International Journal of Humanities Social Science and Management (IJHSSM)
Volume 4, Issue 3, May.-June, 2024, pp: 508-521 www.ijhssm.org

Economic Growth and Environmental Degradation in Nigeria: 1986-2022

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Date of Submission: 06-05-2024 Date of Acceptance: 18-05-2024

Abstract
Recurrent droughts, floods, and cyclones are a few of the consequences of environment degradation, along with the development of disease-carrying vectors like malaria, a decline in food production, and diminished agricultural productivity. Thus, the paper examined the impact of economic growth on environmental degradation in Nigeria from 1986 to 2022 using the Fully Modified Ordinary Least Squares (FMOLS) model. The estimated model revealed that economic growth has a significant negative relationship with environment degradation, proxy as carbon emissions in Nigeria; suggesting that it plays a significant role in the growth of Nigeria's economy over time. However, the negative sign suggested that as the level of environment degradation increases, economic growth decreases by approximately -0.295%. While, the coefficients of trade openness and gross fixed capital formation variables are positively related to environment degradation; suggesting that these two variables are key drivers of environment degradation in Nigeria during the period under investigation. In light of this, the paper recommended the Federal Ministry of Petroleum Resources and Energy create environmental regulations that lower CO2 emissions without endangering economic growth. Additionally, the research paper calls on the Nigeria Customs Service to implement policies that prohibit the importation of ecologically harmful goods, as the paper's findings indicated that trade openness plays a significant role in Nigeria's environment degradation. Finally, to ensure that capital investment do not contribute to environment degradation in Nigeria, the Federal Government acting through relevant agencies like Ministry of Environment can use its infrastructure deficit to leapfrog to greener investments by using environmentally sound technologies and innovations that are currently available.

Keywords: Carbon Emission, Economic Growth, Climate Change, FMOLS and Nigeria
JEL Codes: O4; O44; Q54, C30 and N47

I. Introduction

Over the past few decades, environmental degradation and pollution has become a more serious worldwide problem that affects both developed and developing countries. Significant emitters of greenhouse gases include the US, China, EU27, UK, Russia, Japan, and India, among other large economies. Over 90% of the world's carbon dioxide emissions as measure of environmental degradation and pollution are caused by the use of non-renewable energy sources like coal and fossil fuels, which is the main source of this pollution.

The early 1990s saw the beginning of efforts to fight this catastrophe, spurred by the Kyoto convention and oil shortages, among other things. International accords such as the Paris Agreement and the Kyoto Protocol were formed with the intention of promoting substantial improvements and limiting the amount of greenhouse gases in the atmosphere, particularly among EU member states because of their large emissions. The movement in national policies towards renewable energy sources has been stressed by the United Nations Framework Convention on Climate Change (UNFCCC). Numerous studies' recommendations emphasize the necessity of expanding infrastructure, diversifying energy sources, and improving energy reserves.

The most common Green House Gas (GHG) in the atmosphere is carbon dioxide (CO2), according to research (Bond et al., 2004 and Choi et al., 2009). More than 60% of greenhouse gases in the atmosphere are produced by the burning of fossil fuels and the production of cement. Despite the fact that carbon is a necessary component of life, excessive carbon emissions have a detrimental effect on the ecosystem (Arrigoni *et al*., 2017;

Iddon & Firth, 2013 and Zhang & Wang, 2015). The atmosphere contains the GHGs by nature. Chillingar *et al* (2009) and Kweku *et al* (2018) both discuss how they retain heat and keep the planet warm enough to support life.

Nevertheless, the earth's climate warms above its average level when these GHGs build up and surpass the threshold that is normally required. Rising sea levels due to climate change have resulted in flooding, less rainfall, and other disasters that have a detrimental effect on food security, livestock production, and have made poverty rates higher. CO2 emissions have had a significant negative impact on the environment, hurting both the ecosystem and the people who live there. It is concerning that a number of environmental risks have recently emerged as a result of changes in atmospheric imbalance or environmental temperature. Some of the risks are that the economy will be more susceptible to frequent droughts, floods, and cyclones; some plant and animal populations will decline; disease vectors, such as malaria, will spread; ice on rivers and lakes will freeze and break; food production and agricultural productivity will decline; the death rate will rise; and sustainable development will be threatened. Therefore, it's important to examines the impact of economic growth on environmental degradation in Nigeria.

