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Energy consumption, environmental pollution and economic growth in Nigeria

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Abstract

Nigeria is one of the leading producers and users of fossil fuel in the Africa. Nigeria is well endowed with a variety of fossil energy type, such as crude oil, natural gas and coal. The consumption of fossil fuel in Nigeria has, however, not come without a cost. Even though fossil fuel is an essential input for economic growth, its consumption has contributed significantly in changing the environment in Nigeria. This paper investigates the relationship between energy consumption, environmental pollution and economic growth in Nigeria using autoregressive distributed lag approach to cointegration. The empirical results revealed that there is a long run relationship between energy consumption, CO_2 emissions and GDP. Both in the long run and short run, Energy consumption (FF) has been found to have a significant positive impact on CO_2 emissions, meaning that an increase in energy consumption (FF) increases CO_2 emissions. On the other hand, energy consumption (FF) shows negative insignificant impact on GDP. It was therefore, suggested that renewable source of energy such as solar and wind could be explored and considered as an alternative source of energy since Nigeria is well endowed with solar energy. This will assist in reducing CO_2 emissions and at the same time sustaining long run growth in GDP

Key words: Fossil fuel, CO_2 emission, Economic growth, ARDL approach**.**

1. Introduction

Energy consumption has been on the increase all over the world due to its overwhelming impact on economic growth (Mathew et al., 2018). Energy plays a key role in the economic growth, progress, and development, as well as poverty eradication and security of any nation. Constant energy supply is a vital issue for all countries today. Economic growth in the future crucially depends on the long-term availability of energy from sources that are affordable, accessible, and environmentally friendly. (Ramchandra and Boucar 2011).

However, economies all over the world desire a certain level of economic growth, but environmental pollution as common and controversial environmental issues in this modern age poses threat to achieving this objective. This is because a sizable portion of the world's energy consumption need is met through fossil fuels. Therefore, the increase in global trade and economic activities the world over have caused a significant rise in carbon dioxide (CO_2) emission (Philip and Adeyemi 2018).

In spite of the danger associated with the burning of fossil fuel, however, Nigeria still depends on fossil fuel to meet her energy needs. The country's energy

consumption profile reveals that petroleum products still take a large share of energy consumed in the country. Such dominance of fossil fuel in energy consumption pattern, coupled with worsening trend in carbon emissions from fossil fuel in Nigeria is a clear indication that environmental quality will remain a concern in Nigeria. The concern about environmental quality in Nigeria is a more serious issue that may involve the diminishing of economic productivity (Akinsola & Adeoye, 2014).

Despite the fact that studies on energy consumption, environmental pollution and economic growth in Nigeria are many, there has been no attempt to incorporate some important variables that determine energy consumption and increase environmental pollution like school enrollment as a result of the important role played by population in driving the use of fossil fuel and gross capital formation because the process of industrialization require capital investment which may increase environmental pollution through energy conversion from one form to another. In view of the above, this study examines the relationship between energy consumption, environmental pollution and economic growth in Nigeria. Also, the uniqueness of this study lies in the adoption of new variables which majority of past studies in Nigeria has not considered.

This study is organized as follows. Besides the introduction, section two is a critical review of relevant literature and section three presents model specification, estimation, discussion of results and policy recommendation.

2. Literature Review

An attempt has been made in this section to present the review of past empirical studies regarding the subject matter of this study.

2.1Conceptual Framework

Concept of Energy and Energy Consumption

Energy is a key input for the production of goods and services. Physical capital uses energy to provide its contribution to production. Energy prices exert a wide influence on overall price level.

Energy is a fundamental resource in the economy. Every facet to economic activities in this planet earth required energy in one form or the other to function effectively. Consequently, economic growth is directly related to energy consumption. As Alam, (2006) puts it, “energy is the indispensable force driving all economic activities”.

Energy sources are divided into two: Renewable (an energy source that can be easily replenished) and Nonrenewable (an energy source that cannot be easily replenished). Renewable and nonrenewable energy sources can be used as primary energy sources to produce useful energy such as heat or used to produce secondary energy sources such as electricity.

