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Carbon Emissions, Human Capital Investment and Economic Development in Nigeria

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ABSTRACT

This study examined the joint effect of carbon emission and health investment on economic development in Nigeria by integrating ecological economics approach with the endogenous growth model. Through the adoption of annual time series spanning 1980-2017, the bounds testing approach of the autoregressive distributed lag framework established the existence of co-integration among the variables in the model. The long run estimates revealed that a 1% increase in government health investments enhances economic development (proxied by GDP per capita) by 0.008% while a 1% increase in the level of carbon dioxide (CO_2) reduces GDP per capita by 0.1%. Furthermore, evidence shows that no causal link exists between fossil fuel consumption (FFC) and CO_2 contrary to previous studies. However, unidirectional causality from health outcomes (proxied by life expectancy) to CO_2, as well as from CO_2 to electricity consumption (ELCON) is observed. Also, increased energy consumption (FFC and ELCON) directly influences GDP per capita. The study recommends that efforts to reduce CO_2 should target firms manufacturing cement, asbestos and other dust-generating products as alternative contributors to CO_2 accumulation. Equally, mitigating the health effect of CO_2 will require effective, efficient and adequate public health investment.

Keywords: Carbon Emissions, Government Health Expenditure, Economic Development
JEL Classifications: Q53, H51, O1

1. INTRODUCTION

Increased human activities are known to stimulate the demand for energy with a consequent enhancement of the level of economic growth (Chindo et al., 2015; Lu, 2017). In the course of generating high growth via energy use however, various by-products in the form of pollutants/gases are emitted into the atmosphere thereby, causing a change in climatic conditions and subsequent global environmental challenges. Combustion of fossil fuels (a form of non-renewable energy source) is a major cause of gaseous carbon emission and is said to be widely explored in Africa and particularly, Nigeria (Matthew et al., 2018). Electricity supply which is supposed to be the main source of energy with cleaner environment and reduced level of carbon emission is epileptic and erratic in Nigeria (Afolayan et al., 2019; Chindo et al., 2015) hence, leaving people with no choice but shift to alternative sources of energy involving the burning of fossil fuels and high level of carbon emission. This has resulted to the accumulation of gaseous toxic pollutants in the atmosphere (Alege et al., 2017; Matthew et al., 2018).

Assurance of sustainable economic development has been identified to hinge on the facilitation of continuous reductions in emitted carbon dioxide (CO_2) worldwide (Jiang et al., 2014; Lu, 2017; Salahuddin and Gow, 2014; Wang and Chang, 2014; Wang and Wang, 2015) in order to control its level in the atmosphere. This suggests that targets toward reducing CO_2 may need to focus more on sustainable policy interventions that enable cleaner economic development trajectories (Lu, 2017). This is because at the epicenter of any economic activity is human beings. High level of air/gaseous pollutants will as expected contaminate the environment, have adverse effect on individuals' health status (Matthew et al., 2018; Oguntoke and Adeyemi, 2017), reduce average life expectancy with consequent low productivity and reduced economic development. In the words of Matthew et al. (2015), no meaningful economic activity can go on in the absence of good health hence, having good health is imperative for the progress of any nation. The implication is that more investments in the health sector will be required to impact people's health positively in order to participate effectively in the economy for enhanced development. Put differently, efficient and effective public investments in health will expectedly impact people's health positively thereby, leading to an increase in the country's life expectancy at birth. Fang and Chang (2016) note that high energy consumption which ensures the advancement of human capital is what any country requires for economic development. This is suggestive of the fact that any nation that is desirous of progress and development requires a high level of energy consumption as well as adequate investments in health.

Of all the environmental pollutants that exist, carbon emission has been identified as major (Edoja et al., 2016; Chindo et al., 2014) and is said to account for about 75% of greenhouse gas (GHG) emissions (Abbasi and Riaz, 2016). Kahia et al. (2016) noted that achievement of a high level of growth by a country requires more inputs (energy inclusive) to enlarge its outputs, but energy use also leads to the emission of gaseous pollutants that are unfriendly to human health. This means that more wastes and emissions via increasing use of energy may be generated through a rise in economic activities. It is generally perceived that as the economy grows, the industrial activities increase thereby leading to a high release of CO_2 into the environments (Aye et al., 2017). Available statistics reveal an increase in Nigeria's primary energy consumption from 1.07% in 2012 to 4.28% in 2013 and a further increase to 12.94% in 2014 (Knoema, 2017). This suggests that during the period, gaseous emissions have also risen. To sum it, data from International Energy Agency, IEA show that CO_2 emission from transport alone averaged 47.76% between 2000 and 2014 (International Energy Agency, 2015).

In the literature, studies that explore the links between energy consumption, gas emission and the economy can be divided into two major streams. The first stream focuses on the relationship between energy consumption and economic growth (Bilgili et al., 2017; Dantama et al., 2012; Dinkelma, 2008; Francis et al., 2007; Mehrara, 2007; Narayan and Smyth, 2007; Ogundipe and Apata, 2013). The observation from the conclusions of these studies (a mix of regional and country-specific analyses) is that the relationship between the variables depicts inconsistency. The second stream focuses on the link between pollutants (mostly gaseous emissions) and the economy on one hand, and emissions and health outcomes on the other (Alege et al., 2017; Ansuategi and Escapa, 2002; Mesagan and Ekundayo, 2015; Matthew et al., 2018; Matthew et al., 2019). To the best of the authors' knowledge, specific studies especially in Nigeria that examine energy-economic development link with respect to the integration of gas emission and human capital models are yet to be conducted. The role of human capital as a significant contributor to the growth and development of a nation has well been noted (Adawo, 2011; Ogujiuba, 2017; Oluwatobi and Ogunrinola, 2011). It is necessary to control for emissions and health in energy-economic development relationship in order to avoid the challenge of bias due to omitted variables. This will provide a check on the robustness of the results. This way the study will be distinguished from the ones conducted previously.

