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Environmental Pollution, Economic Growth and Institutional Quality: Exploring the Nexus in Nigeria[1]

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Abstract

The interaction between environmental pollution and economic growth determines the achievement of the green growth objective of developing economies. An economy turns around the inverted U-shaped Environmental Kuznets Curve (EKC) when pollution is effectively dampened by social, political and economic factors as such economy grows. Thus, this study examines the EKC considering the impact of institutional quality on six variables of environmental pollution [carbon dioxide (CO_2), Nitrous Oxide (N_2O), Suspended Particulate Maters (SPM), Rainfall, Temperature and Total Green House Emission (TGH)] using the case of Nigeria. The EKC model includes population density, education expenditure, foreign direct investment, and gross domestic investment as control variables, and it was analysed using the Auto Regressive Distribution Lag (ARDL) econometric technique, which has not been applied in the literature on Nigeria. The results, *inter alia*, indicate that there is EKC for CO_2 and SPM. This implies that the green growth objective can be pursued in Nigeria with concerted efforts. Other environmental pollution indicators did not exert significant influence on economic growth. Therefore, it is recommended that Nigeria's institutional quality be strengthened to limit environmental pollution in light of economic growth.

Key Words: EKC, Economic Growth, Environmental Pollution, Institutional Quality

JEL Classification: C52; O38; O40; O55; P37

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1. Introduction

Due to the extensive attention of researchers on the impact of environmental pollution and climate change on the global economy, achieving sustainable economic development has become a primary goal for most developing countries like Nigeria. The country was once adjured as one of the fast-growing economies in the world and the largest economy in Africa (World Bank, 2015) before it plunged into recession in 2016 (Ministry of Budget and National Planning, 2017). However, this growth has not been without an inverse impact on environmental quality. Table 1(in the Appendix) shows that for four decades-1971-1980, 1981-1990, 1991-2000 and 2001-2010- the measures of environmental pollution (Carbon dioxide emission (CO_2), deforestation, consumption of oil and population) increased with per capita gross domestic products(GDP).Meanwhile, measures to check pollution, such as regulation, environmental training and institutional governance needed to ensure that firms and households are proactive and work towards sustainable environmental quality (Singh et al., 2019), has declined.

In addition, data obtained from the Nigeria Meteorological Agency-NIMET (2012) show that the average annual mean rainfall and temperature in Nigeria had varied. This indicates that Nigeria's weather condition did not show a consistent pattern with the economic activities during the decades. Considering the economic activities, basically, agriculture, manufacturing and services sectors, the most polluting sector are those of agriculture and manufacturing. Economic growth has been on consistent increase in these sectors in the last four decades. Available statistics from the Central Bank of Nigeria (CBN) indicates that the average agriculture and manufacturing income per capita grew faster than the average per capita income of services in the four decades (CBN, 2013).Likewise, environmental challenges and climate change variables showed a proportionate growth. Hence, it implies that the increase in population and enhanced economic activities might have contributed to the fast degrading environment due to the dirty growth syndrome, weak environmental regulations and lack of abatement measures in Nigeria. This is worth exploring in an empirical study such as this present one.

Studies including Omojolaibi (2010), Akpan & Chuku (2011), and Alege and Ogundipe (2013) found significant relationship between carbon dioxide emission and economic growth in Nigeria. However, these studies on Nigeria did not investigate other environmental pollution factors such as local pollutants. That is, major emphasis has been on global pollutant such as carbon dioxide emission. Meanwhile, point pollutants such as suspended particulate matters, temperature and rainfall changes affect the quality of environment and their impacts are easily noticeable on the economy of a country (Panayotou 1997). Previous studies on Nigeria are yet to employ the Autoregressive Distributed Lag (ARDL) to estimate the Environmental Kuznets Curve (EKC) model for Nigeria and they did not determine Nigeria's capacity towards achieving a feasible turning point. The objective of this study, therefore, is to investigate the relationship that the selected variables of environmental quality (carbon dioxide, nitrous oxide, total greenhouse emission, suspended particulate matter, temperature, and rainfall) have with Institutional quality and variables of economic growth in Nigeria between 1970 and 2014.It contributes by employing ARDL to examine the role of institutional quality in bringing about feasible turning point on the EKC considering carbon dioxide emission, nitrous oxide and suspended particulate matters.

The rest of the paper is divided into four sections. Following this introduction is a brief review of relevant literature in section 2. Section 3 describes the methodology and empirical analysis, while the presentation and discussion of results are contained in section 4. Thereafter, the paper is concluded in section 5 with some recommendations.

