ECONOMIC GROWTH AND ENVIRONMENTAL SUSTAINABILITY: ASSESSING THE VALIDITY OF THE ENVIRONMENTAL KUZNETS CURVE IN NIGERIA

MUSA ILIAS BIALA*
Kwara State University, Malete, Nigeria
**Corresponding author: musa.biala@kwasu.edu.ng; 08060884444*

TITUS ADEGOKE ADENIYI
Kwara State University, Malete, Nigeria
titusade1@gmail.com; 08074153699

ABSTRACT
The environmental Kuznets curve (EKC) hypothesis explores the relationship between economic growth and environmental quality, suggesting that environmental degradation initially worsens with economic growth but improves after reaching a specific income threshold. While evidence supporting the EKC exists for some pollutants and countries, results remain mixed for Nigeria. This study therefore reexamines the EKC hypothesis for Nigeria, focusing on key environmental degradation indicators: CO_2 emissions, fossil fuel consumption, resource depletion, and erosion. Specifically, it investigates whether an EKC relationship exists between these indicators and GDP growth. The study also determine Nigeria's growth threshold, above which economic growth benefits the environment. Using time-series data from 1981 to 2023 sourced from the World Bank's World Development Indicators, the study employed threshold regression analysis to evaluate the validity of EKC hypothesis. The results reveal mixed alignment with the EKC hypothesis. While some indicators of environmental degradation validate the EKC hypothesis, others refute it. This study, therefore, concludes that economic growth impacts only some aspects or components of environmental degradation. Accordingly, policy measures such as adoption of green technologies, promotion of renewable energy, and enforcement of stricter environmental regulations are recommended in order to achieve sustainable economic growth. Adopting these measures would reduce pollution, conserve natural resources, and mitigate climate change, fostering a balance between economic growth and environmental sustainability.
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1. INTRODUCTION
Since the discovery of crude oil in commercial quantities in Oloibiri, Niger Delta in 1956, Nigeria has experienced significant environmental degradation, especially in the Niger Delta region. Gas flaring and pollution from industrial activities have disrupted the atmosphere, rendering water sources undrinkable and impacting agricultural activities (Biala, 2019). The country's growing population further strains the environment, while economic activities, despite boosting the economy, have contributed to respiratory diseases and environmental harm. The increase in industrial production and urbanization has led to pollution, with carbon dioxide emissions from cars, generator sets, and industrial machines becoming significant contributors to environmental damage (Adeniyi, 2024; Biala, 2022; Biala, 2019).

A rise in economic activities has led to the massive use of generators, due to insufficient electricity supply, exacerbating environmental problems. The number of motorized vehicles in Nigeria has surged, increasing carbon emissions, especially from the growing numbers of small passenger vehicles and motorcycles. This increase in emissions has raised concerns over air pollution, which significantly affects public health, particularly in children under five, where air pollution is linked to pneumonia and respiratory diseases (World Health Organisation [WHO], 2013).

Nigeria's rapid economic growth has been accompanied by severe environmental degradation, including deforestation, water and air pollution, and inadequate waste management (Biala, 2019). While the country's industrialization has led to economic expansion, it has also resulted in significant ecological damage. This dual challenge of economic growth and environmental degradation is particularly evident in Nigeria, an emerging economy dependent on natural resource extraction. Despite the country's vast resources and growth, issues like carbon emissions, resource depletion, and erosion persist, worsened by weak environmental regulations and insufficient sustainable development efforts (Braure et al., 2012; Biala, 2022).

The relationship between economic growth and environmental degradation has been a subject of study under the Environmental Kuznets Curve (EKC) hypothesis. The EKC suggests that economic growth initially leads to environmental degradation but eventually results in environmental improvement after a certain income threshold is reached. However, the existence of this curve in Nigeria remains contentious, with previous studies providing inconsistent findings. Some studies such as Drabo (2011), Aiyetan and Olomola (2015), and Adeagbo (2022) confirmed the EKC relation for Nigeria, while others (e.g., Adeleye, 2012; Akpan & Chukwu, 2011; Alege & Ogundipe, 2013) rejected it. This divergence of findings has been attributed to omission of certain variables from the previous models. Such variables, which could influence the relationship between economic growth and environmental degradation, include foreign direct investment, fossil fuel consumption, and resource depletion (Adeniyi, 2024).

Using more recent data, this study therefore sought to address these inconsistencies by considering some of the variables omitted from the previous studies. The study uses growth rate of real GDP as a measure of economic growth instead of per capita GDP, a departure from prior research methodologies. It employs a threshold regression analysis, a method that models nonlinear relationships by dividing data into different regimes, to explore the EKC hypothesis in Nigeria. By examining whether environmental indicators like carbon dioxide emissions, fossil fuel consumption, and resource depletion correlate with the growth rate of GDP, the study seeks to assess the applicability of the EKC in Nigeria. The study identifies the threshold growth rate by examining whether economic growth in Nigeria follows the expected pattern of the EKC, with environmental degradation increasing at first and then decreasing as the economy matures.