Following from the foregoing, the objectives of the study are to: (i) Investigate the long run effects of carbon emission (proxied by total CO_2 emission) and health variable on economic development in Nigeria; and (ii) examine the nature of the causal relationship between carbon emission and health outcomes (measured by life expectancy at birth) in Nigeria. The following hypotheses stated in the null forms are formulated and will be examined in the course of the study: (1) H_0: There is no significant long run effect of CO_2 on economic development; (2) H_0: Health has no significant effect on economic development in the long run; and (3) H_0: No causal relationship exists between carbon emission and health outcomes (proxied by life expectancy at birth). Consequently, the remaining parts of the paper are arranged as follows; brief insights from the relevant literature are considered in section two; section three engages the theoretical framework and methodology of the study. Presentation and discussion of results of the econometric estimation are contained in section four; while the concluding section (section five) presents the summary of findings and policy recommendations.

2. LITERATURE REVIEW

Various empirical exploits have been done previously to examine the link between energy use and economic development and mostly, a significant relationship is reported to exist between the two variables (Alaali et al., 2015; Matthew et al., 2018; Narayan and Smyth, 2007). However, not much investigation has been carried out to control for the influence of the by-products (one of which is CO_2) of energy use on the environment and human health generally, in the course of growing the economy. Whereas in the views of Behera and Dash (2017); Jiang and Li (2017), there is a great threat to the economy due to increased emissions of GHG which can lead to a decline in the output of agricultural sector. This may become a threat to food security, cause low income and a subsequent rise in national insecurity.

The validity of the widely known environmental Kuznets curve (EKC) model which suggests a U-shaped relationship between environmental quality and a country's level of development has been the focus of many authors, and hence examined for different countries and regions. Noted among these studies include that of Olugbenga et al. (2014); Christopher et al. (2011); Shahbaz et al. (2013) and the outcomes have been conflicting. While some supported the EKC hypothesis (Bilgili et al., 2016; Christopher et al., 2011) others do not (Al-Mulali et al., 2015; Duan et al., 2016). Studies that specifically examine emissions-energy-development link do not incorporate any health variable in the same framework (Alege et al., 2016; Alege et al., 2017; Mesagan and Ekundayo, 2015). However, studies that investigate emissions-health nexus do not probe further on how this influences the economy (Matthew et al., 2018; Mohammed et al., 2015; Odusanya et al., 2014; Matthew et al., 2019).

Findings from studies on environmental quality/emissions-energy use-development link reveals inconsistency with regards to causality. For instance, Alege et al. (2016) used Wald exogeneity Granger causality test and the outcome reveals a unidirectional causality from fossil fuel to CO_2 emissions and GDP per capita, while as revealed by the study no causal link exists between electric power and carbon emissions. For a group of 25 EU countries and through the adoption of panel non-causality test drawing upon Dumitrescu and Hurlin (2012), Balan (2016) shows that while there exists a bidirectional causation between life expectancy, health expenditures and carbon emissions from sources like petroleum and natural gas, the link between carbon emissions from coal source and the health indicators is unidirectional with causality running from the health indicators to carbon emissions from coal consumption. These findings could suggest that the energy-consumption source of carbon emissions is a crucial factor for consideration in the link between CO_2 emissions and health indicators. This has implications for optimal policy decisions on energy consumption and health-related issues.

Furthermore, Balan (2016) used panel least squares technique to show that CO_2 emissions from natural gas source only has statistically significant and negative effect on life expectancy while other sources do not. However consistent with the findings of Matthew et al. (2018), Balan (2016) shows that CO_2 emissions in the aggregate has statistically significant and negative effect on life expectancy. The study of Shuaibu and Oyinlola (2013) however established no causal link between CO_2 emissions and energy consumption to economic growth due to structural shifts. Likewise in the study for China, Zhang and Cheng (2009) established that neither energy consumption nor carbon emissions leads to economic growth, but a unidirectional causality from GDP to energy consumption and to carbon emissions was reported in the long run.

The seriousness attached to the living conditions of the populace both in the current period and its sustainability in the long term perspective is the focus of Aye et al. (2017); Phimphanthavong (2013). In their views, the decline in environmental quality due to high penchants for high growth rate in countries may impair the health of the populace in the current and this may be sustainable in the long term perspective. Using autoregressive approach, Alege et al. (2017) noted that GHG emissions have been on the increase as far back as the era of industrial revolution. Conceding to this position is Aye et al. (2017) who also came up with the submission that environmental degradation (both in quantity and quality) is a major hallmark of industrialization and development, which happen to be the key drivers of economic growth. While industrialization is important the health of those that will drive economic development is equally necessary for the achievement of economic development holistically.

Matthew et al. (2018) adopted autoregressive distributed lag (ARDL) technique and the outcome reveals a negative relationship between GHG emission and health outcomes. An increase in GHG emissions by 1% is shown to reduce aggregate health outcome proxied by life expectancy at birth by 0.042% in Nigeria. However, the study did not take it further to establish how this influences economic development. Other studies in this category include that of Al-Mulali and Fereidouni (2012); Behera and Dash (2017); Declercq et al. (2011); Yazdi et al. (2014); Mohammed et al. (2015); Narayan and Narayan (2008); Odusanya et al. (2014). For instance, Al-Mulali and Fereidouni (2012); Behera and Dash (2017); Odusanya et al. (2014) in their various studies observed that an increase in the rate of CO_2 is dangerous to the health status. Equally, Mohammed et al. (2015); Yazdi et al. (2014) employed ARDL approach and came up with the findings that public expenditure on health, sulphur oxide and carbon emission have a co-integration in Iran. The study concludes by submitting that public expenditure remains one of the major ways of controlling the effects of the polluting objects on the economy. The reduction of industrial pollution which remains the major cause of air pollution in the main cities in Europe will according to Declercq et al. (2011), enhance life expectancy to a period of approximately 2 years.