2. Brief Review of Related Literature

Environmental Kuznets Curve (EKC) has become a leading theory for explaining the relationship between economic growth and environmental pollution (Egbetokun, Osabuohien & Akinbobola, 2018). The theory states that at the initial level of growth, rising income leads to increase in environmental pollution but as income continues to increase a threshold will be attained when rising income will bring about decrease in the environmental pollution. This depicts an inverted U-shaped curve implying that the economy is growing out of pollution. The EKC relationship depends upon a number of different interrelated factors, which includes; the size of the economy, the composition of production and consumption, the vintage of the technology, the density of economic activity, income inequalities, forms of energy use, preferences towards environmental quality, and the effectiveness of regulations among others (Rothman & Sander, 1998; Galeotic, 1999).

Panayotou (1995) argued that the downturn of the EKC as income increases might be delayed or speedy, weakened or strengthened by policy intervention. Implying that, a higher income per se does not bring about the environmental improvement but the supply response and policy responsiveness to the growing demands for environmental quality through the enactment of environmental legislations and development. Panayotou (1995) also observed that it may take decades for a low-income country to cross from upward to the downward sloping part of the curve and the accumulated damage in the meantime may far exceed the present value of higher future growth. Therefore, active environmental policies are germane to mitigate emissions and resources depletion in the early stages of development.

Grossman and Krueger (1991) modelled the relationship between environmental quality and economic growth by developing a cross-country panel of comparable measures of air pollution in various urban areas. Data was obtained from UN agencies and Global Environmental Monitoring System (GEMS). The study used sulphur-dioxide, smoke and suspended particulates as proxy for environmental quality in the selected countries, including developing and developed countries. After adjusting for the effect of geographic characteristics of different countries, time trend effects in the level of pollution, location and types of environmental quality examined, the authors found that as income increases from low levels, quantities of sulphur dioxide, suspended particulate matters and smoke increase initially and then decrease as the economy reaches a certain level of income. This confirms the presence of traditional EKC for the pollutants.

To explore the EKC phenomenon further, Hettige, Lucas and Wheeler (1992) developed a production toxic intensity index for 37 manufacturing sectors in 80 countries over the period between 1960 and 1988. The toxic intensity was used as the proxy for environmental quality in their model. The panel result indicates the existence of an EKC relationship for toxic intensity per unit of GDP. However, the EKC evidence did not suggest toxic intensity per unit of manufacturing output. Holding the mix of manufacturing constant, Hettige, Lucas and Wheeler (1992) found that manufacturing which is a part of GDP, did not become cleaner or dirtier as income changed but became smaller relative to services and trade in developing economies. The finding implied that higher income leads to a demand for a cleaner environment regardless of whether the environment has been damaged by a toxic-intense manufacturing sector. Also, the authors found that the pattern of EKC for the 1960's was quite different from that of the later decades when toxic intensity in manufacturing in less-developed countries grew most quickly.

To investigate whether GDP and FDI has an impact carbon dioxide emission in Nigeria, Omisakin (2009) used Ordinary Least Squares (OLS) estimation method, co-integration tests, and Granger Causality test. The presence of U-shaped and not inverted U-shape of the EKC was observed for Nigeria between 1970 and 2005. Carrying out a cross-country study, Omojolaibi (2010) tested the EKC between carbon dioxide emission and GDP for Ghana, Nigeria, and Sierra Leone over the period of 1970 and 2006. The pooled OLS results from the study aligned with the EKC while they were at variance with the applicability of the EKC in the countries under study. The fixed effects and pooled effects regression results revealed that higher per capita income, leads to higher CO_2 emission in all the countries. However, individual country effect does not conform to the EKC hypothesis, which is evident in the non-significance of the coefficient for GDP per capita.

Furthermore, testing the same EKC hypothesis for Nigeria alone in the presence of financial development and energy consumption for the period between 1980 and 2008 using OLS, Ajide and Oyinlola (2010) observed that growth rate of per capita GDP plays no significant role in the dynamics of per capita carbon dioxide emission. Financial development, however, was found to be of a significant influence on carbon dioxide emission in Nigeria. The authors assert that no relationship exists between economic growth and carbon dioxide given the signs and significance of the coefficient of per capita growth and its square and there is non-existence of the inverted U-shaped EKC in Nigeria. Their findings contradict that of Omisakin (2009), which shows that economic growth (measured by per capita GDP) is significant but EKC is non-existent in Nigeria.

