ANALYSIS OF THE EFFECT OF ENERGY CONSUMPTION, CO^2 EMISSION ON ECONOMIC GROWTH IN NIGERIA

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ABSTRACT

Developing economy like Nigeria requires energy consumption by productive sector to drive her growing economy. Most ecological economists have argued that the increasing energy consumption leads to increase in CO^2 emission and economic growth in Nigeria. However, few studies have been carried out to investigate the relationship between energy consumption, CO^2 emission and economic growth in Nigeria. Most related studies lack appropriate theoretical framework, the inclusion of relevant variable and the adoption of relevant models; these may have affected the result of their studies. It is against this background that this study investigates the effect of energy consumption, CO^2 emission on economic growth in Nigeria, for the period of 1981 to 2015. The paper relied on Zivot-Andrews unit root technique to examine the unit roots properties of the variables the variables have structural breaks ranging from 1995 to 2010. Also, the ARDL model was employed to examine the effect of energy consumption and CO^2 emission on economic growth. In addition to the explanatory variable are capital and labour. The Granger causality test technique was employed to examine the relationship between energy consumption, CO^2 emission and economic growth. The bounds testing results infer that long-run relationship run from economic growth (RGDP) to Capital, Labour, energy consumption and CO^2 emission. The estimated result of *the ARDL models revealed that energy consumption, capital and labour contribute positively to economic growth. While CO^2 emission contribute negatively to economic growth in the short-run. This result was supported by the long-run estimated. Though in the long-run, capital and labour were not significant. The Granger causality test result revealed a uni-directional causality from capital to economic growth and labour to economic growth. But a bi-directional causality was expressed between energy consumption and economic growth and CO^2 emission and economic growth. An important recommendation resulting from these results is that policy makers should begin to implement policies, especially the energy policy of 2003, toward encouraging the use of alternative energy sources such as solar, wind, and biomass.*

Keywords: *Economic Growth, Energy Consumption, CO^2 Emission*

1. INTRODUCTION

Energy and its environmental impact have prevailed in economic literature over the years; as well, its importance to the economic growth and development. As the largest oil producing producer in sub-Saharan Africa and a member of the Organization of Petroleum Exporting Countries (OPEC), Nigeria is faced with the challenges of growing its economy. Nations pursue economic growth to improve the living standard of their people and Nigeria is not an exception. According to Anaduaka (2009), from 1960 to 1970, the Nigerian economy grew at an annual average of about 3.1 percent. Between 1970 and 1978, this rate grew to about an average of 6.2 percent. Between 1988 and 2004, however, the rate had decreased to about 4 percent before rising to about 4.6 percent between 1995 and 2005. Between 2005 and 2012, the economy experienced a continuous decline to as low as 4.2 percent. The government of Nigeria has been making concerted effort to turn the economy to a sustainable growth and development.

The Nigerian economy remains monocultural and heavily depends on oil which account for about 80 percent of government revenue, 90 to 95 percent of export earnings and over 90 percent of foreign exchange earnings. Thus, energy utilization and consumption has a crucial role to play if the Nigeria economy must grow. This is the basic rationale behind the ongoing deregulation exercise of the Nigerian downstream sector and the promulgation of the comprehensive energy policy of 2003. However, this near total dependence on oil for foreign exchange earnings has its implications. For example, energy consumption sources such as fossil fuel are the major courses of climate change phenomenon commonly known as global warming. The negative externalities caused by energy related economic activities include oil spillage, gas flaring and so on. There is, of course, the agitation that environmental degradation has caused harm in the Niger Delta region of Nigeria. This paradox of plenty and its devastating effect on life, agricultural activities and industrial activities on the oil producing regions has come to be known in the economic literature as resource curse (Aguegboh & Maduene, 2013).The term refers to the paradox that countries and regions with abundance of natural resource tend to have less economic growth and worse worst development outcomes than countries with fewer natural resources. Nigeria, like other 'resource cursed' economies, has not been able to achieve a level of economic growth that is commensurate with the abundant natural resources.

Consequently, depletion and consumption of energy resources which in turn result in CO_2 emission has been argued to be the major course of climate change in Nigeria. Nigeria ranks 38 amongst the global community of nations in terms of CO_2 emissions. This was attributed to the green house gas emission caused by the expensive energy consumption that accompanied growth in the economy (Akpan & Akpan, 2012). Emission in metric tons per million US$ of GDP in Nigeria at 2004 stood at 762 at purchasing power parity (PPP) in US$2000 while the emissions per capital (tone per person) was 0.73 (World Bank, 2007). This was probably due to a faster increase in the use of gas and oil than of coal. Nigeria and Brazil are examples of where this effect has dominated in the total change of emission (World Bank, 2007). In addition, CO_2 emission has on the average grown by 41.3 percent between 1990 and 2011 albeit the downward trend observed in 1992 and 1995. Specifically, emissions from the use of coal/peat fell almost 90 percent indicating a drastic reduction in the use of coal. During this period, the use of oil increase and its emission rose by almost 30 percent while the percentage change observed for natural gas emission stood at 82 percent (World Bank, 2007).