Other studies examine energy use-economic development relationships and report a significantly positive effect of energy use on the economy (Afolayan et al., 2019; Alaali et al., 2015; Narayan and Smyth, 2007; Pirlogea and Cicea, 2012; Yoo and Kim, 2006). As it is with the studies earlier reviewed, these studies fail to control for pollutant emissions as by-products from such activities, as well as health outcomes in the various models specified. This may lead to a bias due to omitted variables and thereby impair the robustness of the research outcomes. This study seeks to bridge the gap by examining the effect of carbon emission and aggregate health outcomes (proxied by life expectancy at birth) on the Nigerian economy through the synthesis of energy-based model and that of new growth/human capital development. By so doing, the study will stand out from those conducted previously.

3. METHODOLOGY

3.1. Theoretical Framework

The framework for this study is anchored on the synthesis of the endogenous growth theory and ecological economics approach, drawing upon the works of Afolayan et al. (2019); Alaali et al. (2015); Matthew et al. (2018) and To et al. (2013). This is informed by their relevance in ensuring the progress of any economy. Endogenous/new growth theory draws attention to the development of human capital endogenously, and the use of other factors that are within the economic system for achieving assured economic growth in the long-term perspectives (Barro and Sala-i-Martin, 1995; Lucas, 1988; 2002; Romer, 1986). This means that the long run economic growth, according to endogenous theory is influenced by such economic factors as quality education and training that is innovation-based, as well as quality health care status which are productivity-enhanced. Conversely, ecological economics is more concerned with optimal growth in the economy through the use of energy (as input) that is not harmful to the environment, as well as ecologically friendly to the organisms.

From the viewpoints of ecological economics, challenges of economic activities in relation to the use of energy are managed and governed in a way that promotes human wellbeing, ensures sustainability and justice. The synthesis of the two approaches follows from the fact that human capital development (through health care, education, training and innovation) from the viewpoint of the proponents of endogenous theory is an input to production, as much as energy is an input from the ecological-economics point of view. The integration allows the use of Cobb Douglas production function which is of the form "input-output," non-linear model for analyzing the contributors to economic development (Afolayan et al., 2019; Matthew et al., 2018). The use of primary energy such as crude oil, coal, natural gas, and so on, which constitute fossil fuels for economic production and growth, emits a lot of CO_2 which according to Matthew et al. (2018), contaminates the environment and affect the health of individuals.

The model of economic development (proxied by GDP per capita) from the synthesis of the approaches of endogenous theory and ecological economics using a typical Cobb Douglas functional form is:

$$GDPPC = AK^{\alpha}H^{\beta}ENER^{\theta}CO_2^{\gamma} \quad (1)$$

Where,
GDPPC: GDP per capita at constant LCU (proxy for economic development); A: Total factor productivity as defined by level of technology; K: Physical capital input; H: Human capital variables; ENER: Energy consumption sources (from fossil fuel and electric power); CO_2: CO_2 (proxy for carbon emissions in kiloton); whereas α, β, θ and γ are output elasticity coefficients attributed to physical capital, human capital, energy consumption and CO_2 in respective terms.

3.2. Empirical Model and Sources of Data

Drawing upon Matthew (2011) and Matthew et al. (2018), this study's model is premised upon the synthesis of endogenous theory and ecological economics to describe the joint effect of human capital and indicators of energy on economic development in Nigeria. The model of Matthew et al. (2018) is modified by dropping some variables and incorporating CO_2 to capture carbon emissions as a by-product of energy use in order to account for environmental quality.

The operational model for the study is therefore implicitly stated as:

$$GDPPC = f\,(GHE, FFC, ELCON, CO_2, GFCF, GRADR) \quad (2)$$

The explicit form of equation (2) in a non-linear Cobb Douglas functional form is specified thus:

$$GDPPC = GHE^{\alpha}.\ FFC^{\beta}.\ ELCON^{\vartheta}.\ CO_2^{\delta}.\ GFCF^{\theta}.\ GRADR^{\sigma} \quad (3)$$

Linearising equation (3) by taking its natural log, with the introduction of the stochastic error term will give equation (4) as follows:

$$InGDPPC_t = \alpha_0+\alpha_1 InGHE_t+\beta InFFC_t+\vartheta InELCON_t+\delta InCO_{2t}+\theta In\,GFCF_t+\sigma InGRADR_t+\varepsilon_t \quad (4)$$

Where,

GDPPC: GDP per capita (constant LCU) is adopted as an indicator of economic development and it refers to the total value of the final goods and services available per person in a country within a year. Data for the variable are sourced from the World Bank (2017) national accounts data.

3.2.1. GHE

Government health expenditure (GHE) is the total government expenditure earmarked and spent on the health sector. It is measured as the proportion of health expenditure in the total government expenditure in a fiscal year, the unit of measurement is percentage. It is computed by the researchers using the absolute values obtained from the CBN annual report and statement of accounts (various issues).

3.2.2. Fossil fuel consumption (FFC)

Fossil fuel energy consumption (measured as percentage of total) indicates the burning of fossil fuel which comprises coal, oil, petroleum, and natural gas products. Increased combustion of fossil fuel is presumed to be a major contributor to the accumulation of gaseous pollutants (like CO_2) in the atmosphere and an enhanced economic growth and development. Data are sourced from the database of the International Energy Agency, IEA.