With a wider study period of 49 years (1960-2008) and using the OLS, Error Correction Model (ECM), and the ARDL approach to co-integration, Akpan and Chuku (2011) support Omisakin (2009) that economic growth has a significant relationship with environmental pollution (carbon dioxide emission). Akpan and Chuku (2011) confirm this for both the short-run and the long-run without any strong evidence that emission will decline in the long-run as growth intensified in Nigeria. Their findings also indicated an N-shaped relationship between income and environment thereby disapproving the EKC's inverted U-shape relationship. Using gas flaring (instead of carbon dioxide) in the Niger Delta region of Nigeria, Kingston (2011) investigated the causal relationship between mineral exploration, economic growth, and environmental pollution. The result of the OLS estimation shows that the impact of oil and natural gas exploration on growth in Nigeria is persistent in the long-run. It was also found that gas flaring (environmental pollution), economic growth, and FDI are statistically linked in Nigeria.

Unlike earlier reviewed studies, Alege and Ogundipe (2013) introduced the role of institutional quality and population density in the study of environmental quality and employed the fractional co-integration analysis. Carbon dioxide emission was used as the endogenous variable in their environmental–economic model. They found a positive linear relationship between GDP and carbon dioxide emission and not the EKC. Alege and Ogundipe (2013)'s results also show a positive relationship between FDI, trade openness and carbon dioxide emission. This is in agreement with Ajide and Oyinlola (2010), Akpan and Chuku (2011) and Kingston (2011).Posu (2014) used dynamic ordinary least square, error correction model, parsimonious model and Vector Error Correction Model (VECM) to study the dynamic interactions among economic liberalization, economic growth and environmental quality in Nigeria. The study did not validate the Pollution Haven Hypothesis (PHH) and the EKC in Nigeria. Rather, like Akpan and Chuku (2011), it found the N-shape relationship between income and the environment. Furthermore, the study found bi-directional causality running among most of the variables. In addition, the use of the VECM by Posu (2014) produces the same result of non-existence traditional U-shape EKC in Nigeria.

Ali, Abdullah, and Azam (2017), in an attempt to investigate the EKC in the context of Malaysia, employed ARDL bound test to investigate the long-run relationship between GDP per capita, financial development, trade openness, foreign direct investment and energy consumption on CO_2 emissions. The findings of the study indicated the presence of EKC hypothesis for Malaysia as the variables revealed negative sign and had significant impact on CO_2 emissions. Similarly, Pata (2018), carried out an empirical research on the renewable energy consumption, urbanisation, financial development, income and CO_2 Emissions in Turkey in an attempt to validate the EKC hypothesis and the findings proved EKC valid. This is similar to a more recent study by Akinyemi, Efobi, Asongu and Osabuohien (2019) where the authors emphasised the conditional role that financial development and institutional framework play for harnessing the potentials of renewable energy for economic outcomes in SSA countries.

The study carried out by Lin, Omoju, Nwakeze, Okonkwo and Megbowon (2016), concluded that there was lack of evidence in Africa for the EKC hypothesis after carrying out an empirical analysis on the relationship between economic development and environmental sustainability for five African countries. The countries being Kenya, Nigeria, Egypt, South Africa and DR Congo (each country representing the regions of Africa), the study employed the STIRPAT framework. The findings showed no significant effects of GDP on CO_2 emissions. This was confirmed by Sarkodie andStrezov (2018), as EKC hypothesis was not validated for Ghana in the research carried out to examine the Environmental Kuznets and Environmental Sustainability curve hypothesis for Australia, China, Ghana and the USA. This is attributed to the fact that developing countries like Ghana and in the African continent have not experienced a fully industrialised economy as the economies are still driven by the agricultural sector compared to other sectors of the economy. Still on the case of Ghana, Patnaik, Temouri, Tuffour, Tarba and Singh (2017) in appraising the need for environmental friendly activities, examined how good corporate social responsibility practices by mining companies can create a cordial relationship with their host communities.

Al-Mulali, Ozturk andSolarin (2016), investigating the EKC hypothesis in seven regions, Central and Eastern Europe, Western Europe, East Asia and the Pacific, South Asia, the Americas, Middles East and North and Sub-Saharan Africa used Pedroni and Fisher cointegration tests and Dynamic Ordinary Least Square (DOLS). The study confirmed the EKC hypothesis in five of the regions except North and Sub-Saharan Africa and Middles East. Twerefou, Adusah-Poku and Bekoe (2016) using the ARDL approach, confirmed that the invalidity of EKC hypothesis in Ghana as a U-shaped relationship existed between per capita and CO_2 emissions.

Conducting a dynamic panel data estimation on selected African countries (Nigeria included), Osabuohien, Efobi and Gitau (2014, 2015) tested and observed the presence of the EKC. Egbetokun and Ogundipe (2016) later confirmed this for good institutions and not for weak institutions in Africa. MdRafayet, Alam, Erick and Bizuayeku (2017) as well as Itochoko and Pierra (2017) employed the Generalised Method of Moment (GMM) method to analyse environmental degradation, institution and economic growth. The results found the existence of inverted U-shaped EKC for Sub-Saharan Africa (SSA) and West Africa, respectively.

