The Social and Management Scientist
Volume 10, Number 1, 2018 ISSN: 2489-0006

ENERGY USE, URBANISATION AND CARBON EMISSIONS: IMPLICATIONS FOR SUSTAINABLE GROWTH AND DEVELOPMENT IN NIGERIA

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Abstract

The role of energy in any economy cannot be overemphasized. Agreeably, Nigeria is endowed with numerous sources of energy. Despite these sources however, Nigeria still depend mainly on non-renewable energy sources which are drivers of carbon (CO_2) emissions. Other identified drivers of CO_2 emissions are urbanization and economic growth. This paper therefore examines the dynamic relationship among energy use, urbanisation, economic growth and CO_2 emissions for the periods of 1970 to 2014. The paper also test for the validity of the Environmental Kuznets Curve (EKC) hypothesis. The paper employs Autoregressive Distributed Lag (ARDL) Bound testing Approach developed by Pesaran, Shin and Smith (2001) to estimate the short-run and long-run relationships among the variables. The estimated results of the paper reveal that energy use, urbanisation and economic growth have significant impacts on CO_2 emissions both in short-run and long-run in Nigeria. However, the paper shows that there is no evidence to support EKC in Nigeria. For Nigeria to have a sustainable development, the paper recommends that there must be a paradigm shift from the current rate of energy use by which CO_2 emissions are inherent to other alternative and low-carbon energy sources that are relatively free from CO_2 emissions. The paper also recommends the establishment of efficient and sustainable urban energy infrastructure to control the growth of emissions in urban areas and that Nigeria should look beyond the EKC notion that economic growth is a solution to environmental pollution.

Keywords: Energy use, urbanisation, economic growth, carbon emissions, sustainable development

1. INTRODUCTION

The importance of energy to every economy cannot be over-emphasized. Energy has been the heart of development and plays several roles in any economy (Atoloye-Kayode, 2013). The increasing dependence on energy to ensure sustainable economic growth and development in modern economies has made the role of energy to be more evident. Energy plays vital role in economic growth and development through foreign exchange earnings from exportation of energy products, employment generation by energy industries, technology transfer in production process, infrastructural development in the process of exploration and many other roles. More fundamentally, the roles of energy in the activities of the industrial sector underscore its link with sustainable growth and development. These roles are essential ingredients for economic, social and environmental developments which are often refer to as the three pillars of sustainable development. In the report of United Nation Commission on sustainable development (2007), energy is said to be crucial for sustainable growth, poverty eradication and achieving the internationally agreed sustainable development goals. Sustainable development entails the use of resources with the aims of meeting human needs while preserving the environment so that these needs can be met both in the present and in the future.

Agreeably, Nigeria is endowed with abundant and diverse energy resources to meet energy needs both in the present and in the future. These include among others solar, hydro, wind, crude oil, natural gas, coal and wood. In spite of these numerous sources, only coal, crude oil, natural gas and hydro are currently utilized in processed forms while wood and solar are used in their crude forms (Ogunleye & Apata, 2013). Among these sources, hydroelectricity is one of the cleanest sources. However, Nigeria has not been able to provide adequate electricity supply to cater for the growing need of an increasing population particularly in the urban areas (Echeta, Okpara & Emerenini, 2013). This according to Olaoye and Akinbode (2012) is due to decades of poor management, lack of adequate planning, inefficiency and inadequate funding, which has made the supply of electricity in Nigeria fitful. This has in turn led to a shift from electricity to other alternative sources of energy which require the use of fossil fuel (Shuaibu & Oyinlola, 2014). Painfully, the use of this form of energy which ought to aid sustainable growth and development in Nigeria, is linked with carbon emissions. Studies carried out by the Federal Environmental Protection Agency (FEPA) (cited in Sambo, 2011), revealed a moderate-to-high concentration of pollutants in the atmosphere, the majority of which are said to come from dangerous fumes emitted from industries, electricity generating sets and automobiles in Nigeria. Increasing evidence has also pointed to the fact that sizeable accumulations of emissions from fossil energy use by human activities are the main drivers of greenhouse gases in Nigeria. Other drivers include technology, economic activities, attitudes, beliefs, political and economic institutions, population and urbanization. For instance, since the 1970s, Nigeria has undergone fast-paced urbanization (that is, the movement of people from rural areas to urban areas and from agriculture to industry), triggered by rapid economic growth and also accompanied by rapid increases in energy demand as well as carbon emissions.