This research hypothesized that in Nigeria, environmental degradation increases with real GDP growth but at a declining rate. This implies that Nigeria may be on the left side of the EKC hump, where environmental degradation persists despite economic growth. The theoretical contribution of this study lies in expanding the EKC framework by incorporating previously omitted variables and applying threshold regression to better capture the nonlinear relationship between economic growth and environmental degradation. By Using the growth rate of GDP (instead of GDP per capita) and testing the EKC in Nigeria, the study aims to offer new insights into how economic growth can eventually lead to environmental improvements, providing useful knowledge for sustainable policy development.

This study is divided into 5 sections. Section 1 covers the introduction while Section 2 reviews the literature on the relationship between economic growth and environmental degradation. Section 3 is concerned with the theoretical framework and methodology adopted for the study. This is followed by Section 4 which presents and analyses the results, while Section 5 presents the conclusion and recommendations emanating from the study.

2. LITERATURE REVIEW

The Environmental Kuznets Curve (EKC) hypothesis suggests that as an economy grows, environmental degradation initially worsens but improves after a certain income threshold, forming an inverted U-shaped curve. This idea, inspired by Simon Kuznets' theory on income inequality, proposes that wealthier economies can afford to prioritize environmental conservation. However, critics argue that economic growth alone cannot ensure environmental improvement without targeted policies. Since its introduction in the 1990s, the EKC has sparked extensive debate, with evidence varying across regions and pollutants, necessitating context-specific analyses.

In Nigeria, studies on the EKC hypothesis yield inconclusive results. Olusegun (2009) found no causal relationship between income and CO_2 emissions, attributing this to missing variables, while Omisakin (2009) reported a U-shaped relationship, opposing the EKC. Similarly, Akpan and Chukwu (2011) linked poverty and traditional energy use to environmental and health outcomes but did not directly address the EKC.

Other research highlights complex dynamics. Drabo (2011) associated trade, population growth, and foreign direct investment (FDI) with increased emissions, emphasizing the need for broader datasets. Adeleye (2012) and Alege and Ogundipe (2013) found early economic growth stages worsened degradation without a clear turning point. Meanwhile, Aiyetan and Olomola (2015) supported the EKC in the long term, though their model's limitations call for more nuanced analyses.

Further studies examined institutional factors. Egbetokun et al. (2020) confirmed the EKC for some pollutants, suggesting good governance enhances environmental outcomes. However, substituting institutional quality for income complicates the EKC's theoretical structure. Similarly, Adeagbo (2022) highlighted the trade-offs between economic growth and environmental sustainability, noting the role of variables like forest depletion and exchange rates.

Overall, the mixed results from Nigerian studies reveal that economic growth alone may not mitigate environmental degradation. Socioeconomic factors such as poverty, energy use, population growth, and governance play crucial roles. The varied methodologies, from Ordinary Least Squares (OLS) to Generalized Method of Moments (GMM), provide diverse insights but often fail to capture the EKC's non-linear nature effectively.

In sum, while the EKC remains a useful framework for understanding growth-environment dynamics, its applicability in Nigeria is uncertain

3. METHODOLOGY

The Environmental Kuznets Curve (EKC) framework underpins the analysis of the relationship between environmental degradation and economic growth. The EKC framework offers a robust theoretical basis for analyzing environmental degradation and economic growth. Unlike the energy ladder model, the EKC model offers a more comprehensive approach, incorporating multiple factors influencing environmental degradation. Its integration with empirical models enables a nuanced understanding of how various factors—income, trade, FDI, and population growth—shape environmental outcomes. It hypothesizes that the relationship between economic growth and environmental quality is non-linear, potentially transitioning from positive to negative as a country achieves a certain income level where environmental quality becomes a priority over further income gains.

3.1 Model Specification

The EKC posits that environmental degradation depends on the growth rate of GDP and its square, commonly expressed in the equation

$$(ED)_t = \beta_0 + \beta_1(GRGDP)_t + \beta_2(GRGDP)_t^2 + \mu_t$$

where *ED* represents environmental degradation, *GRGDP* stands for the growth of GDP, and *u* stands for the error term. In this framework, environmental degradation initially rise with economic growth but eventually decline after reaching a turning point.

Empirical studies have extended this theoretical model to include additional explanatory variables, such as trade openness, foreign direct investment (FDI), population growth, and resource use. Variations in these factors help explain the complexity of environmental outcomes across different regions and economies.

However, this present study modifies the foundational work of Grossman and Krueger (1991) by specifying the model

$$lnEDI_t = \beta_0 + \beta_1 GRGDP_t + \beta_2 GRGDP_t^2 + \beta_3 (GRGDP_t - \tau) + \beta_4 POPGRT_t + \beta_5 lnTRO_t + \beta_6 lnFDI_t + \mu_t$$

where environmental degradation indicators (EDI)—carbon dioxide emissions (COE), fossil fuel consumption (FOS), resource depletion (RED), and erosion (ERO)—are employed alternately as dependent variables. The GRGDP represents growth rate of GDP, τ stands for threshold value of GDP growth rate, FDI is foreign direct investment, POPGRT is population growth rate, and TRO is trade openness. $\beta_0, \beta_1, \beta_2, \beta_3, \beta_4, \beta_5,$ and β_6 are the regression parameters while μ represents the error term.