Hence, to clarify the contradictory findings in the literature on Nigeria, this study re-examines the EKC hypothesis for Nigeria by considering different measures of environmental quality (carbon dioxide, nitrous oxide, total greenhouse emission, suspended particulate matter, temperature, and rainfall) and whether institutional quality plays a significant role at ensuring environmental quality. The re-test is done by applying a more developed econometric method, like Autoregressive Distributed Lag (ARDL). This study fills this observed knowledge gap. The estimated results of the ARDL have the advantage of being reliable when the considered variables are not of equal order of integration. The method is also capable of handling relatively small sample size in the present study. Furthermore, the ARDL method can be used even when some of the explanatory variables are endogenous and it also allows for the estimation of long–run and short–run parameters of the variables under the same framework.

3. METHODOLOGY

3.1 Model Specification

This study adopts the standard EKC model following the pioneer studies of Grossman and Krueger (1991) and subsequently adopted by Alege and Ogundipe (2013) and Osabuohien *et al.* (2014). The EKC model captures the Environmental Kuznets Effect using six environmental variables (carbon dioxide, nitrous oxide, total greenhouse emission, suspended particulate matter, Temperature, and Rainfall).

The specification in equation 3.1 assumes environmental pollution (*ENV*) as a function of income (Y_t) and the squared of income (Y_t^2). Income is used to capture the nature of the pollution-income relationship at the initial stage of development while the squared of income tests for the validity of the EKC by illustrating whether a turning point had occurred or not. X_t and ε_t are other exogenous variables and the disturbance stochastic term, respectively. β_0, β_1, β_2, and β_x are the coefficients.

$$ENV_t = \beta_0 + \beta_1 Y_t + \beta_2 Y_t^2 + \beta_x X_t + \varepsilon_t \quad . \quad . \quad . \qquad 3.1$$

Adding other exogenous variables of the study to equation 3.1 and applying the natural log to variables that are not rates or in the index form, we have

$$lnENV_t = \beta_0 + \beta_1 lnY_t + \beta_2 lnY_t^2 + \beta_3 POPD_t + \beta_4 REGU_t + \beta_5 lnGDI_t + \beta_6 lnEDU_t + \beta_7 lnFDI_t + \varepsilon_t \quad . \quad . \quad . \qquad 3.2$$

ENV_t represents the six selected environmental pollution indicators- carbon dioxide (CO_2), nitrous oxide (NO_2), total greenhouse emission (TGH), suspended particulate matter (SPM1 and SPM2.5), Temperature (TEMP), and Rainfall (RAIN). Y and Y^2 are as defined before and they are measured as gross domestic products (GDP) per capita. Other variables are defined as follows, *POPD*: population density, *REGU*: regulation index represents the role of institution, *GDI*: gross domestic investment, *EDU*: education expenditure, and *FDI*: foreign direct investment. The six different pollution indicators for ENV_t were modelled separately to disaggregate and capture the effects of the independent variables. Moreover, carbon dioxide, nitrous oxide and other greenhouse gases have different global warming potentials. Data on the variables were obtained from the World Bank's World Development Indicators, except for CO_2 which was obtained from the Global Carbon Atlas (source is the Carbon Dioxide Information Analysis Centre (CDIAC)), education expenditure and gross domestic investment (also called gross capital formation) are from the Central Bank of Nigeria, and rainfall and temperature is from the World Bank's Climate Change Knowledge Portal.

Following Wen and Cao (2009); and Ogundipe *et al.,* (2013), the theoretical interpretation of the sign and relationship of the parameters are shown as follow:

1. $\beta_1 > 0, \beta_2 = 0$, it indicates linear shape and monotonically increasing function. As income rises, environmental pressure is increasing.
2. $\beta_1 < 0, \beta_2 = 0$, it indicates linear shape and monotonically decreasing function. As income rises, environmental pressure is decreasing.
3. $\beta_1 > 0, \beta_2 < 0$, it indicates inverted U-shape of the EKC. As income reaches a threshold, environmental pressure decreases as income rises.
4. $\beta_1 < 0, \beta_2 > 0$, it indicates U-shape. Environmental pressure falls with falling income and increasing when income is rising.

The necessary decision regarding the objective of the study is to be ascertained using the sign and the magnitude of β_1 and β_2 respectively. The estimated turning points would be computed using this formula $e^{-\beta_1/2\beta_2}$and compared with the descriptive statistics for GDP per capita.