Most of the energy consumed in the Nigeria is from nonrenewable energy sources: Petroleum products, Hydrocarbon gas liquids, Natural gas, Coal, Nuclear energy. Crude oil, and coal are called fossil fuels because they were formed over millions of years by the action of heat from the earth's core and pressure from rock and soil on the remains (or fossils) of dead plants and creatures such as microscopic diatoms. Crude oil is the dominant source of commercial energy use, accounting for over 70% of national commercial energy consumption, of this, the transport sector accounts for about 70% of commercial

energy consumption. In Nigeria, crude oil has been a major economic growth determinant (Bhattacharyya 2011).

Concept of Environmental Pollution

Consistent with McLaughtin, "Environmental pollution" means the introduction by man into any part of the environment, of wastes, water energy or energy or surplus energy which modify the environment directly or indirectly adversely to affect the opportunity of men to use or enjoy it.

Muralikrishna and Manickam (2017), defined environmental pollution as the contamination of the physical and biological components of the earth/atmosphere system to such an extent that normal environmental processes are adversely affected." pollutants may be naturally occurring substances or energies, but they are considered contaminants when in excess of natural level. Any use of natural resources at a rate greater than nature's capacity to repair itself can bring about pollution of air, water, and land.

Concept of Economic Growth

The literature on growth have widely been based on the quantitative increase in national output and income (Nafziger, 2006; Parkin, 2012; Oloko, 2005; Neamtu, 2014; and Atlay, 2015). For instance, Naziger (2006) refer economic growth to an increase in a country's production or income per capita that are measured by Gross National Product (GNP) or Gross National Income (GNI). Parkin (2012) perceives growth as a sustained expansion of production possibilities measured as the increase in real Gross Domestic Product (GDP) over a given period. Oloko (2005) posits that growth was to be an increase in a country's real level of national output which can be caused by an increase in the quality of resources such as education, health and technology. Similarly, Neamtu (2014) defines growth as the increase in the size of economic result determined by combining and using factors of production and evidence by macroeconomic indicators such as GDP, GNP and National Income (NI) in real terms both total and per capita. Further, Atlay (2015) accentuated that growth is a numerical value to be able to measure the real GDP increase rate.

The above definitions have focused on the quantitative increase in national output as the indicator of growth. This could largely be because of the nature of growth over time. Expectedly, increase in growth should translate into reduction in poverty, inequality and unemployment. This have not been the case with the growth process of many countries.

2.2 Energy Consumption and Environmental Pollution

Yahaya, Razani, Jali and Raji (2018) examines the relationships between energy consumption, financial development, GDP, urbanization and environmental pollution in Nigeria from the period 1980- 2011 by applying autoregressive distributed lag (ARDL) method. The finding shows that in the short-run energy use is positively related with environmental pollution, while financial development and GDP reduce environmental pollution. The long-run analysis shows that energy consumption is positive and significant in influencing environmental pollution.

Nejat, Jomehzadeh et al. (2015) reviewed the status of energy consumption and CO_2 emissions both globally and in 10 selected countries (China, the US, India, Russia, Japan, Germany, South Korea, Canada, Iran, and the UK). The results of the study show the policies energy could be successful if they are enhanced by making them mandatory, targeting net-zero energy

building, and increasing public awareness about new technologies.

The study of Soytas, Sari and Ewing (2007) investigated the dynamic relationship between CO_2 emissions, income and energy consumption in United States. The results of the study showed that CO_2 emissions Granger causes income and energy consumption contributes to CO_2 emissions. A similar exercise was carried out by Ghosh (2009) in India. The study investigated the causal relationship between income and CO_2 emissions in India by incorporating investment and employment as additional determinants of CO_2 emissions but unlike the results of Soytas, Sari and Ewing (2007), the study reported no causality between income and CO_2 emissions.

Ibrahim and Cudjoe (2021) employed Vector Error Correction Model (VECM) to analyzed the environmental impact of energy consumption in Nigeria using time series data from 1990-2018. The study found a long run positive impact of GDP on CO_2 emissions in Nigeria. This refutes the Environmental Kuznet Curve hypothesis that environmental quality improved with an increase in income. They also found that charcoal consumption has a long run tendency of reducing CO_2 emission while fuel wood consumption has a long run possibility of raising CO_2 emission. They also found that usage of gas oil has a negative impact on CO_2 emissions while natural gas consumption and fuel oil consumption has a detrimental impact on CO_2 emission. Hydroelectricity consumption on the other has a long run negative impact on CO_2 emission in Nigeria.