The issue of climate change is not only the outcome of energy consumption. In fact, the supply side is equally a heavy emitter of greenhouse gases with direct consequences on economic activities through rampant degradation of the environment. However, the environmental impact of energy consumption is a factor that has stimulated research interest in the relationship between energy consumption and economic growth. Government, professional and academics alike, are concerned about the impact of energy consumption on the economy. One object of research in this area is to determine whether the economic benefit from high energy consumption can neutralize the consequence negative externality inflicted on the economy or not. This has remained controversial issue in the last two decades. If the marginal social benefit of economic growth is greater than the marginal cost of environmental impact, then it is worthwhile to increase energy consumption to improve economic growth. In the same vein, if energy use cannot improve economic growth, a reduction in energy intensity is needed in order to avoid its negative impact on the economy. Given the abundance energy resources in Nigeria, it becomes worrisome why the economy is still facing the challenges of sustainable economic growth.

With the increasing urban population and the creation of a large class of white collar workers, there is an increasing demand for second hand vehicles in Nigeria, causing air pollution and carbon emission in the country. Most of the vehicles used in Nigeria have very low energy efficiency, mainly because they are imported into the country when quite old. However, no proper assessment has been carried out to establish the level and impact of air pollution from the automobiles. Nigeria does not have an air quality management system and the few existing data/land pollution has been obtained through measurement done on an adhoc basis. The general public may be at risk of suffering from dangerous diseases in the long-run. There is yet to be research evidence to prove this.

But Nigeria being a developing country is very prone to the adverse effect of climate change because of its low capacity to adapt, lack of technology, institutional and financial capacity. The increasing demand for energy by industrial, household and transport sector may also increase the effect of climate change in Nigeria. Though some researches on the energy-environment-growth linkages in Nigeria has been carried out by some Nigerian authors (see: Iwayemi & Adenikinju (2001); Omisakin (2009); and, Jerome (2001)). Omotor (2008), Adenikinju and Folabi (2006) and Adeniran (2009), Odularu and Okonkwo (2009), Chukwu and Ndifreke (2011), Tiwari (2011), Dantama, Abdullahi and Inuwa, (2012) and Akpan and Akpan (2012) have carried out study which centered on energy-environment and growth relationships in Nigeria using a combined simultaneous approach. Moreover, most of these studies mostly focused on testing the validity of the Envirnmental-Kuznet-Curve (EKC) and do not examine the contributions of energy consumptions, carbon emissions to economic growth in Nigeria.

It is against this background that this study examined how environmental degradation and other variables such as energy consumption combine with labour and capital affect the growth process using coherent framework. Since fossil-fuel energy used is the main sources of global warming and the major cause of carbon emission, incorporating energy consumption and carbon emissions will explain the contribution of energy used and the adverse effect of the bi-product from energy consumed. The inclusion of relevant variables such as capital and labour will make the estimate not only unbiased but also consistent (Lutekepol, 1982). However, incorporating more relevant information will make inference more reliable.

LITERATURE REVIEW

Theoretical Literature Review

The links between economic growth, environment and climate change are complex, multidimensional and dynamic such that the implications on the economy are numerous: changes in productivity, resource endowments, and production consumption patterns. The natural environment plays two key roles in relation to economic growth. First, the natural environment provides natural resources, which serves as inputs whether direct or indirect to production of goods and services. Second, the natural environment functions as a link to pollutants which are generated from economic production and consumption. When the functions of the natural environment are seriously impaired, economic growth can slow down or even be negative. This is often the case when the resources are depleted rapidly or in absolute numbers over time.

The traditional and new growth models have been widely used to examine the implication of environment on growth. In such models, energy consumption is considered as inputs to the growth process of an economy (Tsani, 2010). However, the consequences of such energy use which distort growth fundamentals are often ignored. The underlying explanation for this is built upon the possibility of emissions of green house gases which have detrimental effects on aggregate output through, say change in weather and climate conditions which in turn affect productivity. The Ramsey-Cass-Koopmans model of growth has also formed the basis of much related work on climate change economics. Milner and Dietz (2011) built on the standard Ramsey-Cass-Koopmans growth model. Their model is made up of regions with small shares of global CO_2 emissions, so that climate change may be treated as exogenous variable to the region's development choices. Bosello, Roson and Tol (2007) argue that with a constant savings rate, a lower output due to climate change will lead to a proportionate reduction in investment which in turn will depress future production and in almost all cases, future consumption per capital. They argue forcefully that within an endogenous growth framework, growth prospects in absolute and per capital terms may be suppressed via changes in labour productivity and the rate of technical progress.

Another strand of literature, the ecological economic theory, states that energy consumption is a limiting factor to economic growth, especially in modern economies (Binh, 2011). However, Stern (2000) has argued that technological progress and other physical inputs could not possibly substitute the vital role of energy in production process. This may be in view of the fact that energy is a primary value addition to the production processes since other factor inputs (labour and capital) require energy for optimal performance (Belloumi, 2009).