3.3 Technique of Estimation

To estimate the parameters of the models, the econometric methodology employed is the Autoregressive Distributed Lag (ARDL) approach to co-integration and error correction models. This method was postulated by Pesaran, Shin, and Smith (2001) as a superior alternative to Johansen and Juselius (1990) multivariable co-integration test.

The ARDL framework for this work is formulated from equation 3.2 as follows:

$$\Delta lnENV_t = \delta_0 + \pi_1 lnY_{t-1} + \pi_2 lnY_{t-1}^2 + \pi_3 POPD_{t-1} + \pi_4 INST_{t-1} + \pi_5 lnGDI_{t-1} + \pi_6 lnEDU_{t-i} + \pi_7 lnFDI_{t-1} + \sum_{t-i}^{p} \partial_1 \Delta lnENV_{t-i} + \sum_{i=0}^{p} \alpha_1 \Delta lnY_{t-i} + \sum_{t=0}^{p} \alpha_2 \Delta lnY_{t-i}^2 + \sum_{t=0}^{p} \alpha_3 \Delta POPD_{t-i} + \sum_{t=0}^{p} \alpha_4 \Delta INST_{t-i} + \sum_{t=0}^{p} \alpha_5 \Delta lnGDI_{t-i} + \sum_{t=0}^{p} \alpha_6 \Delta lnEDU_{t-i} + \sum_{t=0}^{p} \alpha_6 \Delta lnFDI_{t-i} + \varepsilon_{2t} \quad . \quad . \quad . \qquad 3.3$$

The variables are as previously defined in section 3.2. δ_0 is the drift component and Δ is the first difference operator. The π_1-$\pi_7$denotes the long-run multipliers while the term with summation signs are used to model the short-run dynamic structure. P denotes the lag length while ε_{2t} is the white noise disturbance term.

A bound test for co-integration will be based on F-test restrictions of the joint significance of the estimated coefficient of the lagged level variables in the equations. Since the asymptotic distributions of the F–statistics is non-standard, Pesaran, Shin and Smith (2001) provided two sets of adjusted critical values that provide the lower and upper bounds used for inference. While the first set of critical value assumes that variables are I(0), the other assumes they are I(1). Cointegration exists and so there is an evidence of a long-run relationship if the computed F-statistics exceeds the upper bound critical value. However, the hypothesis is of no cointegration if the F-statistic is below the lower bound.The result will be considered inconclusive for a value within bounds. The Akaike Information Criterion (AIC) will be used to determine the optima lag length for the ADRL model. The autoregressive conditional heteroscedasticity (ARCH) langrage multiplier (LM) is the diagnostic test applied to examine the specified models.

4. Results and Discussions

The analysis is in two parts: the descriptive and the econometric analysis.

4.1 Descriptive Statistics

The descriptive statistics results are presented in Table 4.1.

Table 4.1: Result of Descriptive Analysis

	CO_2	NO_2	RAIN	SPM1	SPM2.5	TEMP	TGH
Mean	0.637	20484.4	92.86	17.97	0.234	27.08	204219.0
Median	0.646	19488.0	93.71	17.41	0.250	27.07	171312.8
Maximum	1.007	46431.0	109.31	30.68	0.297	27.85	374421.7
Minimum	0.307	11576.0	73.01	2.833	0.079	26.22	74939.7
Std. Dev.	0.184	8232.1	7.263	7.644	0.056	0.404	87146.3
	POPD	GDI	REGU	EDU	FDI	GDP	
Mean	121.6	9.31E+09	5.902	76462.3	2.15E+09	1729.31	
Median	114.7	1.74E+09	5.340	8132.6	1.07E+09	1724.11	
Maximum	209.6	8.98E+10	8.571	394900.0	8.84E+09	2562.52	
Minimum	61.63	2.99E+08	4.800	3.940	1.89E+08	1147.07	
Std. Dev.	43.59	2.22E+10	1.114	124436.7	2.52E+09	436.75	

Source: The Authors' Computation

4.2 Econometric Results

The time series properties were examined using Augmented Dickey Fuller (ADF) and Philip-Perron to determine the order of integration of each variable. Table 4.2 shows the results of unit root tests. The results show that while rainfall (RAIN)is stationary at level, other variables (except population density) are stationary at the first difference. Population density is stationary at first difference under Philip-Perron unit root test but stationary at second difference under Augmented Dickey Fuller unit root test. By these results, we assume that the condition for the application of the ARDL technique is satisfied.