The explanatory variables included in the model are informed by theoretical and empirical literature:

1. **Growth Rate of Real GDP (GRGDP):** This variable captures economic expansion and its potential inverted U-shaped association with environmental degradation. It provides insights into how economic expansion correlates with environmental outcomes in the context of the EKC hypothesis.
2. **Population Growth (POPGRT):** POPGRT is hypothesized to correlate positively with environmental pressure due to higher waste generation and resource demand. Represents demographic pressures, where higher population growth often leads to increased resource consumption and waste generation.
3. **Trade Openness (TRO):** This variable represents economic integration, which may either exacerbate or mitigate environmental harm depending on energy use and technological advancements. Facilitates economic growth and technological exchange but may also increase emissions through energy-intensive production and import of polluting technologies.
4. **Foreign Direct Investment (FDI):** This examines the environmental implications of international investments, which can transfer cleaner technologies or increase pollution depending on the host country's regulations. While generally associated with technological

advancement and economic benefits, FDI can also increase pollution, aligning with the pollution-haven hypothesis in weaker regulatory environments.

The coefficients of the explanatory variables were expected to take the following signs: $\beta_0 = 0$, $\beta_1 > 0$, $\beta_2 < 0$, $\beta_3 > 0$, $\beta_4 > 0$, $\beta_5 > 0$, and $\beta_6 > 0$. The expected signs of the coefficients reflect various theoretical scenarios described above. We described the relationship that was expected to hold between GDP growth and environmental degradation with varying signs of β: If $\beta_1 > 0$, and $\beta_2 = 0$, we would have the linear case where the relationship between economic development and environmental degradation is monotonically increasing. If $\beta_1 > 0$ and $\beta_2 < 0$, then there would be an inverted-U shaped relationship between emissions and GDP growth. Finally, if $\beta_1 > 0$, $\beta_2 < 0$ and $\beta_3 > 0$, then an N-shaped relationship between emissions per capita and output growth would be observed. These configurations help capture the nuances of environmental-economic interactions, illustrating how different variables influence the trajectory of environmental quality.

Table 1 depicts the measurement and sources of data used for the study, which spans from 1981 to 2023. All the data were obtained from World Bank's World Development Indicator (WDI) in 2023.

Table 1 Measurement and Sources of Data

	Variable	**Measurement**
1.	COE	Carbon dioxide emissions measured in metric tons per capita
2.	FOS	Consumption of petroleum measured in percentage of total energy consumption
3.	RED	Natural resource depletion measured in percentage of gross national income.
4.	ERO	Erosion measured in millimeters per year
6.	GRGDP	Growth rate of real GDP measured as the percentage change in real GDP per capita.
7.	POPGRT	Population growth rate measured as annual percentage change in population.
8.	TRO	Trade openness measured as the ratio of the sum of exports and imports to GDP
9.	FDI	Foreign direct investment measured in current U.S. dollars

4. RESULTS AND DISCUSSION

Descriptive statistics for each variable used in the study are presented in Table 4.1. These statistics include the mean, median, maximum, minimum, standard deviation, skewness, and kurtosis.

Table 4.1 Descriptive Statistics

Variables	**Mean**	**Min.**	**Max**	**Overall Std.**	**Skewness**	**Kurtosis**	**Coeffv.**
COE	0.621761	0.093119	0.916618	0.182079	-0.906840	4.017723	0.292844
ERO	83341.78	-9670.000	126060.0	33699.44	-1.283315	3.897530	0.404352
FOS	19.75084	15.85414	22.84479	1.508469	-0.134227	2.774739	0.076375
RED	6.448670	0.835361	17.72443	4.051964	0.684803	1.426979	0.628341

GRGDP	2.956346	-13.12788	15.32916	5.270191	-0.785008	4.740569	1.782671
POPGT	2.577475	2.488785	2.709843	0.065115	0.266480	1.833608	0.025263
TRO	32.58685	9.135846	53.27796	11.83397	-0.455237	2.493556	0.363152
FDI	2.45E+09	-1.87E+08	8.84E+09	2.51E+09	1.198086	3.328820	1.024489

Source: *Authors' computation*, 2024.

Carbon dioxide emission in metric tons per capita has an average value of 0.623 with a standard deviation of 0.182, which shows that emission in metric ton per capita differs across the years that were considered in this study. The minimum value of carbon emission in metric ton per capita is 0.093, while the maximum value is 0.916. Amount of erosion has an average value of 83341.78 with a standard deviation of 33699.44, which shows that there is fluctuation in erosion in Nigeria over the years. The minimum value of erosion is -9670, while the maximum value of erosion is 126060. Fossil fuel as a percentage of total energy consumption on petroleum has an average value of 19.751 with a standard deviation of 1.508, which showed that there is significant difference in the value of fossil fuel over the years. The minimum value of fossil fuel is 15.854, while the maximum value of fossil fuel is 22.844. Resource depletion has an average value of 6.449, with a standard deviation of 4.052, which shows that there is minimal difference in resource depletion. The minimum value of resource depletion is 0.835, while the maximum value of resource depletion is 17.724.

