, E. (2007). Energy Prices, Growth, and the Channels in Between: Theory and Evidence. Centre of Economic Research at ETH Zurich, ZUE F7, CH-8092 Zurich, Switzerland, p. 1-30.

Central Bank of Nigeria Statistical Bulletin. (2015). Statistical Data on all Sectors of the Nigerian Economy on CD-ROM, Vol. 26, December, 2014.

Cheng, B. S. (1996). An Investigation of Cointegration and Causality Between Energy Consumption and Economic Growth. – Journal of Energy and Development, 21(1), p. 73-84.

Dantama, Y., Inuwa, N. (2012). The Relationship Between Energy Consumption and Economic Growth in Nigeria. – JORIND, 10(3), p. 293-300.

Dao, M. Q. (2012). Population and Economic Growth in Developing Countries. – International Journal of Academic Research in Business and Social Sciences. 2(1), p. 6-17.

Dyson, T. (2010). Population and Development: The Demographic Transition. New York, NY: Zed Books.

Eregha, B., Mesagan, E., Ayoola, O. (2015). Petroleum products prices and inflationary dynamics in Nigeria. – The Empirical Econometrics and Quantitative Economics Letters, 4(4), p. 108-122.

Eregha, P. B., Mesagan, E. P. (2017). Energy consumption, oil price and macroeconomic performance in energy dependent African countries. – Applied Econometrics, 46, p. 74-89.

Georgantopoulos, A. G. (2012). Forecasting Tourism Expenditure and Growth: A VAR/VECM Analysis for Greece at both Aggregated and Disaggregated Levels. – International Research Journal of Finance and Economics, 96, p. 155-167.

Halicioglu, F. (2009). An Econometric Study of CO2 Emissions, Energy Consumption, Income and Foreign Trade in Turkey. – Energy Policy, 37(3), p. 1156-1164.

Headey, D. D., Hodge, A. (2009). The effect of population growth on economic growth: a meta-regression analysis of the macroeconomic literature. – Population and Development Review, 35(2), p. 221-248.

Hong, C. (2010). The Analysis Model of Cointegration On Economic Growth. IEEE Proceedings of the 2nd Conference on Environmental Science and Information Application Technology, Zhongyuan Univ. of Technol., Zhengzhou, China, July 17-18, 2010, p. 712-715.

Hongwei, M. (2011). Causal relationship among GDP, coal consumption and coal production in China. Grey Systems and Intelligent Services (GSIS), 2011 IEEE International Conference. P. 58-61.

Ighodaro, C. A. (2010). Co-Integration and Causality Relationship Between Energy Consumption and Economic Growth: Further Empirical Evidence for Nigeria. – Journal of Business Economics and Management, 11(1), p. 97-111.

Ishola, W. A., Ejumedia, P. E. (2012). Implications of population growth and oil production on CO_2 emissions: Empirical evidence from Nigeria. – Scottish Journal of Arts, Social Sciences and Scientific Studies, ISSN 2047-1278, p. 42-52.

Isola, W. A., Mesagan, P. E., Alimi, O. Y. (2017). Energy Crisis in Nigeria: Evidence from Lagos State. – Ovidius University Annals, Economic Sciences Series, 17(2), p. 23-28.

Ji, Y., Shen, X., Liu, Q. (2011). Effect of Energy Consumption to Economic Growth in Beijing and Its Sensitivity Analysis. IEEE Proceedings.

Kalemli-Ozcan, S. (2002). Does mortality decline promote economic growth?. – Journal of Economic Growth, 7(4), p. 411-439.

Lau E, Chye X, Choong C. (2011). Energy-Growth Causality: Asian Countries Revisited. – International Journal of Energy Economics and Policy, 1(4), p. 140-149.

Levent, K. (2007). Testing causal relationships between energy consumption, real income and prices: Evidence from Turkey. Available online at http://mpra.ub.uni-muenchen.de/21834/ MPRA Paper No. 21834.

Lise, W., Montfort, K. V. (2006). Energy Consumption and GDP in Turkey: Is There a Cointegration Relationship?. – Energy Economics, 29(6), p. 1166-1178.

Little, B. (2014). Impact of Population, Age Structure and Urbanization on Carbon Emission/Energy Consumption: Evidence from macro- level, cross-country analyses. – Population & Environment, 35(3), p. 286-304

Ludi, K. L., Ground, L. (2006). Investigating the Bank-Lending Channel in South Africa: A VAR Approach. – Working Paper, University of Pretoria, South Africa.

Mallick, H. (2008). Examining the linkage between energy consumption and economic growth in India. – Journal of Developing Areas, 42(2), p. 249-280.

Mantu, K., Hrushikesh, M. (2014). Energy Consumption, Economic Growth and Financial Development: Exploring the Empirical Linkages for India. – Journal of Developing Areas, 48(4), p. 139-159.

Mazur, A. (1994). Population and the Environment. – Journal of Energy and Development, 15(5), p. 371-378.