In more recent trend, renewed interest in examining environment-energy-growth nexus has been focused on the Environmental-Kuznet-Curve (EKC) or what termed the Carbon Kuznet Curve (CKC) hypothesis (Aslandis, 2009; Galleottiet, Manera & Lanza, 2009). The theoretical assumption is that, initially as per capital income rises, environmental degradation exaggerate; however, after the achievement of a critical level of economic growth, it would tend to fall (Tiwari, 2011). In other words, high economic growth is achieved through energy consumption expansion at the expense of more energy and 'green' efficient technologies. However, there is dispute whether energy consumption is a stimulating factor for, or is itself a result of economic growth. However, Tiwari (2011b) extended his earlier work using the same analytical framework but incorporating labour and capital in the framework of production function besides energy consumption, CO_2 emission as a measure of pollution. Tiwari (2011b) further included energy consumption rather than electricity consumption as a measure of energy consumption. Reason was because electricity consumption is not the only energy consumption variable. It is just part of energy consumption. Taking only electricity consumption as energy may not give correct picture of the existing situation.

Empirical Literature Review

There is basically few research works energy consumption, CO_2 emission and economic growth in Nigeria. Few works can be traced to the works of Nnaji, Chukwu and Uzoma (2012). They examined the relationship between CO_2 emission, energy consumption, foreign trade and economic growth in Nigeria. The augmented form of Granger causality test and bounds testing approach to cointegration based on ARDL procedure was employed. The ARDL result revealed economic is determined by energy consumption, CO_2 emission, capital formation and foreign trade. The Granger causality test result revealed uni-directional causality from energy consumption to economic growth, energy consumption to CO_2 emission, CO_2 emission to economic growth, capital formation to economic growth and foreign trade to economic growth. The inclusion of foreign trade in the model does not conform to theory. Also, testing the unit root of the series without accounting for structural breaks may have effect on the estimated model.

Omisakin (2009) investigated the dynamic causal and long run relationships among energy consumption, carbon emission and economic growth in Nigeria within the framework of the Environmental Kuznets Curve (EKC). By using the bounds testing approach to cointegration, he found unidirectional causal relationships running from energy consumption to economic growth, energy consumption to carbon emission and economic growth to carbon emission. In a similar study, Halicioglu (2009) also applied the bounds testing approach to cointegration in a multivariate model with carbon emission, energy use, income and foreign trade. He found bidirectional granger causality both in the short and long-run between the carbon emission and income in Turkey. Ang (2008) found that output growth Granger causes energy consumption in Malaysia. However, there is weak evidence of causality running from carbon emissions to income in the long-run, but no feedback link is observed. These studies lack appropriate modeling caused by the pre-estimation test on the data employed. Limiting their analysis to causality test did not reveal the contribution of each variable to economic growth.

Another category of empirical works, though, very few at the moment have examined the relationship between energy consumption, carbon emissions and economic growth in a simultaneous equation model. Shen (2006) seems to have pioneered this area of research by studying the Environmental Kuznets Curve (EKC) relationship using single and simultaneous equation system with Chinese provincial data from 1993 to 2002. He found three main differences between the single polynomial equation estimators of the EKC, and the simultaneous equation estimation of the EKC. He observed that since the difference tend to cause different policy implications, simultaneity between income and pollution should be considered before regressing income variables on environmental variables in future studies. In similar light, Liu (2005) estimated a simultaneous system in GDP and CO_2 emission, and found that including energy consumption in the regression implies a negative relationship between income and CO_2 emissions, which is contrary to previous findings.

Tiwari, (2011) examined the relationship between CO_2 emission and GDP in India. He found that CO_2 Granger causes GDP while energy consumption does not Granger cause GDP. Also, GDP does not Granger cause CO_2 but energy consumption Granger causes CO_2 emission. It was also found that CO_2 emission Granger causes energy consumption but GDP does not Granger cause CO_2 emission in India.

Binh (2011) employed cointegration and Granger causality technique to examine the relationship between per capital energy consumption and per capital Gross Domestic Product in Vietnam. His result indicates that the LPCEC and LPCGDP are cointegrated and there is a strong unidirectional causality running from economic to energy consumption, but not vice-versa. It was also discovered that the effect of economic growth on energy consumption in Vietnan is time-variant. That is they are significantly different between period before and after structural break breakpoint of 1992. The result substantiated the neoclassical argument that energy consumption is not a limiting factor to economic growth.

Odularu and Okonkwo (2009) investigated the relationship between energy consumption and economic growth in Nigeria from the period 1970 – 2005 applying the cointegration technique. The result derived infers that there exists positive relationship between current period energy consumption and economic growth. With the exception of coal which was positive, a negative relationship exists between energy consumption and economic growth.