Per capita income has average value of ₦1912.749 billion with a standard deviation of ₦473.72 billion, which suggests that there is wide variance in average standard of living in Nigeria within the considered period. The minimum value of per capita income is ₦1388.535 billion, while the maximum value of per capita income is ₦2688.267 billion. The average valued of growth rate of real GDP (GRGDP) is 2.956 percent, which has a standard deviation of 5.270 percent indicating a wide difference in the value of growth rate of real GDP (GRGDP) over the years. Growth rate of real GDP has a minimum value of -13.12 percent, while the maximum value of economic growth is 15.329 percent. This implies that growth rate of real GDP has varied in Nigeria within the considered period for the study. Population growth has an average value of 2.577 percent with a standard deviation 0.065 percent, which indicates minimal difference percentage growth of total population. The minimum value of total population is 2.488 percent, while the maximum value of total population is 2.709 percent. This shows that there has been steady population growth in Nigeria over years with the timeframe considered.

Trade openness as percentage of GDP has an average value of 32.587 percent with a standard deviation of 11.834, which implies that the values of trade openness do not deviate significantly from the mean value. The minimum value of trade openness is 9.135 percent, while the maximum value of trade openness 53.277 percent. Foreign direct investment has average value of -₦2.12 billion with a standard deviation of ₦2.13 billion, which suggests that there is wide variance in foreign direct investment in Nigeria within the considered period. The minimum value of foreign direct investment is -₦8.02 billion, while the maximum value of foreign direct investment is ₦751,578.

4.2 Correlation Analysis

Table 4.2 shows the correlation between every pair of the variables. The p-values of the correlation coefficient in Table 4.2 indicate the statistical significance of the correlation between each pair of the variables. The magnitude of the correlation coefficients (the highest being 0.66) and their corresponding p-values show that the explanatory variables are correlated but not perfectly correlated. Hence, the results obtained in this study were not affected by multicollinearity problem.

Table 4.2 Correlation Matrix

Correlation Probability	COE	ERO	FOS	RED	GRGDP	POPGT	TRO	FDI
COE	1.000							

ERO	0.663	1.000						
	(0.000)	-----						
FOS	-0.077	-0.157	1.000					
	(0.621)	(0.312)	-----					
RED	0.611	0.077	0.041	1.000				
	(0.000)	(0.622)	(0.789)	-----				
GRGDP	0.523	0.479	-0.257	0.307	1.000			
	(0.000)	(0.001)	(0.095)	(0.044)	-----			
POPGT	-0.501	-0.160	-0.203	-0.222	0.059	1.000		
	(0.000)	(0.305)	(0.191)	(0.151)	(0.704)	-----		
TRO	0.651	0.659	-0.215	0.398	0.483	-0.160	1.000	
	(0.000)	(0.000)	(0.165)	(0.008)	(0.001)	(0.304)	-----	
FDI	0.031	-0.277	0.389	-0.117	-0.360	-0.599	-0.406	1.000
	(0.842)	(0.071)	(0.009)	(0.452)	(0.017)	(0.000)	(0.006)	-----

Source: *Authors' computation, 2024*

4.2 Results of Diagnostic Tests

Table 4.3 reports the Augmented Dickey Fuller unit root test, which reveals that trade openness (TRO), foreign direct investment (FDI), carbon emission in metric tons per capita (COE), fossil fuel consumption (FOS), resource depletion (RED), amount of erosion (ERO), per capital income (y) and percentage of total population (POPGRT) follows the I(1) processes. This means that they are all stationary at first difference at 1% level of significance. This implies that they are non-stationary series. The results of the Augmented Dickey Fuller indicates that the order of integration of the variables follows I(1) series which is the short-term dynamics or the rate of change rather than the absolute levels of the variable. Therefore, the study proceeded to test for the presence of cointegrating relationship among the underlying variables. As a result, the co-integration test was conducted using the threshold co-integration to assess the possibility of a long-run relationship in the model.

Table 4.3 Results of the Augmented Dickey-Fuller Unit Root Test (ADF-URT)

Variables	**Unit Root at Level**		**Unit Root at First Difference**		
	Test statistic	***p*-value**	**Test Statistic**	***p*-value**	**I(*d*)**
COE	-2.971807	*p>0.1*	*-4-558869*	*p>0.01****	I(1)
ERO	-2.758165	*p>0.05*	-5.773313	*P<0.01****	I(1)
FOS	-2.810891	*p>0.05*	-6.627115	*p<0.05****	I(1)
RED	-2.534194	*p>0.05*	-8.367274	*p<0.01****	I(1)
GRGDP	-2.805820	*p>0.5*	-11,01565	*p<0.01****	I(1)
POPGT	-0.961445	*p>0.5*	-4.753455	*p<0.01****	I(1)
TRO	-2.489402	*p>0.5*	-7.863688	*p<0.01****	I(1)
FDI	-1.751144	*p>0.5*	-8.349656	*p<0.01****	I(1)

Notes: ***and ** denote the rejection of null hypothesis at $p < 0.01$ and $p < 0.05$ significance level, respectively.