2.3 Energy consumption and Economic growth

The Study of Sama and Tah (2016) determined the effect of Energy Consumption on Economic Growth in Cameroon from the period of 1980 to 2014. The energy sources used to test for this relationship were Petroleum and electricity. The study made used of secondary time-series data. Using the Generalized Method of Moments technique, the results obtained shows that Gross Domestic Product (GDP), population growth rate and petroleum prices, have a positive relationship with petroleum consumption. Also, there was an established positive relationship between Gross Domestic Product (GDP), population growth rate, electricity prices and electricity consumption. Again, the study found a positive and significant relationship between petroleum consumption, electricity consumption, Gross domestic investment (GDI) and population growth rate and economic growth. Furthermore, the empirical result revealed that the rate of inflation and economic growth are positively related.

On the other hand, Ibrahim, Celebi, Odeser and Sancar (2017) examines the causal relationship between energy consumption and the economic growth of Turkey. The analysis was conducted within the Stochastic Impacts by Regression on Population, Affluence and Technology (STIRPAT) framework. This is a salient improvement from the previous studies because this unique method permits synergetic modelling of energy dynamics vis-à-vis its environmental impact. The study applied the structural break unit root test, bound testing cointegration and vector error correction causality analysis. The study found that the importation of energy is the major challenge to the Turkish conservative policy. When controlling for $C0_2$ emissions in the energy import model, the study found that an approximate 0.14% increase emission emanates from imported energy for Turkey in the short-run. Similarly, 1.1% of emissions results from

electricity production and other related activities over the short-run. Even though, evidence of long-run relations was only present in the $C0_2$ emission as well as the financial development models, the correcting process from the short-run deviation to the long-run equilibrium is higher in the electricity consumption model, in that 51% short-run disequilibrium is corrected toward the long-run equilibrium per year compared with 3.3% and 4.8% in the energy import and C02 emission models, respectively. One positive aspect observed is the robustness of Turkey's financial institution to support the energy sector. However, financial institutional support for conservational policy is pathetically weak due to the low potential return.

Using a panel analysis, Shahbaz, Zakaria, Hussain and Mahalik (2018) empirically examined the inter-linkages between energy consumption and economic growth in top ten energy-consuming countries i.e. China, the USA, Russia, India, Japan, Canada, Germany, Brazil, France and South Korea. They use the quantile-on-quantile (QQ) approach of Sim and Zhou (2015) to explore some nuanced features of the energy-growth nexus and to capture the relationship in its entirety. The results show a positive association between economic growth and energy consumption, with considerable variations across economic states in each country. A weak effect of economic growth on energy consumption is noted for the lower quantiles of economic growth in China, India, Germany and France, which suggests that energy as an input has less importance at low levels of economic growth. A weak effect of economic growth on energy consumption is also noted for the highest quantiles of income in the United States, Canada, Brazil and South Korea, which indicates that energy demand decreases with the increase in economic growth as these countries have become more energy efficient. The weakest effect of energy consumption on economic growth is observed at lower quantiles of energy consumption in China, Japan, Brazil and South Korea. The results of the present study can help in the design of energy development and conservation policies for sustainable and long-term economic development.

In Nigeria Bello, Dalhatu and Dahood (2018) examined the energy consumption and economic growth, using the time frame of thirty (30) years period from 1986-2016. It was established in the study that before the introduction of appropriate energy consumption, energy sector funds were grossly mismanaged, contracts were awarded based on 'connections' rather than on merit and high occurrence of corruption in Nigerian power sector. Since power sector has been seen as an important instrument tool to be used by the government to improve the economy, the appropriate growth from power supply have strengthened all sectors in Nigeria economy and minimize the incidence of economic retardation. The result of the study reviewed that: Energy consumption has significant relationship with economic growth in Nigeria.

Olarinde and Adeniran (2018) Energy is critical to the survival and expansion of any economy. In Nigeria, energy consumption has been skewed towards household use, and below thresholds for sector-driven growth. The article updates, in time and methodology, those studies highlighting the significance of energy use for economic growth, using the Bound test and the Auto Regression Distributed Lag (ARDL) to establish the long- and short-run relationships between disaggregated energy consumption and economic growth in Nigeria from 1990 to 2016. The variables considered are real GDP, energy

consumption decomposed into electricity and petroleum consumption, labour and capital. The findings show that, in the short and long run, petroleum consumption and labour have a significant positive relationship with GDP. Furthermore, the causality results show that feedback causation between economic growth and energy consumption as well as labour exists, while one-way causation runs from labour to economic growth.