Dantama et al. (2012) employed cointegration and error correction mechanism to analyze the contribution of disaggregated energy consumption to economic growth in Nigeria over the period 1980 to 2010 and found that a long-run relationship exist between energy consumption and economic growth. The coefficient of coal consumption is positive but statistically not significant, while both oil consumption and electricity consumption revealed positive and significant contribution to economic growth. The error correction model suggests that the speed of adjustment is relatively high and have the expected signed and significant. This study was modified slightly by incorporating electricity consumption and carbon emission. The result shows that in the long-run, economic growth is associated with increased carbon emissions, while an increase in electricity consumption leads to an increase in carbon emissions. It was suggested that Nigerian growth process is pollution intensive. They further found no support for the hypothesized environmental Kuznets Curve (EKC). Granger causality results confirm a unidirectional causality running from economic growth to carbon emissions while no causality was found between electricity and growth (Akpan & Akpan, 2012).

Further analysis of climate change effect on economic growth was examined using cointegration technique. From the result, it was found that higher temperature substantially reduced economic growth in poor countries. Their results also indicated that higher temperatures have wide-ranging effect on agricultural activities, industrial output, investment innovation and political stability. It was added that, longer increase in temperature also show substantial negative effects on poor countries economic growth (Dell, Jones & Olken, 2008). This study is limited based on its techniques of analysis that lacks theoretical justifications and the categorization of poor countries suffers categorization or sample bias.

RESEARCH METHODS

Theoretical Framework and Model Specification

Having comprehensively described the theories related to this study, the study adopts the unified theory of energy and growth, which is basically a synthesis of the mainstream and the ecological economics models of economic growth. The rationale behind this selection is partly due to the fact that thermodynamics implies that energy is essential to all economic production, thereby supporting the criticism leveled against mainstream economic growth models that ignore energy's legitimacy. These arguments provide the springboard for a fusion of the mainstream and ecological economic growth models.

From the theoretical literature perspective, the traditional growth models have undermined the role of energy in the economy. Also, mainstream growth theory considers capital and labour as the basic factors of production, while input such as energy and raw materials are considered intermediate factors. This over-concentration on capital and labour in the traditional theories as primary input in production has led to less and less treatment of energy as a factor in the production function.

Stating from the neoclassical growth theory developed by Solow (1956), a production function was specified as:

$Y = f(A,K,L,)$ - - - 3.1

Where: Y is output, A is technological progress, K is capital stock, L is labour. The neoclassical growth theory assumes that there is a decreasing rate of return to output as labour employed increases. It further assumed that labour and the level of technology grow at exponential rate. Going by the second assumption, the neoclassical growth model argues that the only cause of continuing economic growth is technological progress. According to the neoclassical growth theory, if there is no technological progress, growth in this model will eventually come to halt. By intuition, the model states that increases in the state of technological progress raises the rate of capital; thereby offsetting the diminishing returns to capital that would lead to a halt in growth (Stern, 2012).

The traditional growth models presented above do not capture the role of energy in their respective models, however, ecological economists or the physical growth theorists (Stern, 1999; Spreng, 1993; Chen, 1994; Stern, 1994; Ruth, 1995; Gever *et al.,* 1986; Kaufmann, 1987; Hall *et al.,* 1986; Hannon 1973) have held strongly the role of energy in the production process. Building on the second law of thermodynamics, which states that, a minimum quantity of energy is required to carry out the transformation of matter; therefore, there must be limits to the substitution of other factors of production for energy (Ayres & Nair, 1969; Stern, 2012; Stern, 1997). Since all production involves the transformation of inputs into output in some way, it therefore means that all such transformation require energy. In this way, ecological economists consider energy as an essential factor of production. To buttress their point, the ecological economists employed the frequently used neoclassical production function in the form of Cobb Douglas production function:

$Y = AK^{\alpha}L^{\beta}$ - - - 3.2

Where: Y is output, A is technological progress, K is capital stock, L is labour and α and β are substitutability parameter. Since A is endogenously determined in the new growth model, it is thought to relate to energy in some ways. This is because the amount of technology per unit of time requires some level of energy to work. Technology in this regard refers to plants, machinery and equipment and without adequate supply of energy this technological stock will be obsolete (Elijah & Nsikak, 2013). This is justified through the law of thermodynamics which holds that no production can occur without conversion of energy (Ayres & Nair, 1969). Thus from the theoretical perspective of the endogenous growth model, energy can enter the production function as one of the factors of production.

Based on the theoretical exposition, the empirical model for this study can be expressed as

$Y = f(K, L, E)$ - - - 3.3

Where: Y = total output, K = capital stock, L = labour and E = energy used for production (energy consumption).

However, Romer (2006) had argued that since environmental considerations are absent in such model, many now believe, following Malthus's (1798) classic argument that environmental factors are critical for long-run economic growth. It is against this background that we extend the model to include CO_2 emission as an additional independent variable. In addition, we account for the additional control variables (labour and capital) as determinants of growth in Nigeria. The basic empirical specification of the study is thus presented as follows:

$RGDP = f(LAB, CAP, ENC, CO2)$ - - - - - - - - - - - - - - - - - - 3.4

Where: RGDP = Real Gross Domestic Product, LAB = Total labour force, CAP = total capital, proxied by gross fixed capital formation, ENC = Total energy consumption and CO_2 = carbon emission.