Source: Authors' computation, 2024.

4.2.2 Threshold Testing Approach to Cointegration

The study adopts the threshold cointegration tests, which allows for combining linear and non-linearity adjustment and cointegration to long-run equilibrium. The study tested for the presence of threshold effect (the null of linearity). The result of Threshold Boswijk (BO) cointegration test is presented in Table 4.4.

Table 4.4: Threshold Cointegration

	F-statistic	*P-value*
Equation 1	*41.2200*	*0.0000*
Equation 2	*2.9776*	*0.0090*
Equation 3	*4.3602*	*0.0000*
Equation 4	*29.6320*	*0.0000*

Source: *Authors' computation, 2024.*

Table 4.4 presents the cointegration results for the model specified for this study. The test reveals a long-run relationship between carbon dioxide emission in metric tons per capita, fossil fuel consumption, resource depletion, amount of erosion and the independent variables, which were divided into two (linear and non-linear variables). The non-linear variable is GRGDP while all other variables are linear.

The F-statistics of the threshold cointegration in COE Equation 1 is 41.2200 with associated p-value of 0.0000. This indicates that there is a long-run relationship between carbon dioxide emissions and the independent variables. For the FOS Equation, the F-statistics of the threshold cointegration is 2.9776 with associated p-value of 0.0090. The implication of this is that fossil fuel consumption and the independent variables have long-run relationship. The RED Equation estimated the F-statistics of the threshold cointegration to be 4.3602 with associated p-value of 0.0000. This indicates that there exists a long-run relationship between resource depletion and the independent variables. Lastly, the ERO Equation showed that the F-statistics of the threshold cointegration is 29.6320 with associated p-value of 0.0000, which implies that there is presence of long-run relationship between amount of erosion and the independent variables.

Based on this outcome, the study proceeded to estimating the model using threshold regression. The estimated results are presented next.

4.3 Estimation Results

The results estimated for Carbon emissions (COE), fossil fuel consumption (FOS), resource depletion (RED), and amount of erosion (ERO) with the same set of independent variables of per capital income, growth rate of real GDP, population growth, trade openness and foreign direct investment are presented in Table 4.5.

Table 4.5 Threshold Regression Results

Variables	**ENVIRONMENTAL INDICATORS IN MODEL 2**			
	Equation 1	**Equation 2**	**Equation 3**	**Equation 4**
	COE	FOS	RED	ERO
Threshold Variables				
	GRGDP < 0.5841268	GRGDP < 4.230061	GRGDP < 1.794254	GRGDP < 2.937099
GRGDP t-statistics p-values	0.101182 (8.3298) [0.0000]***	-0.002294 (-0.869) [0.3904]	0.0503 (2.249) [0.0306]***	0.1178 (5.153) [0.0000]***
	0.5841268 < GRGDP	4.230061 < GRGDP	1.794524 < GRGDP	2.937099 < GRGDP
GRGDP t-statistics p-values	0.0014 (0.1880) [0.6425]	-0.462 (-0.997) [0.2650]	0.0890 (0.769) [0.3123]	-0.0128 (-1.1397) [0.2624]
Non-Threshold Variables				
POPGRT t-statistics p-values	-2.216295 (-3.623) [0.0009]***	-0.243 (-0.966) [0.3404]	-0.086 (-0.041) [0.9679]	-1.7459 (-1.723) [0.0941]***
lnTRO t-statistics p-values	0.244373 (2.815) [0.0079]***	-0.0279 (-0.756) [0.4543]	0.652 (2.084) [0.0441]***	0.4878 (3.561) [0.0011]***
lnFDI t-statistics p-values	0.024219 (0.585) [0.5619]	0.000286 (0.0163) [0.9871]	-0.190 (-1.279) [0.2089]	0.2014 (3.1355) [0.0035]***
C t-statistics p-values	3.921285 (3.098) [0.0038]***	3.7006 (7.0552) [0.0000]***	-2.913 (3.521) [0.4335]	9.9027 (4.8664) [0.0001]***

R-squared	0.8513	0.5695	0.32036	0.8133
F-Statistic (p-value)	41.22 (0.000)	2.9776 (0.009)	4.3602 (0.000)	29.63 (0.000)
Normality (p-value)	1.1824 (0.2571)	0.6495 (0.7226)	0.6257 (0.3244)	1.8976 (0.7189)
Serial Correlation	1.404 (0.0281)	1.3225 (0.2845)	0.8430 (0.1280)	1.5709 (0.8762)
Heteroskedasticity Test	0.6710 (0.8425)	1.6232 (0.1437)	1.2558 (0.2130)	1.1769 (0.4276)