Although a number of studies have examined the relationship among energy use, economic growth and carbon emissions in Nigeria, the majority of these studies failed to take urbanization into cognizance in their analysis. An exception to this is the study of Ali, Law, and Zannah (2016). However, the finding of the study that urbanization does not have any significant impacts on carbon emissions is counter-intuitive from an economic point of view and therefore the need to re-examine such relationship for Nigeria. The need to take urbanization into cognizance is of utmost importance, given the United Nations reports on World Urbanization (2014) which predicted that India, China and Nigeria together are expected to account for 37 per cent of the projected growth of the world's urban population between 2014 and 2050; and that Nigeria is projected to add 212 million urban dwellers. In the light of the foregoing, this paper is interested in adding to the repository of existing knowledge by examining the relationship among energy use, urbanization, economic growth and carbon emissions in Nigeria.

2. **LITERATURE REVIEW**

The relationship among economic growth, energy consumption, and the environment has been extensively investigated. An assessment of the existing literature on energy-economy-environment link over the past two decades shows that most studies focused on either the nexus of energy-economy or environment-economy. However, there are many studies that have integrated both nexuses in a multivariate framework for different economies.

Examining the dynamic causal relationship between carbon dioxide emissions, energy consumption, economic growth, foreign trade and urbanization in Japan, Hossain (2012) used time series data for the period of 1960-2009. It was found that over time, higher energy consumption in Japan gave rise to more carbon dioxide emissions. As a result, the environment will be polluted more. But in respect of economic growth, trade openness and urbanization the environmental quality was found to be normal good in the long-run.

In a panel context, Akpan and Abang (2014) investigated the link between environmental quality and economic growth so as to answer the relevant question of whether economic growth alone could serve as a long-run solution to environmental damage as implied in the EKC hypothesis. The study analysed the relationship using a panel of 47 countries over the period of 1970-2008. Using random effect estimation and two-stage least square, the study concluded that relying on a quadratic model can easily mislead researchers to ratify the existence of EKC. According to the study, the relationship between economic growth and environmental quality is shown to be typified by an N-shaded curve.

Similarly, Li and Lin (2015) in a panel context for 73 countries over the period of 1971 to 2010 adopted the Stochastic Impacts by Regression on Population, Affluence and Technology (STIRPAT) framework and found that in the low-income group, urbanization decreases energy consumption but increases CO_2 emissions, while in the middle-/low-income and high-income groups, urbanization significantly increases both energy consumption and CO_2 emissions. For the middle-high-income group, the study revealed that urbanization does not significantly affect energy consumption, but does hinder the growth of emissions.

In the case of Nigeria, Omisakin (2009) investigated the dynamic causal and long run relationship among energy consumption, carbon emissions and economic growth in Nigeria within the framework of the Environmental Kuznets Curve (EKC). The study used the bound testing approach to cointegration and found unidirectional

 ISSN: 2489-0006

causal relationships running from energy consumption to economic growth, energy consumption to carbon emissions and economic growth to carbon emissions.

The study of Shuaibu and Oyinlola (2013) examined the nexus between energy consumption, CO_2 emissions and economic growth in Nigeria, for the period 1970-2011 within a dynamic multivariate framework. The study used the Zivot-Andrews unit root test, Gregory-Hansen cointegration test and the VAR approach. The study found that the effect of CO_2 emissions and energy consumption on growth in Nigeria was time-varying between, before, and after the structural breakpoint. On the other hand, Bello and Abimbola, (2010) investigated whether the level of economic growth influence environmental quality in Nigeria within EKC framework for the periods 1980-2008. The study used the ordinary least squares method and observed that carbon emission in Nigeria is not driven by economic growth but by financial development. The study also showed that the inverted U shaped Environmental Kuznets Curve does not exist for Nigeria.