The model in its econometric linear form can be expressed as:

$RGDP_t = \beta_0 + \beta_1 CAP_t + \beta_2 LABt + \beta_3 ENC_t + \beta_4 CO_{2t} + \mu_t$ - - - 3.5

Where: β0 to β4 are the parameters to be estimated and μ is the error term. The theoretical expectations about the signs of the coefficients of the parameters are as follow: β1, β2, β3, > 0, while β_4, < 0.

As used by Elijah and Nsikak (2013); Sari, et al (2008) and Olusegun (2008), this study adopted the Autoregressive Distributed Lag (ARDL) bounds testing approach developed by Pesaran and Smith (2001). Following Pesaran and Smith (2001), the Error Correction Model (ECM) of the unrestricted Autoregressive Distributed Lag (ARDL) equation based on equation 3.6 is specified in its log form as follows:

$$\Delta RGDP_t = \beta_0 + \beta_1 lnCAPt_{-1} + \beta_2 lnLABt_{-1} + \beta_3 lnENC_{t-1} + \beta_4 lnCO_{2t-1} \quad \sum_{i=1}^{k} \alpha_1 \Delta RGDP_{t-i} + \sum_{i=1}^{k} \alpha_2 \Delta CAP_{t-I} + \sum_{i=1}^{k} \alpha_3 \Delta LAB_{t-i} + \sum_{i=1}^{k} \alpha_4 \Delta lnENC_{t-I} + \sum_{i=1}^{k} \alpha_5 \Delta CO_{2t-i} + \lambda ecm_{t-1} + \mu_t \quad - - - 3.7$$

Where: ECM is the error correction factor μ_t is the white noise error term.

As noted by Gujarati and Porter (2009), the log transformation model is used to reduce heteroscedasticity as well as skewness in a model. Most economic variables have the feature of being positive skewed and they are heteroscedastic. Therefore a logarithmic transformation of such variable reduces both skewness and heroscedasticity.

Estimation Procedures

Unit Root Test

Several studies have found that the conventional unit root tests (Augmented Dickey Fuller and Philip-Perron) fail to reject the unit root hypothesis for the series that are actually trend stationary with a structural break (Binh, 2011;

Muhammad, Tasneem & Saghir, 2006). Thus, unit root test developed by Zivot and Andrew (1992) will be used for this study. Zivot and Andrew basically modified the Perron unit root test that considered a breakpoint as endogenous.

Thus, to test for unit root against the alternative of trend stationarity process with a structural break both in slope and intercept, the following regression are used:

$$\Delta Y_t = c + \alpha Y_{t-1} + \beta t + ?\Delta Ut + \sum_{j=1}^{k} d_j \Delta Y_{t-j} + \varepsilon_t \quad - \quad - \quad - \quad 3.7$$

$$\Delta Yt = c + \alpha Yt\text{-}1 + \beta t + \theta \Delta T_t + \sum_{j=1}^{k} d_j \Delta Y_{t-j} + \varepsilon t \quad - \quad - \quad - \quad 3.8$$

$$\Delta Yt = c + \alpha Yt\text{-}1 + \beta t + \theta \Delta Ut + ?\Delta Ut + \sum_{j=1}^{k} d_j \Delta Y_{t-j} + \varepsilon t \quad - \quad - \quad - \quad 3.9$$

Where ΔUt is an indicator of dummy variable for a mean shift occurring at each possible break date (TB) while ΔT_t is corresponding trend shift variable.

The null hypothesis in all the three models is $\alpha = 0$, which implies that the series $\{y_t\}$ contains a unit root with a drift that excludes any structural break, while the alternative hypothesis $\alpha < 0$ implies that the series is a trend-stationary process with a one-time break occurring at an unknown point in time. The Zivot and Andrews method regards every point as a potential break date (TB) and runs a regression for every possible break-date sequentially. From amongst all possible break-points (TB), the procedure selects as its choice of break-date *(TB)* the date which minimizes the one-sided t-statistic for testing α $(\alpha = 1)$.

The ARDL bounds test was employed to analyze the effect of energy consumption, CO_2 emission on economic growth. The bound test involves estimating the long-run parameters in equation using OLS method and then tests the null hypothesis (H_o) of no long-run relationship against the alternative hypothesis (H_1) that there is long-run relationship. The hypothesis was tested by comparing the calculated F-statistic against the critical values given the Pesaran and Smith

(2001). If the computed F-statistic exceeds the upper critical values, the null hypothesis of no long-run relationship can be rejected. On the other hand, if the F-statistic falls below the lower critical value, then the null hypothesis can be rejected. Lastly, if the F-statistic lies between the upper and lower critical values, the result is rendered inconclusive. In such circumstance, knowledge of cointegration rank of the forcing variable is required to proceed further (Pesaran & Smith, 2001).

Having established the long-run relationship among variables, the study proceeded by analysing the long-run coefficient. The long-run analysis shows the effect of the independent variables on the dependent variable. After which the short run dynamics was analyzed using the parsimonious error correction model (ECM) based on the ARDL model. In addition to analyzing the short-term effect of the independent variables on the dependent variable, the ECM coefficient was analyzed to know the speed of adjustment from the short-run disequilibrium to the long-run equilibrium model.