3.2.3. ELCON

Electric power consumption (expressed in kWh per capita) is a measure for total net consumption (that is, gross consumption less energy consumed by the generating units). This includes the total consumption values of the industrial sector, commercial activities and the households. Electric power consumption in these areas will enhance the substantial performance of economic activities which require electricity thereby, engendering economic development. Data are sourced from the IEA's database.

3.2.4. CO_2

CO_2 is adopted as a proxy for carbon emissions (in kilotons). It refers to those stemming from the consumption of fossil fuel and the manufacture of cement. They include CO_2 produced while consuming solid, liquid and gas fuels and gas flaring. In the study, the effect of CO_2 on the economy is examined, as well as its nature of causality with the health indicator is investigated. Collection of data is from the database of U.S. CO_2 Information Analysis Center.

3.2.5. GFCF

Gross fixed capital formation (GFCF) (expressed as a percentage of GDP) is a measure for physical capital. It indicates capital investments in fixed assets, infrastructural facilities and social structures (such as roads, bridges, railways, schools, health, and so on) in a country. Data are sourced from the World Bank (2017) national accounts data.

3.2.6. GRADR

Graduation rate is adopted as a measure for the level of educational attainment. As an indicator for completion rate, it is computed by the researchers from graduate turn-out as a per cent of total university enrolment obtained from the Nigerian National Universities Commission (NUC). Empirical evidence has shown that higher level of education is associated with higher productivity and real wages. Including a measure of educational attainment in the model will examine how it impacts total national output of a country and economic development, rather than the use of mere school enrolment with high rate of drop-outs which usually, is unaccounted for.

3.2.7. α_0

Is the constant term; α_1, β, ϑ, δ, θ and σ are parameters of the regressors to be estimated; while ε is the stochastic term. Intuitively, it is expected that all the explanatory variables will have positive effects on the regressand (GDPPC). The study period is 1980-2016.

3.3. Estimation Technique

Time series of most variables (especially, those of the developing countries) are non-stationary with the presence of unit roots. Conducting a regression on non-stationary time series will likely produce results that are prone to bias thereby, leading to a spurious regression. In the opinion of Adebiyi (2003), it is expedient for data involving macro time series to test for unit roots and co-integration before a structural relationship is estimated and reported for potential policy use. It is in the light of this that the process of estimation started with the execution of the unit root test and order of integration of the variables by adopting Phillip Perron (PP) test. This is followed by co-integration analysis through the adoption of the bounds test approach of the ARDL framework. This is to ascertain the existence or otherwise of the long run relationships among the variables in the model. The two-step bounds test approach of the ARDL technique was first developed in the work of Pesaran and Shin (1995; 1999) and later extended by Pesaran et al. (2001).

The Monte Carlo evidence depicts that the technique of ARDL has several advantages over other conventional methods of co-integration (Emran et al., 2007; Menyah and Wolde-Rufael, 2010). First, ARDL corrects for possible endogeneity of explanatory variables. Secondly, the ARDL has good properties for small and finite sample estimation. Thirdly, the ARDL does not formally require unit root test as it is not affected by the order of integration of the series. Fourthly, ARDL allows the estimation of both the long run and the short run models simultaneously. Lastly, the application of ARDL makes it possible to obtain the long run unbiased estimates of the model (Belloumi, 2014; Emran et al., 2007; Kripfganz and Schneider, 2016; Menyah and Wolde-Rufael, 2010; Osabohien et al., 2017). The third phase in the estimation procedure sees the adoption of vector error correction mechanism (ECM) to check for deviations in the long run equilibrium relationship between the dependent and the explanatory variables. The motive is to establish the short run dynamics of the model. In the last phase of the estimation, the granger causality test was employed to investigate the direction of causal relationship among the major variables in the model. The ARDL model for the study is formulated thus:

$$\begin{aligned}\Delta InGDPPC_t = {} & \tau_0 + \alpha_1 InGDPPC_{t-1} + \alpha_2 InGHE_{t-1} + \alpha_3 InFFC_{t-1} \\ & + \alpha_4 InELCON_{t-1} + \alpha_5 InCO_{2t-1} + \alpha_6 InGFCF_{t-1} \\ & + \alpha_7 InGRADR_{t-1} + \sum_{i=1}^{a} \delta_i \Delta InGDPPC_{t-i} \\ & + \sum_{i=0}^{b} \theta_i \Delta InGHE_{t-i} + \sum_{i=0}^{c} \gamma_i \Delta InFFC_{t-i} \\ & + \sum_{i=0}^{d} \theta_i \Delta InELCON_{t-i} + \sum_{i=0}^{e} \Pi_i \Delta InCO_{2t-i} \\ & + \sum_{i=0}^{f} \sigma_i \Delta InGFCF_{t-i} + \sum_{i=0}^{g} \psi_i \Delta InGRADR_{t-i} + \varepsilon_t \end{aligned} \quad (5)$$

Where,

τo: The drift component; Δ: The difference operator; a, b, c, d, e, f and g: Are optimal lag lengths for each incorporated series, which may or may not be equivalent to each other. All other variables are as defined earlier. The appropriate lag length is 2 and selected based on akaike information criterion before the estimation of the model is executed. The second part of equation (5) with the summation signs represents the short run dynamic model while the first part with α_i is used to model the long run.