A review of literature on the subject matter revealed that a considerable number of studies have used panel data to investigate the relationship between carbon emissions and economic growth within the framework of the Environmental Kuznets Curve (EKC) (Gershon *et al*. 2024; Espoir *et al*. 2023; Khan, 2023; Sisodia *et al*. 2023; Alaganthiran & Anaba, 2022; Mitić *et al*. 2022; Khalfaoui *et al*. 2021; Osadume and Edih, 2021 and Olubusoye & Musa, 2020) with mixed empirical results. The varied empirical literature results could be attributed to the lack of country-specific case studies, as assuming all countries as homogeneous could lead to bias. Thus, a more in-depth analysis of the impact of economic growth on environmental degradation using carbon emissions as proxy for environmental degradation at a country-specific level using more disaggregate data seem particularly promising. To this effect, this paper contributes to the literature by empirically investigating impact of economic growth on environmental degradation in Nigeria by incorporating two key variables that should be addressed in the economic growth- environmental degradation relationship in the Nigerian context-trade openness and capital investment as relevant indicators of economic growth.

Five sections make up the remainder of the paper. A brief overview of the literature is provided in the next section, which includes a theoretical assessment, empirical evidence, and the concepts of economic growth and carbon emissions. The analytical framework and the empirical findings from the data analysis are presented in Sections Three and Four. Section five concludes the paper with conclusion and recommendations.

II. Materials and Methods

Conceptual Review

Economic Growth refers to the gradual rise in an economy's output of goods and services, as indicated by an increase in the GDP or GNP. According to Palmer (2012), economic growth refers to the expansion of a country's production capacity, which makes it possible for the economy to produce more goods and services overall. An increase in real gross domestic product, which indicates a rise in the value of national output, income, and expenditure, is another outcome of economic expansion. The Gross Domestic Product (GDP) of an economy is a measure of its size, and the GDP growth rate is a metric of economic development (Picardo, 2020).

Environmental degradation is the term used to describe how human activity is causing the environment to deteriorate; this can lead to resource depletion, contamination of the air, water, and soil, ecosystem loss, and the extinction of animals (flora and fauna). The process by which the foundational resources (air, water, soil, and land) are diminished, diminishing their uniqueness and quality, is known as environmental degradation. This has an impact on the biological environment's overall health. The main resources that are susceptible to depletion or degradation due to excessive use and unfavorable human activity are air, water, and soil/land. In order to ascertain whether or not higher economic growth may mitigate environmental deterioration under the EKC hypothesis in Nigeria, carbon (CO2) emissions are employed in this article as an index of environmental degradation.

Carbon emissions are regarded as greenhouse emissions that causes global warming and indirectly, environmental degradation. Carbon dioxide emissions are those stemming from the burning of fossil fuels and the manufacture of cement. They include carbon dioxide produced during consumption of solid, liquid, and gas fuels and gas flaring (Climate Watch Historical GHG Emissions, 2023).

Empirical Review

Using annual data from 2000 to 2017, Gershon *et al* (2024) used static panel estimating techniques to examine the interaction effects of energy consumption and economic growth on carbon emissions for seventeen selected African countries. The outcome demonstrates that while rising energy consumption has a negative impact on carbon emissions, it has a beneficial impact on economic growth. But energy use has a bigger effect on economic expansion than it does on the environment. The study discovered that the negative environmental effects of energy consumption are lessened or attenuated (indirectly lowering carbon emissions) as a result of economic growth brought about by Africa's energy transformation. The study's key finding is that the switch to renewable energy is lessening the damaging effects that rising energy use and economic expansion are having on the environment. Therefore, a modification is suggested to adapt the energy intensity theory to Sub-Saharan Africa: carbon emissions are directly related to the quantity of energy derived from fossil fuels used per unit of output. The study made the case for giving economic expansion and energy efficiency a top priority to significantly lessen the damaging effects of energy use on the environment.