Table 4.2: Results of Unit Root Tests

Variables	ADF	P-value	Remarks	Philip-Perron	P-value	Remarks
CO_2	-7.601	0.0000	I(1)	-7.847	0.0000	I(1)
NO_2	-6.621	0.0000	I(1)	-6.181	0.0000	I(1)
RAIN	-5.696	0.0000	I(0)	-5.763	0.0000	I(0)
SPM1	-7.147	0.0000	I(1)	-7.147	0.0000	I(1)
SPM2.5	-5.412	0.0001	I(1)	-5.502	0.0000	I(1)
TEMP	-9.619	0.0000	I(1)	-3.073	0.0357	I(0)
TGH	-7.960	0.0000	I(1)	-8.046	0.0000	I(1)
POPD	-6.271	0.0000	I(2)	-3.435	0.0592	I(1)
GDI	-4.235	0.0001	I(1)	-5.378	0.0000	I(1)
REGU	-10.501	0.0000	I(1)	-10.531	0.0000	I(1)
EDU	-3.956	0.0002	I(1)	-5.733	0.0000	I(1)
FDI	-8.662	0.0000	I(1)	-8.355	0.0000	I(1)
GDP	-5.955	0.0000	I(1)	-6.072	0.0000	I(1)

Note: I(1)- the stationarity of the variables is at first difference. I(0)- the stationarity of the variables is at level.

Source: The Authors' computation

The ARDL bond tests in Table 4.3 show that the F- statistics is greater than the Pesaran critical value at 10% lower bound (1.92) and upper bound (2.89).We may reject the null hypothesis that there is no long-run relationship between environmental pollution and the explanatory variables. This implies that, in the long-run, the factors identified affect environmental pollution.

Table 4.3 displays the short-run and long-run coefficients of the variables in the model. Based on the EKC model specified, our focus is on the long-run coefficients. Economic growth has a long-run effect on carbon dioxide emissions, suspended particulate matter 1 and 2.5. Furthermore, economic growth has no significant effect on other indicators of environmental pollution. The turning point was calculated to be $1792.38 for carbon dioxide, $1472.76 and $1449.39 for suspended particulate matter 1 and 2.5, respectively. These points are within the range of Nigeria's GDP per capita. These results contradict earlier studies like Ajide and Oyinlola (2010) and Alege and Ogundipe (2013) and support recent studies like Osabuohien, Efobi and Gitau (2014, 2015), Egbetokun and Ogundipe (2016), MdRafayet, Alam, Erick and Bizuayeku (2017), Itochoko and Pierra (2017), and Pata (2018).

Nigeria's population has been rated as one of the fastest-growing in the world (UN DESA, 2017).The results reveal that population density has a significant negative relationship with suspended particulate matter 1 and 2.5, in the long run. This implies that suspended particulate matter 1 and 2.5 reduces as the population increases. This can be attributed to the situation of Nigeria in the tropics where burning of firewood to keep warm is not needed and there is the increasing use of gas cooking stoves in the cities. With education expenditure on the increase in Nigeria in the past four decades, there has been a significant pollution reduction in carbon dioxide and temperature but a significant increase in suspended particulate matter 1. This may imply an increased expenditure in climate change awareness but not specifically on local pollution.