In a similar but slightly distinct study, Chuku and Ndifreke (2012) examined the relationship among energy consumption, trade, the environment and growth in Nigeria. The study used combined simultaneous approach. The result from the income equation and trade equation suggested that production activities in Nigeria are pollution-intensive and environmentally unfriendly. However, contrary to theoretical expectations, the emissions equation returned a U-shaped Environmental Kuznets Curve for Nigeria. In contrast to the findings of Chuku and Ndifreke (2012), the study of Akpan and Chuku (2012) on the relationship between Economic Growth and Environmental Degradation in Nigeria for the periods 1960 to 2008 found no support for the existence of the EKC hypothesis in Nigeria. The study which used Autoregressive Distributed Lag framework rather showed that Nigerian situation when confronted with data is exemplified by an N-shaped relationship.

Similarly, Akinsola and Adeoye (2014) investigated the relationship among air pollution, economic growth and the Environmental Kuznets Curve (EKC) hypothesis in Nigeria. The study used annual data from 1980-2010 and applied error correction model and the Granger causality test. The result of the study indicated that EKC does not hold for Nigeria, even though economic growth has significant impact on air pollution.

Using a multivariate framework, Nnaji, Chukwu and Uzoma (2013) analysed the dynamic causal relationship among carbon emissions, energy consumption, foreign trade and economic growth in Nigeria for the period 1970-2009. The study employed an augmented form of Granger causality and the bounds testing approach to cointegration to test the interrelationship between the variables. The study found a unidirectional causality running from energy consumption to economic growth; from energy consumption to carbon emissions; from carbon emissions to economic growth; from capital formation to economic growth and from trade to economic growth. The study also indicated that economic growth is determined by energy consumption, carbon emissions, capital and foreign trade. While a similar study of Sulaiman (2014) on the relationship between energy consumption, CO_2 emissions and economic growth

 ISSN: 2489-0006

in Nigeria concluded that any effort to lower the problem of CO_2 emissions by reducing energy consumption could negatively affect economic growth and therefore, suggested that renewable source of energy such as solar and wind could be explored and considered as an alternative source of energy in Nigeria.

In a recent study, Ali, Law, and Zannah (2016) examined the dynamic impact of urbanization, economic growth, energy consumption and trade openness on CO_2 emissions in Nigeria 1971-2011. Using the autoregressive distributed lags (ARDL) approach, the study found that urbanization does not have any significant impact on CO_2 emissions in Nigeria, while economic growth and energy consumption have positive impacts on CO_2 emissions. The study however found a negative impact of trade openness on CO_2 emissions and recommended open economy policies that will reduce carbon emissions in Nigeria.

As observed from the above review, many empirical studies have examined the relationships among energy use, urbanization, economic growth and carbon emissions both in the developed and developing countries but with mixed results. These differences in their results might be due to differences in sample data and method of analysis.

3. METHODOLOGY AND DATA

This study adopts a simple and straight-forward model of Grossman and Krueger (1995). Grossman and Krueger (1995) had shown that the link between economic growth and environmental pollution follows an inverted U-shaped pattern, referred to as the Environmental Kuznets Curve (EKC). The concept behind the EKC is that as a country develops, certain levels of environmental degradation are inevitable. Environmental degradation continues until it reaches a peak and then begins to fall.

Grossman and Krueger (1995) specified the relationship between the indicators of the environmental pollution and per capita GDP as follows:

$$CO_2 = \beta_0 + \beta_1 Y_t + \beta_2 Y_t^2 + X_t + \varepsilon_t \qquad (1)$$

Where CO_{2t} is a measure of pollution level (as proxy for environmental quality), Y_t is per capita GDP, Y_t^2 represents its geometric transformation and X_t is a vector of other covariates while ε_t is the normally distributed stochastic term. EKC is confirmed to exist if $\beta_1 > 0$ and $\beta_2 > 0$