Using panel data spanning from 1996 to 2019, Espoir *et al* (2023) reexamined the impact of economic growth on CO2 emissions conditional on the dynamics of urbanization, renewable energy, and good governance across 47 African nations. The study uses the Dumitrescu-Hurlin causality test and pooled mean group ARDL (PMG-ARDL) approaches to determine the short- and long-term impacts on CO2 emissions of economic growth, urbanization, use of renewable energy, and good governance. The PMG estimator's findings support the EKC hypothesis because, over time, a 1% increase in GDP per capita causes emissions to rise by 0.61%, but a 1% increase in its square causes emissions to fall by 0.03%. Growth in the economy has no discernible short-term impact on emissions. Additionally, the findings show that renewable energy has a significantly negative long-term impact while governance has a good long-term effect. However, a bidirectional relationship between CO2 emissions and each of the explanatory variables is revealed by the causality test.

Khan (2023) investigated the connection between economic growth and carbon emissions in some selected ECOWAS member states between 1991 and 2022. For the data analysis, a panel data regression technique was used. Out of the eight explanatory variables, the Fixed Effect Model (FEM) estimates show that four are adversely correlated with CO2 emissions, one of which is statistically significant, while the remaining three are not statistically significant. Three of the eight independent variables have negative effects on CO2 emissions, whereas five have positive effects on emissions, according to the Random Effect Model (REM) estimations. Consequently, the study concluded that the region's climatic change cannot be solely attributed to GDP development, industrial expansion, and CO2 emissions. According to the study, in order to lower carbon emissions in this area, it is imperative to promote the use of renewable energy sources and associated techniques.

Abdulkarim (2023) investigated the long- and short-term dynamic effects of socioeconomic factors on ecological sustainability in Nigeria, as well as the possibility of an environmental Kuznets Curve. For this investigation, annual time series data from 1980 to 2020 were used, together with the Autoregressive Distributed Lag approach in the presence of structural breakdowns. In the medium and long terms, the empirical results are consistent with the environmental Kuznets curve hypothesis for Nigeria. In the short and long terms, energy consumption and total imports worsen environmental degradation, while total exports both short- and long-term enhance environmental quality. In the short term, environmental degradation increased due to financial development, which in the long run markedly reduced the extent of such harm. On the other hand, urbanization sparked a short-term decline in biodiversity loss but ultimately led to a major increase in environmental harm. The study suggested that in order to support the development and diversification of energy sources to accommodate more renewable energy sources that produce less carbon dioxide, the government, policymakers, and all other stakeholders in the energy sector should take extra actions in order to promote efficiency in Nigeria’s production processes and lower carbon emissions.

Sisodia *et al* (2023) evaluated the association that exists among a number of energy-related factors such as energy use, renewable energy use, carbon pollution and the economic growth of European Union countries. 21 years of data, from 2000 to 2020, are the subject of the variable examination. A panel VECM model and related tests, including the panel unit root test, cointegration test, and causality test, are used. The expansion of economies in a number of EU member states is positively impacted by the many variables mentioned above. The results of the heterogeneous causality test suggested that energy consumption and the rate of economic development are indirectly related. The study's conclusions indicate that in order to support economic development, EU member states must implement policies aimed at improving energy consumption efficiency.

The potential for economic growth, the use of renewable energy, and technical innovation to achieve environmental sustainability by lowering CO2 emissions in Bangladesh is examined by Raihan *et al* (2022). Time series data from 1980 to 2019 were used, and the Dynamic Ordinary Least Squares (DOLS) method was applied. A 1% increase in economic growth is associated with a 1.3% rise in CO2 emissions, according to the DOLS estimate findings, which also demonstrate that the long-run coefficient of economic growth is positive and significant with CO2 emissions. Additionally, the coefficient of renewable energy use is negative and substantial, meaning that a 1% increase in renewable energy use is linked to a 0.15% long-term reduction in CO2 emissions. Furthermore, there is a negative but statistically insignificant estimated long-run coefficient of technical innovation, meaning that a 1% increase in technological innovation leads to a 0.07% decrease in CO2 emissions. The article offers policy suggestions intended to help Bangladesh achieve emission reduction and environmental sustainability. These include encouraging the use of renewable energy sources, developing a low-carbon economy, and funding technical innovation.