4. RESULTS AND DISCUSSION

4.1. Descriptive Statistics

The descriptive statistics of the datasets reveal the characteristics of each of the variables employed in the study which are GDP per capita, GHE, life expectancy at birth, fossil fuel energy consumption, electric power consumption, CO_2, GFCF and graduation rate. The instruments used to achieve this are the mean, standard deviation, range (minimum and maximum values) as well as the values of skewness, kurtosis and Jarque-Bera. Table 1 presents the summary statistics of the variables as follows:

The findings in Table 1 show the mean values of 2.518, 3.869, 0.976, 2.974, 2.407, 4.571, 2.449 and 3.232 as the average growth of GDPPC, LLE, GHE, FFC, CO_2, ELCON, GFCF and GRADR. This indicates that ELCON has the highest growth rate. This is also revealed in their maximum values of 2.554, 3.978, 1.988, 3.129, 2.449, 5.055, 3.562 and 4.468 with their respective minimum values of 2.490, 3.819, 0.095, 2.766, 2.348, 3.929, 1.697 and 2.487. The standard deviations of 0.0215, 0.0513, 0.572, 0.084, 0.033, 0.268, 0.416 and 0.545 show that the highest degree of variation is firstly associated with GHE and then, followed by graduation rate compared with the others. The skewness 0.507, 0.945, 0.050, −0.101, −0.469, 0.011, 0.634 and 1.200 suggests that all the variables except for FFC and CO_2 are positively skewed. This means that the probability of getting an extremely positive outcome is high when compared with the variables whose dataset is more negatively skewed. The kurtosis values of 1.664, 2.299, 1.776, 2.613, 1.751, 2.550, 3.514 and 3.339 show that GFCF and GRADR with values >3 are leptokurtic while others are platykurtic with values <3 and tending towards the extremes. The Jarque-Bera result 4.334, 6.258, 2.325, 0.278, 3.761, 0.296, 2.805 and 9.064 with the probabilities of 0.115, 0.0438, 0.313, 0.870, 0.152, 0.862, 0.246 and 0.011 indicates a normal distribution for the variables except, LE and GRADR with probability values of 0.0438 and 0.011which are <0.05 (5%).

Table 1: Descriptive statistics of variables

Diagnostic term	LGDPPC	LLE	LGHE	LFFC	LCO_2	LELCON	LGFCF	LGRADR
Mean	2.517587	3.869317	0.976184	2.973670	2.407301	4.570880	2.449057	3.232472
Median	2.507637	3.836221	0.916291	2.981126	2.412951	4.508990	2.479471	3.060115
Maximum	2.554245	3.977811	1.987874	3.128513	2.448574	5.054525	3.561614	4.468204
Minimum	2.489987	3.818811	0.095310	2.765690	2.348400	3.929273	1.697449	2.487404
Standard deviation	0.021483	0.051340	0.572166	0.083659	0.033269	0.267958	0.416486	0.544685
Skewness	0.506622	0.944538	0.050236	−0.100585	−0.469035	0.011091	0.633581	1.200465
Kurtosis	1.664131	2.299483	1.776153	2.612880	1.751057	2.549871	3.514285	3.338756
Jarque-Bera	4.333943	6.258135	2.324674	0.277566	3.761410	0.296199	2.805281	9.063797
Probability	0.114524	0.043759	0.312754	0.870417	0.152483	0.862345	0.245947	0.010760
Sum	93.15071	143.1647	36.11881	104.0784	89.07014	159.9808	88.16604	119.6015
Sum sq. dev.	0.016615	0.094888	11.78548	0.237959	0.039847	2.441255	6.071112	10.68056
Observations	37	37	37	35	37	35	36	37

Source: Authors' computation, 2019 using E-views 10.0

4.2. Regression Analysis

4.2.1. Unit root/stationarity test

It is wide knowledge in the literature that the execution of econometric analysis with time series that are non-stationary may lead to nonsensical regression (Granger, 1986). Hence, the first step in any econometric analysis involving time series is for the analysis of the unit root for all the variables under study to be carried out. As posited by Pesaran et al. (2001), it is crucial to know the variables' level of stationarity before conducting a co-integration test among the variables. Table 2 shows the outcome of PP test for stationarity thereby, revealing the stochastic nature of the variables.

As shown in Table 2, the critical values at 5% level of significance are presented in the parentheses. The outcome as revealed shows the presence of unit roots for all the variables at levels with the exception of life expectancy and GFCF. This implies that the null hypothesis of no unit roots for all the variables at levels could not be rejected. The variables that could not attain stationarity at levels were then differenced once to attain a stationary state as shown in Table 2, column 2. The condition for stationarity is that the absolute value of the PP statistic should be more than the absolute critical value that corresponds to the concerned variable as shown by the asterisks (**) in Table 2. As indicated in Table 2, there is a mix of I(0) and I(1) series for the study sample which is a necessary condition for employing the technique of ARDL.

4.2.2. Co-integration analysis using bounds testing approach

Due to the fact that the series are integrated of different orders in I(0) and I(1), a co-integration analysis is conducted using the bounds test approach of the ARDL technique developed by Pesaran et al. (2001), in order to investigate the existence of long run relationships among the studied variables in the model. The analysis is hinged on testing the null hypothesis of no co-integration where jointly, the coefficients of lagged regressors in the ARDL error correction model are assumed to be zero (that is, $\alpha_1 = \alpha_2 = \alpha_3 = \alpha_4 = \alpha_5 = \alpha_6 = 0$). While the alternative hypothesis of a long run relationship is stated as: $\alpha_1 \neq \alpha_2 \neq \alpha_3 \neq \alpha_4 \neq \alpha_5 \neq \alpha_6 \neq 0$ and is equally tested. In the bounds test approach, the F-statistic is compared with the Pesaran et al. (2001) critical value at 5% and 1% significance levels respectively. The lower critical value assumes variables are integrated at order zero while upper critical value assumes variables are integrated at order one process. Thus, computed F-statistic that falls below the critical value at lower region I(0) suggests there is no co integrated series, an F-statistic between the lower region I(0) and upper region I(1) reveals an inconclusive result while an F-statistic greater than the upper region shows evidence of a co integrated series leading to the rejection of the null hypothesis of no co integration. The outcomes of the analysis are as shown in Table 3.