Source: Authors' computation, 2024

4.3.1 Results Estimated from the COE Equation

As it can be seen from Table 4.5, the R-squared in the carbon dioxide emission in metric tons per capita in the COE equation is 0.8513, which implies that 85.13 percent variation in emission in metric tons per capita is explained by the independent variables (growth rate of real GDP, population growth, trade openness, and foreign direct investment, The F-statistics is 41.22 with an associated p-value of 0.000. This indicates the overall statistical significance of the equation, with the model indicating high goodness of fit or explanatory power. With regards to the normality of the data, the JarqueBera test was employed to test whether data are normally distributed. The statistic value of 1.1824 with an associated p-value of 0.2571 indicates normality of data, which makes the study concludes that the variables are normally distributed. In terms of presence or absence of autocorrelation of the residuals, the study carried out Breusch-Godfrey Serial Correlation LM test. The statistic value of 1.404 with an associated p-value of 0.0281 led to the conclusion that there is absence of autocorrelation in the emission in metric tons per capita equation. Furthermore, concerning the presence or absence of heteroskedasticity of the residuals, the study carried out the Breusch-Pagan-Godfrey Heteroskedasticity test. The statistical value of 0.6710 with an associated p-value of 0.8425 implies that we do not reject the null hypothesis. Hence, it was concluded that heteroskedasticity does not exists in the equation.

Having just evaluated the overall diagnostic statistics of the equation, the study now proceeds to examine the performance of the explanatory variables in the equation, as contained in Table 4.5.

a) Growth Rate of Real GDP (GRGDP): This is the threshold variable with the threshold value obtained being 0.5841. The coefficient of growth rate of real GDP when less than threshold value of 0.5841 is positive and statistically significant, while it is positive but not statistically significant when greater than the threshold value. It implies that a percentage increase in growth rate of real GDP would lead to percentage increase in carbon dioxide emission in metric tons below the threshold level of 0.5841. This result is partially in line with our priori expectation that there exists a positive relationship between growth rate of real GDP and carbon dioxide emissions.

b) Annual Percentage of Total Population (POPGRT): The coefficient of population growth is -2.217 with an associated p-value of 0.0009. This indicates that the coefficients of population growth is negative and statistically significant. The implication of this is that a percentage increase in population would bring about a percentage decrease in emission in metric tons by 2.217. The study found that population growth had significant effect on carbon emission in metric tons per capita in Nigeria. Thus, this findings is not in line and conformity with our a priori expectation as well as the findings reported by Aiyetan and Olomola (2015) who reported that population growth had a positive effect on carbon dioxide emissions.

c) Trade Openness (TRO): The coefficient of trade openness is 0.2443 with an associated p-value of 0.0079. This indicates that the coefficient of trade openness is positive and statistically significant. The implication of this is that a percentage increase in trade openness would lead to a 0.2443 percentage increase in emission in metric tons per capita. This result is in line with the a priori expectation postulated in Chapter three, where a positive relationship is posited. This conform to the findings of Chandran and Tang (2013), Karssalari, (2014) and Muftau, et al. (2014).

d) Foreign Direct Investment (FDI): Foreign direct investment has a positive coefficient of 0.0242 with an associated p-value of 0.5619. It implies that foreign direct investment is not statistically significant. Since FDI lead to the transfer of cleaner and more efficient technologies from developed to developing countries. As multinational corporations invest in foreign markets, they may bring with them advanced technologies and management practices that help to reduce pollution and minimize environmental impact. Additionally, the presence of foreign firms operating in Nigeria may exert pressure on domestic firms to adopt higher environmental standards in order to remain competitive.

4.3.2 Results Estimated from the FOS Equation

As shown in the third column of Table 4.5, the R-squared is 0.5695, which implies that 56.95 percent variation in fossil fuel consumption on petroleum is explained by the independent variables (growth rate of real GDP, population growth, trade openness and foreign direct investment. The F-statistics is 2.9776 with an associated p-value of 0.009. This indicates the overall statistical significance of the equation, with the model indicating high goodness of fit or explanatory power. With regards to the normality of the residual, the JarqueBera test was employed to test of the data are normally distributed. The statistic value of 0.6495with an associated p-value of 0.7226 indicates normality of residual, which makes the study concludes that the variables are normally distributed. In terms of presence or absence of autocorrelation of the residuals, the study carried out Breusch-Godfrey Serial Correlation LM test. The statistic value of 1.3225 with an associated p-value of 0.2845 led to the conclusion that there is absence of autocorrelation in the fossil fuel consumption on petroleum equation. Furthermore, concerning the presence or absence of heteroskedasticity of the residuals, the study carried out the Breusch-Pagan-Godfrey Heteroskedasticity test. The statistical value of 1.6232 with an associated p-value of 0.1437 implies that we accept the null hypothesis that heteroskedasticity is present in the model. Hence, it was concluded that heteroscedasticity does not exists in the equation.

a) Growth Rate of Real GDP (GRGDP): This is the threshold variable with the threshold value obtained being 4.230. The coefficient of growth rate of real GDP when less than threshold value of 4.230 is statistically significant, while it is positive but not statistically significant when greater than the threshold value. It implies that a percentage increase in growth rate of real GDP will lead to percentage increase in emission in metric tons below the threshold level of 4.230. This result is in line with the a priori expectation that a positive relationship exists between growth rate of real GDP and carbon dioxide emissions.