In analyzing the Granger-causality relationships, our main interest is to find out the lead or lag relationship between variables. The Granger (1969) approach to the question of whether X causes Y is to determine how much of the current Y can be explained by past values of Y, and then to see whether adding lagged values of X can improve can improve the explanation. Y is said to be Granger-Caused by X if X helps in the prediction of Y, or if the coefficients on the lagged Xs are statistically significant. Note that, two ways causation is frequently the case: where X Granger-Cause Y or Y Granger-cause X. In this study, the researcher looks at a case of Granger-Causality that entails aggregate energy consumption and real gross domestic product.

The following equations are used to determine the causality:

$$\Delta \mathrm{Y} = \alpha + \sum_{i=1}^{k} \beta \Delta X i_{t-1} + \sum_{i=1}^{m} \Upsilon i$$

$$\Delta \mathrm{X}_{\mathrm{i}} = \alpha + \sum_{i=1}^{k} \beta_{i-1} + \mu + \sum_{i=1}^{m} \delta i \Delta \Upsilon_{t-1}$$

Where Y is economic growth proxied by RGDP and X_i is primary energy consumption and CO_2 emission in Nigeria.

In the Granger-Causality test, the null hypothesis is that there is no causality between two variables. The null hypothesis is rejected if the probability of F-statistic given in Granger Causality result is less than 0.1, i.e at a 1 percent level of significance. Otherwise, we accept the null hypothesis. However, the aim of employing Granger-Causality test was to determine the order of relationship.

4. PRESENTATION AND DISCUSSION OF RESULTS

Unit Root Test Results

The results of Zivot and Andrews unit root test are presented in Table 4.1. These results suggest that all the variables are integrated of I(0) and I(1) at 5% significance level. This test indicates the most probable break-points in the data. It was found that almost all the series exhibits structural breaks clustering around 1995 to 2009.

Table 4.1: Zivot-Andrews Unit Root Test with Structural Break

VARIABLES	BREAK DATE	Z-A TEST STATISTIC	CRITICAL VALUES	REMARKS
RGDP	1995	-11.56152	-5.08	I(0)
DLNCAP	2010	-8.6616	-5.08	I(1)
LNLAB	2006	-9.5336	-5.08	I(0)
LNENC	2009	-7.4023	-5.08	I(0)
$DLNCO^2$	2009	-7.6304	-5.08	I(1)

The critical values for Zivot and Andrews test are -5.57, -5.08 and -4.82 at 1%, 5% and 10% level of significance respectively.

Source: Authors' Computation using Eviews 9.5

Since the result of the unit root test showed that all the variables are stationary at levels and at first difference, it therefore justifies the use of ARDL model for estimation.

The result of the bounds testing approach to cointegration is presented in Table 4.2. From the result, the computed F-Statistic is 6.606212. This value exceeds the upper bounds critical value of 3.49 at the 5 per cent significance level and 2.56 at the 5 per cent significance level. This implies that all the variables are co-integrated. Based on this, we infer that long-run relationship run from RGDP to Capital, Labour, Energy consumption and CO^2 emission.

Table 4.2: ARDL Bound Test Result

Test Statistic	Value	K
F-statistic	6.606212	4

Critical Value Bounds

Significance	I0 Bound	I1 Bound
10%	2.2	3.09
5%	2.56	3.49
2.5%	2.88	3.87
1%	3.29	4.37

Source: Authors Computation using Eviews 9.5

Having established the long-run relationship among the variables, we proceed to estimate the long-run and short-run coefficients based on equation 3.7 above. The result of the ARDL approach is presented in table 4.3.

Table 4.3: ARDL Long-Run and Short-Run Estimated Results

ARDL Cointegrating And Long Run Form
Original dep. variable: RGDP

Cointegrating F orm

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(RGDP(-1))	0.335262	0.211854	1.582513	0.1320
D(DLNCAP)	0.855579	0.261201	3.275558	0.0048
D(DLNCAP(-1))	0.035005	0.014461	2.420649	0.0360
D(LNLAB)	0.662551	0.264956	2.500608	0.0383
D(LNLAB(-1))	0.796459	0.562649	1.415552	0.6659
D(LNENC)	0.503113	0.143353	3.509609	0.0026
D(LNENC(-1))	0.003121	0.119690	0.026076	0.1884
D(DLNCO2)	-0.823520	0.335565	-2.454130	0.0263
D(DLNCO2(-1))	-0.611355	0.525141	-1.164173	0.1711
ECM(-1)	-0.810105	0.198032	-4.090778	0.0004

Cointeq = RGDP - (5.2611 *DLNCAP + 32.7259*LNLAB 4.418 3*LNENC +
22.4737*DLNCO2 267.451 6)

Long Run Coefficients

Variable	Coefficient	Std. Error	t-Statistic	Prob.
DLNCAP	0.261061	0.180470	1.446562	0.2252
LNLAB	0.725911	0.941888	0.770698	0.1365
LNENC	0.418345	0.200087	2.090815	0.0052
DLNCO2	0.473744	0.180358	2.626687	0.0018
C	-7.451607	3.425895	-2.175083	0.0034

Source: Authors' Computation using Eviews 9.5

The short-run dynamic estimate is reported in table 4.3. The results show that the error correction factor is correctly signed and also statistically significant as expected. This shows rapid rate of adjustment from the short-run disequilibrium to the long-run equilibrium. As can be seen from the result, about 81 percent of the deviation from equilibrium was corrected within one year.