As revealed in Table 3, the findings depict that the calculated F-statistic (10.957) exceeds the critical values at both the upper (3.28) and lower (2.27) regions at 5% significance level respectively. Comparisons of the F-statistic (10.957) with the upper and lower bounds at 1% level of significance equally reveal the same outcome. The outcome of the test thus establishes co integration and the existence of a long-run relationship among the variables in the model. That is, the calculated $F_Y(Y/GHE/CO_2/LE/GRADR/GFCF/FFC/ELCON) = 10.957$ (which is higher than the upper bound value of 3.99 at 1% level. Therefore, the null hypothesis of no co integration is rejected at both the 1% and 5% significance levels respectively. The finding implies that economic development is responsive to changes in these explanatory variables. This is suggestive of the fact that the model is sustainable in the long run.

4.2.3. ARDL, ECM results and discussion

With co-integration among variables in the model established, next is the analysis of the ARDL results (that is, coefficients of the explanatory variables in the long run), as well as the short run dynamics via the determination of the coefficient of the error correction term. Table 4 shows the long run relationship of the ARDL estimation (upper panel) while the outcome of the ECM regression is presented at the lower panel of Table 4 as follows:

Evidence as shown in the upper panel of Table 4 reveals that in the long run, GHE and FFC have significantly positive relationships with economic development (proxied by GDP per capita, GDPPC). In specific terms, a 1% rise in GHE will increase GDPPC by 0.008% at 1% level while an increase in FFC by 1% will raise GDPPC by 0.025% at 5% level of significance. Equally, an increase in electric power consumption (ELCON) has a direct effect on GDPPC although, not significant. Specifically, a 1% increase in ELCON will raise GDPPC by 0.01%. The positive effect of electricity and FFCs on economic development in this

Table 2: Unit root test result

Variables	Phillip perron at levels	Phillip perron at first difference
LGDPPC	−0.542388 (−2.945842)	−4.840749 (−2.948404)**
LLE	2.741410 (−1.950394)**	−0.828296 (−1.950687)
LGHE	−1.687857 (−2.945842)	−7.577412 (−2.948404)**
LFFC	−2.885057 (−2.951125)	−7.601017 (−2.954021)**
LCO_2	−1.369490 (−2.945842)	−5.782195 (−2.948404)**
LELCON	−1.36750 (−2.951125)	−8.565612 (−2.954021)**
LGFCF	−2.972683 (−2.945842)**	−4.994857 (−2.951125)**
LGRADR	0.232720 (−2.945842)	−4.988741 (−2.948404)**

Source: Authors' computations, 2019 using E-views 10.0, **indicates significance level is at 5%

Table 3: Bounds test result

F-bounds test		Null hypothesis: No levels relationship		
Test statistic	Value	Level of significant (%)	I(0)	I(1)
F-statistic	10.95735	10	1.99	2.94
K	7	5	2.27	3.28
		2.5	2.55	3.61
		1	2.88	3.99

Source: Authors' computations, 2019

Table 4: ARDL result

Dependent variable: LGDPPC Method: ARDL Long run relationship				
Variable	Coefficient	Std. Error	t-statistic	Prob.*
LGHE	0.007999	0.002488	3.215422	0.0074
LFFC	0.024980	0.010558	2.365914	0.0357
LCO_2	−0.101180	0.047284	−2.139818	0.0536
LELCON	0.010310	0.006170	1.670839	0.1206
LGFCF	−0.000355	0.005330	−0.066619	0.9480
LGRADR	−0.015838	0.005110	−3.099389	0.0092
C	0.471814	0.231382	2.039111	0.0641
Short run relationship/ECM regression				
D(LGHE)	0.007999	0.001529	5.231739	0.0002
D(LGHE(−1))	−0.005658	0.001529	−3.701306	0.0030
D(LFFC)	0.024980	0.006710	3.722839	0.0029
D(LFFC(−1))	0.028451	0.006540	4.350068	0.0009
$D(LCO_2)$	−0.101180	0.027893	−3.627464	0.0035
$D(LCO_2(-1))$	−0.192726	0.032680	−5.897392	0.0001
D(LELCON)	0.010310	0.003684	2.798663	0.0161
D(LELCON(−1))	−0.014440	0.002848	−5.069679	0.0003
D(LGFCF)	−0.000355	0.001853	−0.191566	0.8513
D(LGFCF(−1))	−0.006643	0.001979	−3.356312	0.0057
D(LGRADR)	−0.015838	0.002558	−6.191110	0.0000
D(LGRADR(−1))	0.012730	0.002573	4.947228	0.0003
CointEq(−1)*	−0.175531	0.014899	−11.78105	0.0000

Source: Authors' computations, 2019 using E-views 10.0, Prob.*means significant at 5% and 10% levels; variables' lag lengths are automatically generated via AIC: Akaike information criterion, D(−1)signifies differenced and lagged

study is consistent with the findings in the literature that increased energy consumption enhances economic development (Afolayan et al., 2019; Alaali et al., 2015; Aye et al., 2017; Balan, 2016; Liu et al., 2018; Lu, 2017; Matthew et al., 2018; Odhiambo, 2009; Ogundipe and Apata, 2013; Quedraogo, 2010). However, the insignificant effect of electricity on economic development in Nigeria can be traced to its inadequate and epileptic nature of supply, which may be linked to inefficiency and ineffectiveness in the energy sector. This has interfered with the smooth running of most economic activities especially that of small enterprises, which happen to be the major source of livelihood and economic development. Many people have had to resort to alternative sources of energy with the resultant effect of a high concentration of pollutant emissions that generate heat and cause climate change.