2.4 Environmental Pollution and Economic Growth

In another panel analysis, Aye and Edoja (2017) Investigated the effect of economic growth on CO_2 emission using the dynamic panel threshold framework. The analysis is based on data from a panel of 31 developing countries. The results indicate that economic growth has negative effect on CO_2 emission in the low growth regime but positive effect in the high growth regime with the marginal effect being higher in the high growth regime. Their finding provides no support for the Environmental Kuznets Curve (EKC) hypothesis; rather a U-shaped relationship is established. Energy consumption and population were found to exert positive and significant effect on CO_2 emission. Financial development indicator in the model did not change the conclusion about EKC hypothesis. Employing panel causality methods, there is evidence of significant causal relationship between CO_2 emission, economic growth, energy consumption and financial development. The findings emphasize the need for transformation of low carbon technologies aimed at reducing emissions and sustainable economic growth. This may include energy efficiency and switch away from nonrenewable energy to renewable energy.

In the case of Malaysia Saboori, Sulaiman and Mohd (2012) attempts to establish a long-run as well as causal relationship between economic growth and carbon dioxide (CO_2) emissions. Using data for the years from 1980 to 2009, the Environmental Kuznets Curve (EKC) hypothesis was tested utilizing the Auto Regressive Distributed Lag (ARDL) methodology. The empirical results suggest the existence of a long-run relationship between per capita CO_2 emissions and real per capita Gross Domestic Product (GDP) when the CO_2 emissions level is the dependent variable.

In summary, from the reviewed literature, it could be concluded that studies on energy consumption, environmental pollution and economic growth in Nigeria did not include some variables like gross capital formation and school enrollment. Therefore, there is a need for further study to examine nexus between these variables in the recent times.

3. Methodology

This paper makes use of secondary data such that fossil fuel, CO_2 Emission and School enrollment were extracted from world development indicators (WDI) and Real gross domestic product from CBN statistical bulletin.

3.1 Model Specification

3.1.1 Unit root test

This study uses Augmented Dickey Fuller (ADF) and Phillip Perron (PP) tests to find the order of intergradation and stationarity level of the variables.

3.1.2 Autoregressive distributed lag (ARDL) model

The study uses a modified version of the model from Dogan and Turkekul (2015)

for the association between CO2 emissions and other independent variables as expressed in equation (1)

$$CO2 = f(GDP, FF, SE) \quad (1)$$

The variables FF, CO2, GDP, and SE represent Fossil Fuel, carbon emissions, gross domestic product, and school enrollment which is a control variable, respectively. The study uses Autoregressive Distributed Lag (ARDL) to determine the long-run relationship between these variables. ARDL bounds testing method was offered by Pesaran et al. (2001) and it has number of advantages over other traditional techniques. The technique can be applied in the case variables are I(0), I(1) or are in mixed and therefore, it is appropriate for this study. The models can be expressed as:

$$\Delta \ln CO_{2t} = \phi_0 + \sum_{i=1}^{m} \beta_{1i} \Delta \ln CO_{2t-i} + \sum_{i=0}^{m} \beta_{2i} \Delta \ln GDP_{t-i} + \sum_{i=0}^{m} \beta_{3i} \Delta \ln FF_{t-i} + \sum_{i=0}^{m} \beta_{4i} \Delta \ln SE_{t-i} + \alpha_1 \ln CO_{2t-i} + \alpha_2 \ln GDP_{t-i} + \alpha_3 \ln FF_{t-i} + \alpha_4 \ln SE_{t-i} + \varepsilon_1 \quad (2)$$

In equation (2), ε represents the error term, t denotes the time trend and Δ indicates the first difference operator. Lag selection is built on the Akaike information criteria (AIC). Moreover, the decision concerning the long run depends on F-statistic. The null hypothesis that no cointegration among the variables is indicated by H0: β1 = β2 = β3 = β4 = 0 while the alternative hypothesis is that the variables have long run relationship, specified as H1: β1 ≠ β2 ≠ β3 ≠ β4 ≠ 0. Pesaran et al. (2001) formulated two critical values; the lower critical bound value (LCB) and the upper critical bound value (UCB). Therefore, a higher value of F statistic than the UCB implies rejection of the null hypothesis and it is concluded that cointegration exist between the variables. However, a lower value of F statistics than the LCB suggests that null hypothesis cannot be rejected and it is concluded that cointegration does not exist between the variables. Moreover, the estimated dynamic error correction model determines the short run and long run associations between the variables. The significant negative value of the error correction term (ECT) further endorses the presence of long- run relationship.