The analysis of the short-run estimates shows that changes in capital, labour and energy consumption have positive short-run impact on economic growth in Nigeria, while CO^2 emission expresses a negative impact on economic growth. This means that a 1 percent increase in previous value of RGDP, changes in the current value of capital, previous value of labour, and current value of energy consumption leads to about 34, 86, 80, 50 percent increase in RGDP in Nigeria, respectively. While the current value of CO^2 emission shows that a 1 percent increase in CO^2 emission leads to about 82 percent decrease in economic growth in the short-run. These results are however in conformity with theoretical expectation. The parsimonious short-run results also revealed that the selected variables are significant in influencing RGDP at 5 percent significant level.

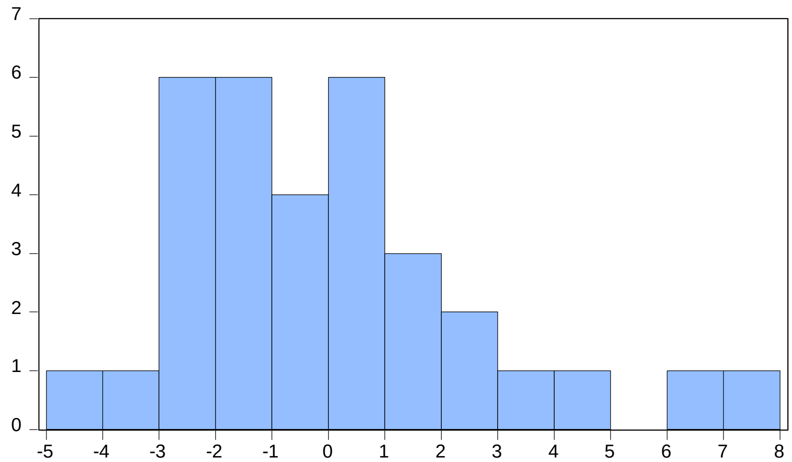
The long-run estimate as shown in table 4.3 reported that capital, labour and energy consumption has positive relationship with RGDP, while CO^2 emission shows a negative relationship. This also implies that, a 1 percent increase in capital, labour, energy consumption will lead to about 26, 73 and 41 percent increase in RGDP in Nigeria, respectively. While a 1 percent increase in CO^2 emission leads to about 47 percent decrease in economic growth in the long-run. This result is also in conformity with theoretical expectation of the model. But capital and labour are not significant in influencing RGDP at 5 percent significant level.

The ARDL estimated result in table 4.3 was subjected to some diagnostic test such as the normality test, serial correlation test, heteroscedasticity test and the stability test, respectively. The Jarque-Bera normality test was employed to test the normality of the residuals in the estimated model. The result in table 4.4

reveals that the residual are normally distributed. This is shown by the Jarque-Bera statistic that is significant.

In the serial correlation test, the null hypothesis of no serial correlation in the residual was tested. The result is presented in table 4.5.

Table 4.4: Normality test



Series: Residuals	
Sample 1983 2015	
Observations 33	
Mean	1.52e-13
Median	-0.383725
Maximum	7.092172
Minimum	-4.757597
Std. Dev.	2.677256
Skewness	0.803889
Kurtosis	3.424549
Jarque-Bera	3.802136
Probability	0.149409

Source: Authors Computation using Eviews 9.5

Table 4.5: Serial Correlation Test

Breusch-Godfrey Serial Correlation LM Test:

F-statistic	2.686316	Prob. F(2,16)	0.0986
Obs*R-squared	8.295508	Prob. Chi-Square(2)	0.0158

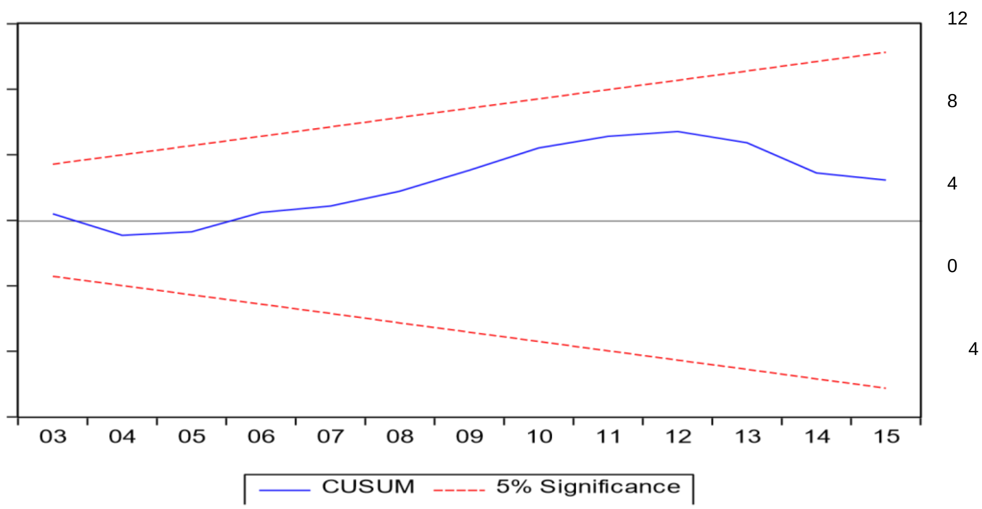
Source: Authors Computation using Eviews 9.5