Conversely, CO_2 emissions, GFCF and graduation rate (GRADR) are all observed to impact GDPPC negatively. A detailed analysis of the findings shows that a 1% rise CO_2 in the atmosphere will retard economic development (GDPPC) by 0.1% at 5% level, while an increase in capital investment (GFCF) by 1% will reduce economic development insignificantly by 0.00036%. Equally, a 1% rise in university graduation rate will lower economic development by 0.016% at 1% level of significance. The negative impact of CO_2 on economic development in Nigeria is suggestive of the effect of its accumulation in the air on the health of the populace. High concentration of CO_2 and other pollutants in the atmosphere due to the use of unsafe and dirty energy source can impair breathing, cause lung cancer, and affect vision and any other undesirable health outcomes (Oguntoke and Adeyemi, 2017; Matthew et al., 2018). This may impact negatively on labour productivity, reduce average life expectancy, and increase mortality with a resultant negative effect on economic development. Health is a crucial factor in determining the quality of human capital which in itself is a necessary factor for economic growth and development. Hence, the popular saying "health is wealth and a healthy nation is one that is wealthy" is sacrosanct and not a mere say.

One striking finding however from the study contrary to assertions in the literature is the conflicting effect of FFC and that of CO_2 on economic development (GDPPC). While increased FFC positively impacts GDPPC in the study, CO_2 emission which is claimed in previous studies to be influenced by FFC (Alege et al., 2016; Aye et al., 2017; Matthew et al., 2018) however, has a negative effect on GDPPC in Nigeria. Does this suggest that FFC is not a major cause of CO_2 accumulation in the atmosphere in Nigeria? To ensure robustness and ascertain this finding, a bi-variate Granger causality test was conducted to investigate the causal relationship between the variables and the findings presented in subsection 4.2.4 earmarked for the outcomes of Granger causality test.

The graduation rate is observed to negatively impact economic development and this can be particularly linked to a situation in the country where more emphasis is placed on attendance at school and mere accumulation of credentials/certificates rather than competence, skill acquisition and innovative abilities. This may cast aspersion on the quality of education received from the tertiary institutions in the country. A detailed analysis reveals that in the long run, an increase in graduation rate by 1% reduces economic development (GDPPC) by approximately 0.02%. A functional education is supposed to contribute positively to enhanced economic development but as shown in the findings, this can be said to be lacking in Nigeria. This implies that education in Nigeria is not sufficient to positively impact economic development (that is, GDPPC). This corroborates the outcome of a study which establishes that rising graduation rate accentuates the challenge of unemployment (Afolayan et al., 2019) due to Oladeji's (1989a; 2014) proposition of overproduction hypothesis, at the instance of proliferation of educational institutions in the country.

Analysis of the regression of ECM in the lower panel of Table 4 reveals that the coefficient of error correction term is negatively signed, statistically significant at 1% level and within the magnitude of 0 and 1 in absolute terms as expected. Specifically, the coefficient (–0.1755) reveals the systemic dynamism from the short run to the long run equilibrium. The ECM coefficient of (–0.1755) shows the model speed of adjustment from external shocks. This implies that about 17.55% of the disturbance to the system in the previous period could be corrected in the current period as it converges to the long run equilibrium state. This signifies a moderate rate of adjustment in the course of restoring any errors or distortions in the model due to exogenous shocks.

4.2.4. Granger causality test

Pairwise Granger causality test was employed to investigate the direction of causal relationship between pairs of variables that are of interest in the study and the findings are as revealed in Table 5. The null hypothesis of no causality between two variables cannot be rejected if the probability value of the F-statistics is >0.05 ($P > 0.05$). Contrarily, the null hypothesis is rejected if the probability value is ≤0.05 ($P \leq 0.05$).

As observed, Table 5 reveals evidence supporting a unidirectional causality from health outcome (that is, life expectancy) to CO_2 emissions. That is, health outcome due to investment in the health sector Granger causes CO_2 emissions. This implies that due to high life expectancy, people will continue to engage in more economic activities which have the tendency to enhance the concentration of CO_2 in the atmosphere. As noted by Mohamed et al. (2012), the rate of growth of CO_2 in the atmosphere is about 0.5% per year and its level has been predicted to rise to 450 ppm by the year 2050 (Aye et al., 2017). On the contrary, there is no evidence to show that CO_2 Granger causes average life expectancy in Nigeria.

Table 5: Pair wise granger causality test

Null hypothesis	Obs.	F-statistic	Prob.
LLE does not granger cause LCO_2E	35	2.89235	0.0710
LCO_2E does not granger cause LLE		0.56091	0.5766
LGDPPC1 does not granger cause LCO_2E	35	0.18182	0.8347
LCO_2E does not granger cause LGDPPC1		2.15180	0.1339
LFFC does not granger cause LCO_2E	33	1.75753	0.1910
LCO_2E does not granger cause LFFC		0.19259	0.8259
LELCON does not granger cause LCO_2E	33	0.02816	0.9723
LCO_2E does not granger cause LELCON		7.53810	0.0024
LGDPPC1 does not granger cause LLE	35	3.59713	0.0398
LLE does not granger cause LGDPPC1		11.1481	0.0002

Source: Authors' computations, 2019

Furthermore, the study found no causal relationship between FFC and CO_2 emissions. That is, neither FFC nor CO_2 Granger causes each other. This implies that the change in the level of CO_2 concentration in the air is not Granger caused by FFC but that other factors (such as manufacturing activities in the cement, garment and other related industries) may be responsible. This finding is inconsistent with the outcome of Alege et al. (2016). The outcome of this study suggests that any target towards ensuring the use of cleaner and renewable energy source may not significantly reduce the concentration of CO_2 in the air. Equally, economic development (proxied by GDPPC) does not Granger Cause CO_2 neither does CO_2 Granger cause GDPPC. This implies that any actions taken to reduce CO_2 emission may not necessarily affect economic development. Conversely, the finding from the study reveals that electricity consumption does not Granger cause CO_2 emissions. This evidence supports the assertion in the literature that cleaner/renewable energy sources do not contribute to pollutant emissions which reduce environmental quality. Thus, encouraging the use of electricity is a right move towards achieving an environment that is sustainable. However, CO_2 is found to Granger cause electric power consumption. The fact that people may become aware of the contribution of non-renewable energy towards raising the level of CO_2 in the air, they may decide to opt for the use of electricity which is cleaner and renewable.