Following the study Akinsola and Adeoye (2014), the relationship among energy use, urbanization, economic growth and carbon emissions is modelled econometrically as follows:

$$CO_2 = \beta_0 + \beta_1 GDP_t + \beta_2 GDP_t{}^2 + \beta_3 GDP_t{}^3 + \beta_4 ENG_t + \beta_5 URB_t + \varepsilon_t \qquad (2)$$

Where CO_2 is carbon emissions per capita, GDP is GDP per capita growth, as a measure of economic growth, ENG is energy use, measure as kilotons of oil equivalent per capita and URB is urbanization, measured by urban population growth - annual percentage. The inclusion of the cubic function in the model is to capture the possible functional forms beyond the inverted U-shape. This is as included in Akpan and Abang (2014). The data for this study are secondary and were sourced from World Bank Development Indicators (2015) for the periods of 1970 to 2014.

3.1 Econometric Procedure

3.1.1 The ARDL Bounds Testing Approach to Cointegration

To examine the long-run relationships among energy use, urbanization, economic growth and carbon emissions, the study employed the Autoregressive Distributed Lag (ARDL) bounds test approach to co-integration developed by Pesaran, Shin and Smith (2001). The ARDL approach has several advantages over other traditional approaches. This approach can be applied irrespective of whether the series are integrated of I(0), I(1) or mutually cointegrated. In this way the pre-testing problem associated with the standard cointegration test such as the classification of variables into I(0) and I(1) is avoided. In this paper, the ARDL approach to co-integrated is estimated using unrestricted error correction model (UECM). The UECM integrates the short-run dynamics with the long-run equilibrium without losing any long-run information. The UECM is specified as follows:

$$\Delta CO_{2t} = \delta_0 + \beta_{CO} CO_{2t-1} + \beta_{GDP} GDP_{t-1} + \beta_{GDP^2} GDP^2{}_{t-1} + \beta_{GDP^3} GDP^3{}_{t-1} + \beta_{ENG} ENG_{t-1} + \beta_{URB} URB_{t-1} + \sum_{i=1}^{k} \delta_i \Delta CO_{2t-i} + \sum_{i=0}^{k} \phi_i \Delta GDP_{t-i} + \sum_{i=0}^{k} \gamma_i \Delta GDP^2{}_{t-i} + \sum_{i=0}^{k} \pi_i \Delta GDP^3{}_{t-i} + \sum_{i=0}^{k} \eta_i \Delta ENG_{t-i} + \sum_{i=0}^{k} \omega_i \Delta URB_{t-i} + \mu_t \quad (3)$$

Where δ_0 is the drift component and Δ is the first difference operator. The β's denote the long-run multipliers while the terms with summation signs are the short-run dynamics. The lag length selection is based on Akaike Information Criterion (AIC).

4 EMPIRICAL RESULTS AND DISCUSSIONS

4.1 Unit Root Test

The application of ARDL is based on the assumption that the variables are stationary at levels [I(0)] or at first difference [I(1)] . The presence of an *I*(2) series will render the computed *F*-Statistic invalid. Hence, pre-testing for unit roots in ARDL procedure is pertinent to ensure that none of the variables is I(2) or beyond. In view of this, the Augmented Dickey-Fuller (ADF) test and the Phillips-Perron (PP) test were employed to test for the stationarity of the variables. The results are presented in Table 1. below.

Table 1: Unit Root Test Results

	ADF		PP		Order of integration
variables	Level	1st Difference	Level	1st difference	

 ISSN: 2489-0006

CO_2	-2.739056	-7.970895*	-2.707354	-8.293443*	I(1)
GDP	-5.682986*	-8.898404*	-5.767323*	-19.42437*	I(0)
GDP^2	-5.909454*	-7.663697*	-5.917995*	-40.65561*	I(0)
GDP^3	-6.373695*	-7.606896*	-6.373695*	-41.56798*	I(0)
ENG	-2.737099	-5.643134*	-2.665726	-5.623893*	I(1)
URB	-2.003938	-4.860879*	-2.064604	-6.460651*	I(1)

The asterisks * denote rejection of the unit root hypothesis at 1%.

The results in table 1 above indicate that the variables are integrated either in levels or at the first difference, I(0) or I(1), with no variable with I(2) or higher order.