From table 4.5, the F-statistic and the Obs-R^2 are significant; we therefore conclude that there is no serial correlation in the model.

Test for heteroscedasticity of the residuals was also conducted. The result in table 4.5 suggest the absence of heteroscedasticity in the residuals of the model. This is because the F-statistic and the Obs R^2 are significant.

Figure 1.0: Parameter Instability Test

It is important to determine whether the parameters of the estimations are stable across different sub-samples of the study period. CUSUM Test which plots the cumulative sum of the recursive residuals together with the 5% critical lines was employed. The CUSUM test indicates parameter instability if the cumulative sum goes outside the area between the two critical lines. The result of the test is presented in figure 1 below:



Source: Authors Computation using Eviews 9.5
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From the above figure, the cumulative sum is inside the critical line, therefore, we conclude that the parameter estimates are stable over time.

Table 4.6: Granger Causality Test Result

In the granger causality test, the null hypothesis is that there is no causality between two variables. The null hypothesis is rejected if the probability of F-statistic given in the Granger causality result is less than 0.05 at 5 percent level of significant. Below are the results of Granger causality test conducted between energy consumption, CO^2 emission, capital, labour and economic growth.

Pairwise Granger Causality Tests

Null Hypothesis:	Obs	F-Statistic	Prob.
CAP does not Granger Cause RGDP	33	4.22744	0.0180
RGDP does not Granger Cause CAP		0.20085	0.8192
LAB does not Granger Cause RGDP	33	5.86120	0.0032
RGDP does not Granger Cause LAB		1.94925	0.1612
ENC does not Granger Cause RGDP	33	4.65529	0.0071
RGDP does not Granger Cause ENC		3.31735	0.0107
CO2 does not Granger Cause RGDP	33	8.01573	0.0004
RGDP does not Granger Cause CO2		6.08851	0.0036

Source: Authors' Computation using Eviews 9.5

The null hypothesis was rejected at 5 percent, showing that unidirectional causality runs from capital to RGDP, labour to RGDP. While bi-directional causality exists between energy consumption and RGD and CO^2 emission and RGDP.

5. POLICY IMPLICATION, CONCLUSION AND RECOMMENDATIONS.

This study examined the impact of energy consumption, CO^2 emission on economic growth in Nigeria. Other relevant variables employed to were capital and labour. The study adopts Zivot-Andrews unit root with structural breaks test to examine the unit root properties of the series. From the unit root test result, it is justified that the ARDL model is appropriate for this study. This is shown by the varying order of integration in the series. The series were integrated of order I(0) and I(1). However, following Pesaran and Smith (2001), the analysis was carried out using the ARDL methodology. In addition to ARDL model, to achieve the objective examining the relationship between variables, the Granger causality test was employed.

The result of the cointegration test based on the bounds testing approach shows that the variables are mutually cointegrated, which suggest a long-run relationship between variables in the model. The result of the long-run estimate shows that capital, labour and energy consumption contribute positively to economic growth, while CO^2 emission contributes negatively to economic growth. But labour and capital do not significantly contribute to economic growth in Nigeria. By implication, energy consumption and carbon emission are important stimulants of economic growth in Nigeria. The result of the short-run dynamics shows that changes in capital, labour and energy consumption have positive short-run impact on economic growth in Nigeria, while CO^2 emission expresses a negative impact on economic growth. This result corroborates the long-run estimated result. However, the result of energy consumption and carbon emission are not surprising. Nigeria is a growing economy which requires more energy to drive industrialization. The use of this energy emits carbon dioxide which may be harmful to other economic activities such as agriculture that produces raw materials for industries. Therefore, we expect that increase in CO_2 emission should have negative effect on economic growth as energy consumption increases.

Based on the results obtained, the study recommends that, as much as non-renewable energy is important in driving economic growth, policy makers should begin to implement policies toward encouraging the use of alternative energy sources such as solar, wind, biomass. These renewable energy sources are clean energy that does not contain harmful substances like carbon dioxide that are harmful to the environment. Also, the comprehensive energy policy of 2003 should be monitored for proper implementation. This will encourage energy users on the proper use of energy resources to drive economic growth in Nigeria.

Finally, Nigeria should design new environmental policies to reduce environmental degradation, especially in the area of gas flaring and release of toxic gases from industries and vehicles.

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