b) Annual percentage of total population (POPGRT): The coefficient of population growth is -0.243 with an associated p-value of 0.3404. This indicates that the coefficients of population growth is negative but not statistically significant. The study concludes that population growth have significant effect on fossil fuel consumption in Nigeria. Thus, this findings is not in line and conformity with the a priori expectation as well as the findings reported by Aiyetan and

Olomola (2015) who reported that population growth had a positive effect on fossil fuel consumption.

c) Trade Openness (TRO): The coefficient of trade openness is -0.0279 with an associated p-value of 0.0.4543. This indicates that the coefficient of trade openness is negative but not statistically significant. The interplay between trade, technology transfer, regulations, economic growth, specialization and innovation can contribute to a negative relationship between trade openness and fossil fuel consumption in Nigeria.

d) Foreign Direct Investment (FDI): Foreign direct investment has a positive coefficient of 0.00029 with an associated p-value of 0.9871. It implies that foreign direct investment is not statistically significant. FDI brings about transfer of cleaner and more efficient technologies from developed to developing countries. And as multinational corporations invest in foreign markets, they might bring advanced technologies and management practices that could help to reduce pollution and minimize environmental impact in Nigeria.

4.3.3 Results Estimated from the RED Equation

Table 4.5 shows that the R-squared in the RED equation is 0.3204, which implies that 32.04 percent variation in resource depletion is explained by the independent variables (growth rate of real GDP, population growth, trade openness and foreign direct investment. The F-statistics is 4.36 with an associated p-value of 0.000. This indicates the overall statistical significance of the equation, with the model indicating high goodness of fit or explanatory power. With regards to the normality of the residual, the JarqueBera test was employed to test of the data are normally distributed. The statistic value of 0.6257 with an associated p-value of 0.3244 indicates normality of residual, which makes the study concludes that the variables are normally distributed. In terms of presence or absence of autocorrelation of the residuals, the study carried out Breusch-Godfrey Serial Correlation LM test. The statistic value of 0.8430 with an associated p-value of 0.1280 led to the conclusion that there is absence of autocorrelation in the resource depletion equation. Furthermore, concerning the presence or absence of heteroskedasticity of the residuals, the study carried out the Breusch-Pagan-Godfrey Heteroskedasticity test. The statistical value of 1.2558 with an associated p-value of 0.2130 implies that we do not reject the null hypothesis. Hence, it was concluded that there is absence heteroscedasticity in the equation.

Having just evaluated the overall diagnostic statistics of the equation, the study now proceeds to examine the performance of the explanatory variables in the equation.

a) Growth Rate of Real GDP (GRGDP): This is the threshold variable with the threshold value obtained being 1.79. The coefficient of growth rate real GDP when less than threshold value of 1.79 is statistically significant, while it is positive and not statistically significant when greater than the threshold value. It implies that an increase in growth rate of real GDP will lead to decrease in resource depletion below the threshold level of 1.79. This result is in line with the a priori expectation postulated in Chapter three, where a positive relationship between growth rate of real GDP and resource depletion is posited. This conform to the findings of Grossman and Krueger (1991).

b) Annual Percentage of Total Population (POPGRT): As it can be seen from the Table 6, the coefficient of population growth is -0.086 with an associated p-value of 0.9679. This indicates that the coefficients of population growth is negative and statistically significant. The implication of this is that a percentage increase in population will bring about a percentage decrease in resource depletion by 0.086. The study concludes that population growth have significant effect on resource depletion in Nigeria. Thus, this findings is not in line and conformity with the a priori expectation as well as the findings reported by Aiyetan and Olomola (2015) who reported that population growth had a positive effect on resource depletion.

c) Trade Openness (TRO): It could be seen in the Table that the coefficient of TRO is 0.652 with an associated p-value of 0.044. This indicates that the coefficient of TRO is positive and statistically significant. The implication of this is that a percentage increase in TRO will lead to a percentage increase in resource depletion by 0.652. The study concludes that TRO have significant effect on resource depletion in Nigeria. This result is in line with the a priori expectation postulated in Chapter three, where a positive relationship is posited. This conform to the findings of Chandran and Tang (2013), Karssalari, (2014) and Muftau, et al. (2014).

d) Foreign Direct Investment (FDI): Table 6 also shows that foreign direct investment has a negative coefficient of -0.190 with an associated p-value of 0.2089. It implies that foreign direct investment is not statistically significant. Since FDI lead to the transfer of cleaner and more efficient technologies from developed to developing countries. As multinational corporations invest in foreign markets, they may bring with them advanced technologies and management practices that help to reduce pollution and minimize environmental impact. Additionally, the presence of foreign firms operating in Nigeria may exert pressure on domestic firms to adopt higher environmental standards in order to remain competitive.