4.2 The ARDL Bounds testing approach to Cointegration

The ADRL for the presence of long-run relationships is reported in Table 4.2.

Table 2 Bounds Test Results for Cointegration Relationship

Critical value bounds						
K	1%		5%		10%	
	I(0)	I(1)	I(0)	I(1)	I(0)	I(1)
5	3.41	4.68	2.62	3.79	2.26	3.35
F CO_2 (CO_2 / ENG, GDP, GDP^2, GDP^3, URG) = 5.070706						

The bounds F-test for cointegration test above shows an evidence of a long-run relationship between carbon emissions and its determinants. The computed F-statistic = 5.070706, is greater than the upper bound of the 1% critical values, resulting in the rejection of the null hypothesis of no long-run relationship among energy use, urbanization, economic growth and carbon emissions in Nigeria. This evidence rules out the possibility of estimated relationship being spurious. Since the results support the existence of cointegration among the series, we estimate the long-run coefficients.

Having found long run relationships among the variables, the next step is to estimate the long run relationships and the short-run error correction representation of the variables. The estimated results for the long-run and short-run relationships are presented in Tables 4.3 and 4.4 respectively.

Table 3: Results of Estimated long-run Coefficients Using ARDL Approach

Dependent Variable: CO_2			
Regressor	Coefficient	T-Statistic	P-value
ENG	0.105945	2.238094	0.0368**

GDP	-0.023255	-1.527151	0.0142***
GDP^2	-0.004725	-2.603203	0.0170**
GDP^3	0.000189	2.620195	0.0164**
URB	0.438096	5.307074	0.0000***
Constant	-0.604331	-1.288758	0.2122

Note: *** and ** denote significant levels at 1% and 5% respectively

Table 4: Error Correction Representation for the Selected ARDL Model

Dependent variable: CO_2			
Regressor	Coefficient	T-Statistic	P-value
D(CO_2 (-1))	0.101947	0.483939	0.6337
D(CO_2 (-2))	0.611878	3.742213	0.0013***
D(ENG)	0.260977	2.219847	0.0382**
D(ENG(-1))	0.291172	2.576221	0.0180***
D(GDP)	-0.004607	-1.089598	0.2888
D(GDP(-1))	0.009401	1.978007	0.0619**
D(GDP(-2))	-0.014238	-3.535194	0.0021***
D(GDP2)	-0.000684	-1.898601	0.0721*
D(GDP2(-1))	0.001375	4.266890	0.0004***
D(GDP3)	0.000028	1.835850	0.0813*
D(GDP3(-1))	-0.000052	-3.678762	0.0015***
D(GDP3(-2))	0.000013	2.361259	0.0285*
D(URB)	0.095781	1.126447	0.2733
D(URB(-1))	-0.136365	-2.377545	0.0275*
ECM(-1)	-0.653953	-3.055429	0.0062***

R^2 = 0.8081, Adjusted R^2 = 0.616199, Durbin-Watson statistic = 2.293212, F-statistic = 4.211040 (0.001)***. Note***, ** and * denote significant levels at 1%, 5% and 10% respectively.

The result in Table 4.3 shows that there is a long-run relationship among energy use, urbanization and carbon emissions in Nigeria. Interestingly, most of the long-run coefficients are statistically significant. As expected, the impact of energy on carbon emissions is positive. Specifically, the result indicates that a unit increase in energy use will increase carbon emission by 10% in Nigeria, all things being equal. The result conforms to the findings of Omisakin (2009) and Nnaji, Chukwu and Nnaji (2013) for Nigeria.

The result also shows that the rate of urbanization has positive impact on carbon emissions in Nigeria. Expectedly, the impact is significant and high. We suggest a number of factors that could have contributed to this finding. As pointed out in the literature, a higher rate of urbanization increases the demand for materials, energy and natural resources which in turn generates some negative environmental externalities. Indirect energy use in the production of goods and transportation may also have contributed to this. This finding is similar to the findings of Li and Lin (2015) for 73 countries, but different from the findings of Ali, Law and Zannah (2016) for Nigeria.