In the final analysis, evidence from Table 5 shows bidirectional causality between GDPPC and life expectancy. That is, either GDPPC or life expectancy Granger causes each other. This suggests that progress in the economy through a high income will ceteris paribus; contribute to high average life expectancy in the economy. Likewise, higher life expectancy will contribute to the progress and development of the economy due to high level of experience.

4.2.5. Diagnostic tests

Series of diagnostic tests were conducted to address the issues related to the goodness of fit of the ARDL error correction model. These tests investigated heteroscedasticity, serial correlation, normality and omitted variables (Ramsey-RESET test). The findings in Table 6 reveal no challenges of heteroscedasticity, serial correlation, omitted variables or normality.

Table 6: Diagnostic test results

Test	F-statistic	P-value	Chi-square/t-statistic	P-value
Breusch-godfrey serial correlation LM test	0.651948	0.5418	3.691177	0.1579
Heteroskedasticity test: Breusch-pagan-godfrey	1.479467	0.2462	22.42630	0.2636
Jarque-bera: (Normality)			0.727146	0.695188
Ramsey-RESET (log likelihood ratio): (Omitted variables)	0.331975	0.5761	0.576173	0.5761

Source: Authors' computations, 2019

Evidence from Table 6 depicts that the estimated economic development (GDPPC) model certifies the diagnostic tests of constant error variance (homoscedasticity), symmetry in the distribution of its error terms (Jaque-Bera normality test), and correctly specified with no issue of omitted variables. This suggests that the goodness of fit of the model is fulfilled and the results from our analyses are robust and reliable for making inferences and drawing optimal policy decisions.

5. CONCLUSION AND RECOMMENDATIONS

Health is considered very crucial in the enhancement of quality human capital and labour productivity for the development of any economy. Increased human economic activities have been identified to contribute immensely to carbon emissions as well as other gaseous pollutants leading to environmental degradation which consequently, result to undesirable health outcomes (such as low average life expectancy and high rate of mortality). By integrating ecological economics approach and endogenous growth models, the study investigates the joint effect of carbon emissions (proxied by CO_2) and an indicator of health investments on economic development in Nigeria using annual time series spanning 1980-2016. The study employs bounds testing approach of the ARDL framework and co-integration is established among the adopted variables in the model. Empirical findings from this study are consistent with the outcomes of most studies that have been conducted in the past (Afolayan et al., 2019; Balan, 2016; Dinkelma, 2008; George and Oseni, 2012; Khan and Khan, 2010; Umoru and Yaqub, 2013; Liu et al., 2018; Lu, 2017; Matthew et al., 2018; Osabohien et al., 2019).

Findings from the long run estimation reveal that GHE, completion rate, FFC and CO_2 emissions significantly explain economic development (proxied by GDP per capita) while electric power consumption is not significant although, has a direct relationship with economic development in Nigeria. The supply of electricity in Nigeria is insufficient and also unstable and may have been responsible for its insignificance in influencing economic development in Nigeria. The outcome also shows that GHE, FFC and electric power consumption have a positive relationship while the link of CO_2, gross capital formation and graduation rate with GDP per capita is negative.

Further application of pair wise Granger causality test to investigate causal relationships between variables depicts that no causal link exists between FFC and CO_2. In order words, FFC does not Granger cause CO_2 as much as CO_2 does not Granger cause fossil fuel combustion. This finding suggests that FFC is not a major contributor to the accumulation of CO_2 in the atmosphere in Nigeria. Concentration of CO_2 in the air leading to environmental degradation may have been due to increased economic activities in the manufacture of cement, asbestos and any other dust-gathering products, and not necessarily via the consumption of fossil fuel as emphasized in previous studies. This outcome contradicts Alege et al. (2016) where Wald exogeneity causality test reveals a unidirectional causality running from FFC to CO_2 emissions. Conversely, a unidirectional causality is observed to run from CO_2 to electric power consumption and also, from life expectancy to CO_2 emissions, implying that as people live longer the tendency is there that they continually engage in economic activities, which may increase the accumulation of CO_2 in the atmosphere.

From the foregoing, the study makes the following recommendations. First, policies that will enhance environmental quality through the reduction in the level of pollutant emissions should be targeted towards the manufacturing sector. Industries that produce cement, asbestos and other dust-generating products should be made to adopt cost-effective method in order to reduce the opportunity cost of production and mitigate the effect of negative externalities on the populace. Second, education in Nigeria should be made functional and to serve the purpose of development by de-emphasizing the mere accumulation of credentials/certificates that are worthless. Suffice to say that stakeholders in the education sector (policy makers inclusive) should be focused on the delivery and acquisition of quality and sufficient education that is development-oriented rather than emphasis on mere education measures like school enrolments. Third and lastly, government should ensure effective, efficient and quality health expenditure that will deliver quality health care to the people whenever there is the need for it. This way, life expectancy will increase, mortality will reduce and an enhanced economic development can be assured. Such expenditure should be monitored to a logical conclusion for an assurance of its proper utilization for the purposes for which they are earmarked.

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