Mohammed, A., Ismat, A., Jeroen, B., Guido, V. H. (2012). Energy Consumption, Carbon Emission and Economic Growth Nexus in Bangladesh: Cointegration and Dynamic Causal Analysis. – Energy Policy, 45, p. 217-225.
Nadia, S. O. (2012). Energy Consumption and Economic Growth: Evidence from the Economic Community of West Africa ECOWAS). – Energy Economics, 36, p. 637-647.
National Bureau of Statistics. (2018). Nigeria GDP Annual Growth rate. Available at http://www.nigerianstat.gov.ng/.
Obas, J. E (1996). Energy, Economic Growth and Causality in Developing Countries: A case study of Tanzania and Nigeria. – Energy Policy, 24(5), p. 447-453.
Onolemhemhen, R. U., Bello, S. L., Iwayemi, A. P. (2017). Evaluating the Nexus between Energy Demand and Economic Growth Using the VECM Approach: Case Study of Nigeria, China, and the United States. – World Academy of Science, Engineering and Technology, International Journal of Social, Behavioral, Educational, Economic, Business and Industrial Engineering, 11(6), p. 1601-1606.
Onuonga, S. M. (2012). The relationship between Commercial energy consumption and Gross domestic income in Kenya. – Journal of Developing Areas, 46(1), p. 305-314.
Ray, S., Ray, I. (2011) Impact of Population Growth on Environmental Degradation: Case of India. – Journal of Economics and Sustainable Development, 2(8), p. 72-77.
Romer, D. (2009). Advanced Macroeconomics" Printed by A division of MCGraw-Hill Companies. Growth in Nigeria: Implication for energy policy and Climate protection. (ICEPCP 2013) April 15-16.
Shaari, M. S, Rahim, H. A., Abd Rashid, I. M. (2013). Relationship among Population, Energy Consumption and Economic Growth in Malaysia. – International Journal of Social Sciences, 13(1), p. 39-44.
Shahbaz, M., Sarwar, S., Chen, W., Malik, M. N. (2017). Dynamics of electricity consumption, oil price and economic growth: Global Perspective. – Energy Policy, 108, p. 256-270.
Shahiduzzaman, M., Alam, K. (2012). Cointegration and Causal Relationships Between Energy Consumption and Output: Assessing the Evidence from Australia. – Energy Economics, 34(6), p. 2182-2188.
Solow, R. M. (1956). A contribution to the theory of economic growth. – Quarterly Journal of Economics, 70, p. 65-94.
Soytas, U., Sari, R. (2006). The Relationship between Energy and Production: Evidence from Turkish Manufacturing Industry. – Energy Economics, 29(6), p. 1151-1165.
World Development Indicators. (2014). World Bank Data on CD ROM.
World Development Indicators. (2016) World Bank Data on CD-ROM, First Quarter Report, Washington, DC.
Yu, S. H., Choi, J. Y. (1985). The Causal Relationship between Energy and GNP: An International Comparison. – Journal of Energy and Development, 10(2), p. 249-272.

Appendix

Variables	Coefficient	Std. Error	t-Statistic	Prob.
Model I				
D(GCF)	0.073941	0.052951	1.396413	0.1740
D(EC)	0.163970	0.562502	0.291501	0.7729
ECT(-1)	-0.092086	0.017605	-5.230649	0.0000
Model II				
D(GCF)	0.025941	0.062203	0.417030	0.6805
D(P)	6.978546	3.016209	2.313681	0.0300
D(P(-1))	-14.211968	6.352975	-2.237057	0.0353
D(P(-2))	4.432507	2.095119	2.115634	0.0454
ECT(-1)	-0.103231	0.018466	-5.590270	0.0000
Model III				
D(GCF)	0.077725	0.054066	1.437602	0.1616
D(OP)	0.017909	0.069836	0.256447	0.7995
ECT(-1)	-0.088812	0.017812	-4.986141	0.0000
Model IV				
D(GDP(-1))	0.726330	0.373406	1.945149	0.0778
D(GDP(-2))	0.511226	0.304124	1.680980	0.1209
D(GDP(-3))	0.279755	0.193919	1.442641	0.1770
D(GCF)	-0.044532	0.076930	-0.578864	0.5743
D(EC)	-0.198123	0.594410	-0.333311	0.7452
D(EC(-1))	0.728726	0.631311	1.154307	0.2728
D(EC(-2))	-1.317115	0.633126	-2.080337	0.0617
D(EC(-3))	-0.702981	0.656920	-1.070117	0.3075
D(P)	7.999297	4.132158	1.935864	0.0790
D(P(-1))	4.868545	12.96199 6	0.375601	0.7144
D(P(-2))	-5.052553	8.686713	-0.581641	0.5725
D(P(-3))	4.054775	2.617129	1.549322	0.1496
D(OP)	-0.088091	0.109923	-0.801391	0.4399
ECT(-1)	-0.208573	0.049064	-4.251080	0.0014