Table 4.3: ARDL Results

Variables	CO_2	NO_2	RAIN	SPM1	SPM2.5	TEMP	TGH
Short-run coefficients							
D(lnGDP)	39.37*** (12.09)	-2.717 (7.820)	11.18 (7.571)	43.36*** (9.940)	29.19*** (9.413)	-0.868 (0.983)	-15.15 (10.89)
D(lnGDP(-1))	-1.335*** (0.268)	----	----	-43.06*** (13.09)	----	----	----
D($\ln GDP^2$)	-2.623*** (0.820)	0.164 (0.531)	-0.745 (0.513)	-2.978*** (0.675)	2.022*** (0.640)	0.057 (0.066)	1.071 (0.741)
D($\ln GDP^2$(-1))	----	----	----	2.910*** (0.888)	----	----	----
D(POPD)	0.209*** (0.070)	-0.002 (0.004)	0.114*** (0.017)	-0.005 (0.348)	0.930*** (0.139)	0.013*** (0.002)	-1.017** (0.376)
D(POPD(-1))	0.368*** (0.085)	----	----	1.532*** (0.468)	----	----	1.446*** (0.415)
D(lnEDU)	-0.038* (0.021)	0.002 (0.014)	0.007 (0.013)	0.062*** (0.019)	0.014 (0.016)	-0.002 (0.001)	0.009 (0.019)
D(EDU(-1))	0.048* (0.023)	----	----	----	----	----	----
D(lnGDI)	-0.071* (0.039)	0.038 (0.035)	-0.056** (0.023)	-0.000 (0.044)	0.039 (0.042)	0.002 (0.003)	-0.173*** (0.049)
D(lnGDI(-1))	0.113* (0.035)	-0.098*** (0.030)	----	----	----	----	0.147*** (0.043)
D(lnFDI)	-0.107** (0.038)	0.073*** (0.022)	-0.004 (0.021)	-0.001 (0.025)	0.041* (0.024)	-0.004 (0.003)	-0.059** (0.028)
D(lnFDI(-1))	0.219*** (0.044)	----	----	----	----	----	----
D(REGU)	-0.098 (0.089)	-0.006 (0.067)	-0.016 (0.052)	-0.288*** (0.083)	-0.113 (0.077)	0.007 (0.007)	0.052 (0.089)
D(REGU(-1))	-0.299* (0.101)	----	----	----	----	----	----
CointEq(-1)	-0.727*** (0.065)	-0.619*** (0.096)	-1.017*** (0.149)	-0.998*** (0.129)	-0.576*** (0.086)	-1.081*** (0.150)	-0.726*** (0.115)
Long-run Coefficients							
lnGDP	86.12*** (18.15)	3.840 (11.40)	-4.285 (6.683)	123.4*** (14.88)	97.29*** (18.25)	0.695 (0.841)	3.694 (18.44)
$\ln GDP^2$	-5.748*** (1.218)	-0.294 (0.769)	0.296 (0.451)	-8.458*** (1.007)	-6.683*** (1.236)	-0.048 (0.056)	-0.237 (1.248)
POPD	0.012 (0.010)	-0.004 (0.005)	-0.002 (0.002)	-0.017** (0.007)	-0.034*** (0.011)	0.000 (0.000)	-0.011 (0.010)
lnEDU	-0.158** (0.063)	0.013 (0.026)	0.007 (0.015)	0.072** (0.028)	0.015 (0.043)	-0.004** (0.002)	0.019 (0.045)
lnGDI	-0.154* (0.078)	0.142*** (0.043)	-0.038* (0.020)	0.158*** (0.038)	0.112* (0.060)	0.001 (0.002)	-0.243*** (0.069)
lnFDI	-0.680*** (0.145)	0.194** (0.072)	-0.002 (0.029)	-0.057 (0.062)	0.052 (0.065)	-0.001 (0.003)	-0.105 (0.065)
REGU	0.065 (0.203)	0.301** (0.146)	0.005 (0.055)	-0.310*** (0.109)	-0.161 (0.149)	0.005 (0.007)	0.329* (0.177)
C	-308.1*** (66.56)	-10.70 (42.20)	20.74 (24.81)	-450.9*** (54.95)	-358.8*** (67.27)	0.762 (3.114)	2.779 (68.29)
Turning Point	$1792.38	----	----	$1472.76	$1449.39	----	----
Adjusted R^2	0.93	0.96	0.33	0.98	0.93	0.64	0.96
D-W statistic	2.26	1.72	1.88	2.46	2.28	2.09	2.13
ARCH LM Test	0.054 [0.8159]	0.008 [0.9278]	1.171 [0.2852]	0.519 [0.4756]	1.418 [0.2557]	0.226 [0.6366]	2.588 [0.0890]
Bounds Test F – statistic	7.705	4.380	4.949	3.381	4.299	5.017	3.019
Critical Value Bounds		10%	5%	2.5%	1%		
I0		1.92	2.17	2.43	2.73		
I1		2.89	3.21	3.51	3.9		

Note: ***, ** and * represent 1%, 5% and 10% levels of significance, respectively. Standard error is in parenthesis () while probability value is in parenthesis [].

Source: The Authors' computation

The future productive capacity of Nigeria (gross domestic investment also called gross capital formation) does not significantly increase temperature instead it significantly reduces the level of carbon dioxide emissions, rainfall and total greenhouse gases. It, however, contributes to nitrous oxide, suspended particulate matter1 and 2.5.This implies that Nigeria's future production capacity contributes to pollution and reduces rainfall. The reduction in the level of rainfall could adversely affect the agricultural sector, which is still the largest employer of labour in Nigeria. The reduction in carbon dioxide emissions and total greenhouse gases in Nigeria indicates that gross domestic investment contributes to better air and ambient quality. As such, there are opportunities to create and/or attract more investments in environmentally cleaner technologies using fiscal incentives, instruments and tax holidays. The negative effects of education expenditure and foreign direct investment on carbon dioxide emissions support this finding, as carbon dioxide is a component of and the most concentrated greenhouse gas in the atmosphere. These effects that reduce carbon dioxide emissions are contradicted by the positive effect of gross domestic investment and foreign direct investment on nitrous oxide (another component of greenhouse gases).