4. Results and Discussion

This section discusses the findings of the study. For good econometric estimation there is need to check stationarity of the data. Therefore, unit root test was conducted using PP test in addition to ADF tests. The estimation of the ADF is built on Schwarz Information Criterion (SIC) and the PP estimate is built on Kemel Newey West bound selection. Table 2 depicts the unit root tests result in for both ADF and PP test. The results suggest that some of the variables are stationary at I(0) while others are found to be stationary at I(1). No variable among them are found to be stationary at I(2), hence, the ARDL bound testing method is appropriate as technique to analyze these variables.

Table 1. Result of Unit Root Test Results.

Variables	ADF Test Statistics				PP Test Statistics			
	Constant		Trend		Constant		Trend	
	Level	First difference	Level	First Difference	Level	First Difference	Level	First Difference
lnFF_t	-3.207 (0.027)**	-6.977 (0.000)***	-3.334 (0.076)*	-6.909 (0.000)***	-3.235 (0.025) **	-7.647 (0.000) ***	-3.390 (0.067)*	-7.677 (0.000)***
lnCO_2t	-1.411 (0.566)	-6.575 (0.000)***	-2.530 (0.312)	-6.482 (0.000)***	-1.299 (0.619)	-7.399 (0.000)***	-2.580 (0.290)	-7.060 (0.000)***
$lnGDP_t$	-0.945 (0.762)	-3.874 (0.005)***	-1.512 (0.806)	-3.777 (0.029)**	-0.311 (0.913)	-3.874 (0.005)***	-3.176 (0.104)	-3.777 (0.029)**
ln$SE1_t$	-1.656 (0.444)	-5.123 (0.000)***	-1.979 (0.593)	-5.004 (0.001)***	-1.726 (0.410)	-5.112 (0.000)***	-2.422 (0.362)	-4.986 (0.001)

***, ** and * Denotes 1%,5% and 10% significance level respectively.

Source: Authors computation using Eviews 9.

Table 2 present the findings of bound test for the existence of cointegration. The bound test result endorses the presence of long-run association since the value of F-statistic is above the upper bound critical values at 1% significance level.

Table 2 Bounds Test Result

Model 1					
				Bounds critical values	
				[Unrestricted intercept & no trend]	
Model	**F-stats**	**Lag**	**Level of significance**	**I(0)**	**I(1)**
($lnCO_{2t}$|$lnFF_t$$lnGDP_t$$lnSE_t$)	**5.058**	**1**			
			1%	4.29	5.61
			5%	**3.32**	**4.35**
			10%	2.72	3.77
			2.5%	3.69	4.89

Source: Authors computation using Eviews 9.

The long run result from Table 3 reveals that Fossil fuel consumption was found to have a positive and significant impact on CO_2 emission during the study period. It reveals that a unit changes in the fossil fuel consumption influence CO_2 emission by 0.505. This relationship is statistically significant at 5% level of significance. The result suggested that fossil fuel consumption was responsible for an increase in CO_2 emission of the country. This also shows that; Nigeria rely heavily on fossil fuel for its energy demand. This result is consistent with the findings of Azodo (2019) and Nnaji, Chukwu and Nnaji (2013) who found positive relationship between CO_2 emission and energy consumption (fossil fuel).

On the other hand, economic growth has a negative and statistically significant impact on CO_2 emission in the long-run. To be specific, an increase in economic growth would lead to a decrease in CO_2 emission. The finding is consistent with the findings of other researchers in Nigeria.

According to the result of the findings, there is a positive relationship between school enrollment and CO_2 emission during the study period. This relationship is statistically insignificant. The coefficient of school enrollment is 0.072. This means that a percentage increase in school enrollment will cause CO_2 emission to increase by 0.072, though the relationship is insignificant.

The short-run results from the estimation are reported in Table 3. The result denotes that economic growth has a negative and significant relationship with CO_2 emission. This is similar with the finding of the long-run coefficient result. The findings also reveal that fossil fuel consumption has a positive and statistically significant relationship with CO_2 emission, this result is consistent with the findings of Nnaji et al (2013).