4.3.4 Results Estimated from the ERO Equation

The R-squared in the ERO equation (Column 4) is 0.8133, which implies that 81.33 percent variation in amount of erosion is explained by the independent variables (growth rate of real GDP, population growth, trade openness, and foreign direct investment). The F-statistics is 29.63 with an associated p-value of 0.000. This indicates the overall statistical significance of the equation, with the model indicating high goodness of fit or explanatory power. With regards to the normality of the data, the JarqueBera test was employed to test if the data are normally distributed. The statistic value of 1.8976 with an associated p-value of 0.7189 indicates normality of data, which makes the study concludes that the variables are normally distributed. In terms of presence or absence of autocorrelation of the residuals, the study carried out Breusch-Godfrey Serial Correlation LM test. The statistic value of 1.5709 with an associated p-value of 0.8762 led to the conclusion that there is absence of autocorrelation in the amount of erosion equation. Furthermore, concerning the presence or absence of heteroskedasticity of the residuals, the study carried out the Breusch-Pagan-Godfrey Heteroskedasticity test. The statistical value of 1.1769 with an associated p-value of 0.4276 implies that we do not reject the null hypothesis. Hence, it was concluded that heteroskedasticity does not exists in the equation.

Having just evaluated the overall diagnostic statistics of the equation, the study now proceeds to examine the performance of the explanatory variables in the equation.

a) Growth rate of real GDP (GRGDP): Economic growth was found to be significant when growth rate of real GDP is less than the threshold value of 2.9371, but not statistically significant when greater than the threshold level. Therefore, it was concluded that a percentage increase in growth rate of real GDP will lead to 2.9371 percentage increase in amount of erosion below the threshold level value. This result is in line with the a priori expectation postulated in Chapter three, where a positive relationship between growth rate of real GDP and amount of erosion is posited.

b) Annual Percent of Total Population (POPGRT): As it can be seen from the Table, the coefficient of population growth is -1.7459 with an associated p-value of 0.0941. This indicates that the coefficient of population growth is negative and statistically significant. The implication of this is that a percentage increase in population growth will bring about 1.7459 percentage decrease in amount of erosion. The study concludes that population growth have significant effect on amount of erosion in Nigeria. Thus, this findings is not in line and conformity with the a priori expectation as well as the findings reported by Aiyetan and Olomola (2015). Population growth often results in increased demand for timber, fuel wood, and agricultural land, leading to deforestation. Trees play a crucial role in preventing erosion, as their roots help bind soil particles together. Deforestation reduces this protective cover, making the soil more susceptible to erosion by wind and water.

c) Trade Openness (TRO): The coefficient of TRO is 0.4878 with an associated p-value of 0.0011. This indicates that the coefficient of TRO is positive and statistically significant. The implication of this is that a percentage increase in TRO will lead to 0.4878 percentage increase in amount of erosion. The study concludes that TRO have significant effect on amount of erosion in Nigeria. This result is in line with the a priori expectation postulated in Chapter three, where a positive relationship is posited. This conform to the findings of Chandran and Tang (2013), Karssalari (2014) and Muftau et al. (2014).

d) Foreign Direct Investment (FDI): Table 6 also showed that foreign direct investment has a positive coefficient of 0.2014 with an associated p-value of 0.0035. It implies that foreign direct investment is statistically significant. The logical explanation of this is that a percentage increase in foreign direct investment will lead to 0.2014 percentage increase in amount of erosion. This result is in line with the a priori expectation postulated in Chapter three, where a positive relationship is posited. Also, this conform to the findings of Chandran and Tang (2013), Karssalari (2014) and Muftau et al. (2014).

5. CONCLUSION

The study explores the intricate relationship between economic growth and environmental degradation in Nigeria, focusing on testing the Environmental Kuznets Curve hypothesis. The findings reveal that the impact of economic growth on environmental indicators is threshold-dependent. Below the threshold, GDP growth contributes to resource depletion and erosion. Above the threshold, both factors exhibit limited or no effects on certain indicators, with per capita income negatively influencing carbon dioxide emissions. Trade openness and foreign direct investment also significantly contribute to environmental degradation, particularly in carbon emissions and resource depletion. Therefore, study partially validates the EKC hypothesis, showing that economic growth can initially increase environmental degradation, but this relationship does not hold consistently across all indicators. The findings emphasize the importance of adopting sustainable practices to align economic growth with environmental preservation. Overall, the study underscores the need for context-specific strategies that balance economic development with environmental sustainability, reinforcing the relevance of the EKC framework in guiding policy decisions.

Recommendations emanating from this study include the adoption of green technologies, renewable energy, and circular economy models, alongside stringent environmental regulations. Sustainable population policies, responsible trade practices, and eco-conscious FDI strategies are also crucial. Policymakers are urged to prioritize investments in clean energy, resource efficiency, and conservation initiatives to achieve balanced growth.

While providing valuable insights, the study acknowledges limitations such as data inconsistency, Nigeria's regional diversity, and socio-political challenges. It calls for future research to expand beyond Nigeria to include Sub-Saharan Africa or other African nations for comparative analysis. Additionally, exploring alternative environmental indicators, such as air and water pollution, and employing micro-level studies with primary data could yield deeper insights into the economic-environmental nexus. Future research should incorporate broader variables, advanced models, and localized data to develop effective policies that balance economic growth with environmental sustainability.

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