However, the results do not provide evidence of the existence of EKC hypothesis for Nigeria. The study established the existence of N-shaped relationship between carbon emissions and economic growth in Nigeria. This conclusion is based on the coefficient value on Table 4.3 where $\beta(1) < 0$, $\beta(2) < 0$ and $\beta(3) > 0$, showing a typical sign of an N-shaped relationship. This is a confirmation that instead of inverse U-shape, as predicted by the EKC hypothesis, Nigerian case follows a different way. This N-shaped environmental pollution-economic growth relationship is similar to that of Akpan and Chuku (2012), which equally found an inverted N-shaped environmental degradation-economic growth relationship for Nigeria, but different from that of Bello and Abimbola, (2010) which found U-shaped.

The results of the short-run dynamics as presented in Table 4.4 shows that the overall fit is satisfactory at the value of R^2 = 0.8081. This shows that the independent variables in the model jointly accounted for about 81 per cent of the total variation in carbon emissions. The elasticity status of the model shows that energy and economic growth are also significant in explaining short-run changes in CO_2 emissions per-capita in Nigeria. The impact of urbanization is not significant in the short-run. However, its lag has a negative impact on carbon emissions in Nigeria.

The coefficient of the ECM (-1) as shown in table 4.4 is significant and correctly signed, showing that the model has a self-adjusting mechanism for adjusting the short-run dynamics of the variables with their long-run values. This shows that there is a long-run relationship between carbon emissions and its determinants. The speed of adjustment as shown by the coefficient of ECM (-1) indicates the short-run deviations from the long run equilibrium are being corrected by 65 per cent each year. The diagnostic tests show that error term of short run models is free of serial correlation and heteroskedasticity. The Ramsey reset test shows that functional form for the short run models are well specified.

5. CONCLUSION AND POLICY IMPLICATIONS

This paper investigated the relationship among energy use, urbanization, and economic growth and carbon emissions in Nigeria over the periods of 1970 to 2014. The Autoregressive Distributed Lag (ARDL) bounds test was employed to examine the long-run and the short-run relationships among the variables.

The empirical result of the bounds test revealed that carbon emissions in Nigeria is responsive to changes in energy use, economic growth and urbanization. In the long-run, energy use and urbanization were found to be associated with increase in carbon emissions. The EKC hypothesis was not validated by the results. The empirical analysis showed the evidence of an N-shaped between carbon emissions and economic growth in Nigeria.

The above findings have several policy implications for sustainable growth and development in Nigeria. The findings that energy use has positive impact on carbon emissions imply that energy use is a major contributor to carbon emissions in Nigeria.

Since sustainable development calls for an efficient use of energy, there is therefore the need for an efficient use of energy in Nigeria. The development and adoption of more efficient technologies for using energy particularly for transportation is an essential ingredient. However, there is the need for paradigm shift from the current rate of consumption of fossil fuel in which carbon emissions are inherent. Attention should therefore be shifted from fossil fuel consumption to other alternative and low-carbon energy sources. An alternative and viable option for Nigeria is to increase the use of alternative sources of energy that are relatively free from carbon emissions. The paper therefore recommends that priority be given to renewable energy sources such as solar, hydroelectricity and wind, as they are more sustainable than other sources.

Furthermore, policies should be focused on controlling the scale of urbanization and urban populace should be guided to establish energy-saving and low-carbon life-styles. The government should proactively improve public infrastructural facilities so as to harness the urban agglomeration effect. Establishing efficient and sustainable urban energy infrastructure is essential to controlling the growth of carbon emissions. There is also the need for government to build institutional capacities to assist in maintaining a sustainable environmental management in urban areas in Nigeria.

The fact that Nigeria's case is exemplified by an N-shape rather than the EKC hypothesized inverted U-shape presents a big policy issue. The implication of this is that any benefit of economic growth on environmental pollution in Nigeria is merely temporal. Relying on EKC hypothesis could be a deceptive guide for making environmental policy in Nigeria. Nigeria should therefore look beyond the EKC notion that economic growth is a solution to environmental pollution and take measures that are required to reduce carbon emissions in Nigeria.

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