On the other hand, school enrollment has a positive and statistically insignificant impact on CO_2 emission. The error correction term depicts 65% speed of adjustment to the long-run equilibrium, i.e. it shows 65% of deviation from the equilibrium that needs to be corrected in the long-run. The error correction term satisfies the theoretical requirement, that is, being negative, less than one in absolute value and significant, the coefficient of the error correction term confirms the cointegration relationship among the variables.

Table 3 Estimated Long-run and Short-run Coefficient

Long run result			**Short-run result**		
Dependent Variable, $lnCO_2$			**Dependent variable, lnGDP**		
Regressors	Coefficient	T.ratio (pvalues)	Regressors	Coefficients	T-ratio (p value)
LnFF	0.505	3.169 (0.003)***	$\Delta lnFF_t$	0.656	6.049 (0.000)***
LnGDP	-0782	-5.643 (0.000)***	$\Delta lnGDP_t$	-0.511	-4.596 (0.000)***
LnSE1	0.072	0.586 (0.561)	$\Delta lnSE1_{t-1}$	0.047	0.602 (0.550)
C	7.664	5.257 (0.000)	ECT_{t-1}	-0.653	-5.166 (0.000)***

***, **, and * are significant level at 1%, 5% and 10% respectively.

Source: Authors computation using Eviews 9.

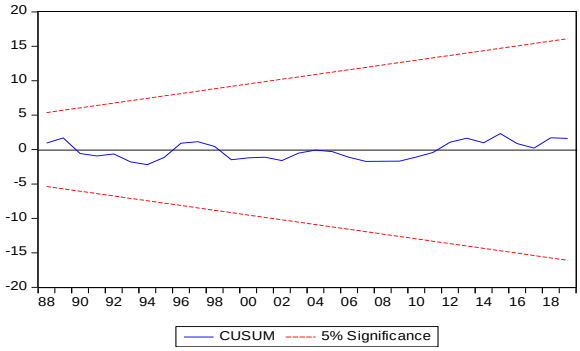
Table 4 presents the post-estimation diagnostic checks. The estimated model shows that there is no problem Heteroskedasticity, serial correlation and the errors are normally distributed. Furthermore, the study applies CUSUM and CUSUM square to know the stability of the model. Figure 1 and 2 present the CUSUM and CUSUM square, the figures show that the model is stable as CUSUM and CUSUM square lines are not outside the 5 percent critical line.

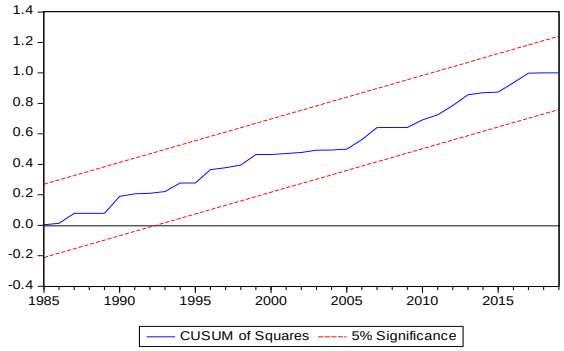
Table 4 Diagnostic Test

Test Statistics	F Version
A. Serial Correlation	F(1,31) = 0.156 (0.694)
B. Functional form	F(1,31) = 1.062 (0.310)
C. Normality	0.825 (0.661)
D. Heteroskedasticity	F(5, 32) = 0.479 (0.788)

Note: P value are given in ()

Source: Authors computation using Eviews 9.





5. Conclusions

The paper investigated energy consumption, environmental pollution and economic growth in Nigeria by employing ARDL bound testing method. The results of the bound test indicate that there exists a co-integration between the variables. The long-run estimates show that energy consumption and school enrollment are positively related with environmental pollution, while GDP reduce environmental pollution. The short-run analysis also indicates that a rise in energy consumption is related with higher environmental pollution.

The implication of the results obtained in this study is that since energy consumption is linked to concentration of CO2 emissions in Nigeria, especially the fossil fuel energy consumption, the policymakers should consider low emissions technology in order to lessen (CO2 emissions) damaging effect. The result also signifies the need for using other forms of energy such as wind and solar energy to realize a clean and better environment. The positive association found between energy consumption and CO2 emissions is consistent with the conclusion of previous studies (Omri, 2014; Salahuddin and Gow, 2014). Finally, there is a need for future studies to consider other factors that may influence environmental quality.

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