The negative relationship between foreign direct investment and carbon dioxide emissions negates the popular notion that the major proportion of foreign direct investment in Nigeria goes to oil exploration as posited in Alege and Ogundipe (2013). This finding reemphasises the results obtained in Ajide and Oyinlola (2010).The positive relationship between foreign direct investment and nitrous oxide emissions indicate that foreign direct investment has not supported green agriculture in Nigeria. The above is in line with the submission made by El-Kassar and Singh (2017) with respect for business activities be more environmentally friendly (i.e. green) through the adoption of green innovations and technologies; as well as the development of green supply chain processes through requisite capabilities (Singh &El-Kassar, 2018). This is essential as regulation in Nigeria (i.e. institutional quality) is can check only suspended particulate matter 1 and 2.5 but not effective enough to limit nitrous oxide and total greenhouse gases. Rather, nitrous oxide and total greenhouse gases emissions are increasing while regulation has no significant effect on other environmental indicators. It will be interesting to know the factors responsible for this ineffective regulation in further studies.

Theoretically, the implication of the findings in this study is that the EKC does not hold for all the measures of environmental quality and economic growth is not the only factor that can increase or limit environmental pollution. Practically, Nigeria's increasing population still consumes a reasonable level of carbon resources; the reducing level of rainfall in Nigeria may affect the productivity of agriculture sector and raw materials supplies to manufacturing sector and exports; and Nigeria's institutional arrangements are not effective enough to reduce environmental pollution, except for suspended particulate matter 1.

5. Conclusion

This study was carried out to examine the relationship among the various variables of environmental pollution, institutional quality measured by regulation index and economic growth in Nigeria within the period 1970 and 2017. The ARDL results show that Nigeria has been making efforts to grow green by curbing global pollutants (carbon dioxide emissions) and local pollutants (suspended particulate matter 1 and 2.5) as the EKC was found for them. Although Nigeria has experienced the EKC under carbon dioxide, increases in the population per unit area of Nigeria leads to an insignificant increase and not decrease in carbon dioxide emissions. This implies that Nigeria's increasing population still consumes a reasonable level of carbon resources. Evidence that connotes increasing education awareness on climate change and global warming but not for local pollution was observed. The negative effect of the future production capacity on the level of rainfall may have an implication on the agriculture sector being the highest employer of labour in the country. It may also reduce the supplies of raw materials to the manufacturing sector and export earnings from the export of agricultural produce in Nigeria. This deduction may be escalated by the increasing emissions of nitrous oxide resulting from gross domestic investment, foreign direct investment, and weak or ineffective regulation. The ineffective regulation (i.e. institutional arrangement) has been unable to generally curtail environmental degradation indicators, except for suspended particulate matter one.

This study hereby recommends the following: First, the government of Nigeria should enforce stricter environmental regulations in the main polluting sectors, as well as, periodic environmental impact assessment aimed at erring firms or organisations and they should also bear the full cost of environmental clean-up. Human capacity should be developed in the relevant ministries, departments and agencies for this purpose. Furthermore, policies to regulate the use of improved technologies that reduce the level of emission in production and discharge of wastes should be enforced in the extractive industries. In addition, the study recommends an evenly spatial population distribution through direct government intervention towards creating low carbon communities and cities. Although the study found that with carbon dioxide and suspended particulate matter one and 2.5, the country can achieve the turning point on the EKC, due to its increasing population, there is still need for Nigeria to take responsibility to reduce emissions below the levels they are currently. In this regard, it is recommended that policies be implemented to check the quality of used vehicles and machines, bush burning, grazing, use of fertilisers, and extractive activities.

It is needful to consciously inculcate environmental improvement standards and good health habits through the basic schooling curriculum in Nigeria. This stems from the country's struggles to generate and distribute adequate electric power that has made individuals to embark on private electricity generation. Consequently, leading to uncontrollable use of poor grade generators which may have contributed to suspended particulate matter 1 and 2.5 and impair human health. In addition to the use of a basic schooling curriculum, Nigerian regulatory agencies should embark on public orientation, advertisement and campaigns towards environmental improvement awareness and to motivate the citizenry with a sense of responsibility about all environmental challenges.

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Appendix

Table 1: Trend of Environmental Pollution and Economic Indices (1971-2010)

Variables	Periods			
	1971 – 1980	1981 – 1990	1991 – 2000	2001 – 2010
GDP in dollars (constant US dollars 2010)	1,911.7	1,389	1,277.3	1,840.9
CO_2 metric ton per capita	0.83	0.76	0.45	0.66
Population density per square kilometre	68	83	116	147
Institution (ECOF Scores)	3.84	3.81	3.83	4.35
Forest area in square metres	3.0	2.8	1.7	1.0
Per capita consumption of electricity in watts	0.000738	0.00118	0.000983	0.001
Consumption of oil in kg per capita	667.0	731.85	736.27	746.05

Source: Authors' Compilation.