The impact of carbon dioxide emissions on economic growth is examined by Abubakar and Abdullahi (2022), who additionally scrutinize into whether the relationship between CO2 emissions and economic growth depends on Nigeria's financial progress between 1980 and 2020. The Autoregressive Distributed Lag estimation methodology (ARDL) estimation method was utilized in the investigation. The outcomes of the cointegration boundary test demonstrated a long-term correlation between CO2 emissions, financial development, economic growth, and energy consumption. Empirical evidence suggests that CO2 emissions have no long-term effect on economic expansion. On the other hand, there is evidence that CO2 emissions and financial development work together to foster economic growth over the long run, indicating that CO2 emissions only affect the economy in the presence of financial development. In order to lower the level of CO2 emissions from productive activities to a moderate rate with efficient productivity across major sectors of the economy, the study recommended that the government use clean production technology and reduce the use of fossil fuels (oil and gas).

For a panel of eight South-Eastern European nations, Mitić *et al* (2022) investigates the causal relationship between CO2 emissions, economic growth, accessible energy, and employment from 1995 to 2019. Panel unit root tests, panel cointegration techniques, and panel causality tests were employed in the work. The findings demonstrate a short-run, bidirectional panel causal relationship between employment and CO2 emissions as well as between employment and available energy. The findings also show a one-way causal relationship between GDP and employment and energy availability. The estimated coefficients of the lagged ECT in the CO2 emissions, GDP, and employment equations are statistically significant, according to the long-run causal relationship results, suggesting that these variables may be important in the system's adjustment process as it deviates from long-run equilibrium.

Espoir *et al* (2021) used panel and time-series approaches on datasets covering the years 1995-2016 in an effort to comprehend the varied consequences of temperature and emissions on income in Africa for the first time. The empirical findings showed that, globally, in Africa, a 1% increase in average temperature causes an income decrease of 1.08%, while a 1% increase in CO2 emissions causes an income increase of 0.23%. The findings of the emissions effect suggest that, in the long run, productivity may be greatly impacted by environmental laws created especially to lower CO2 emissions throughout Africa. Furthermore, the outcome implies that economic growth is inhibited by a change from ideal temperature ranges to severe patterns. According to the report, national policies should take precedence over global climate regulations when it comes to long-term CO2 emissions reduction in Africa.

Using wavelet coherence analysis, Khalfaoui *et al* (2021) reexamined the evidence of co-movement and lead-lag nexus between carbon dioxide emissions and economic growth in G7 countries during a two-century period. The main conclusions show that (i) GDP per capita and carbon dioxide emissions have a cyclical relationship. This suggests that during business cycle upswings, both economic growth and carbon dioxide emissions increase, but that the latter can be predicted at the one- to two-year scale using GDP as an indicator function. (ii) A time-scale, bidirectional causal relationship between GDP per capita and carbon dioxide emissions. This suggests that lowering carbon dioxide emissions will inevitably have a negative impact on economic expansion. In addition, the result suggests that alternative clean energy sources should be quickly adopted in order to cut carbon dioxide emissions without slowing down economic growth. The report suggested that policymakers in the G7 nations should improve short- and long-term economic cooperation.

Osadume and Edih (2021) examined how, in a few West African nations, economic expansion affected carbon emissions between 1980 and 2019. The essential theoretical underpinning is provided by Simon-Steinmann's economic growth model. Panel econometric techniques were used in the study for statistical analysis. The result shows that, for the pooled samples, the independent variable had a short-term, favorably significant impact on the dependent variable with considerable cointegration. The study came to the conclusion that economic expansion has a considerable impact on carbon emissions, with a 1% increase in economic growth translating into a 3.11121% increase in carbon emissions per unit. The report suggested that policies be put in place to promote the creation of carbon trading hubs and the use of energy-efficient buildings by businesses and the government.

Olubusoye and Musa (2020) used the ARDL model, Mean Group (MG), and Pooled Mean Group (PMG) models to investigate the Environmental Kuznets Curve (EKC) hypothesis in 43 African countries divided into three income groups between 1980 and 2016. The EKC hypothesis is accepted in just 21% of the sample but rejected in 70% of the nations in the whole sample. The findings indicate that in 79% of the nations, carbon emissions rise in tandem with economic expansion, whilst in just 21% of the countries does economic growth result in a decrease in carbon emissions. According to the study's findings, most African nations would see increasing emissions as their economies grow. To curb the growth in carbon emissions, these nations should implement every policy option available, including a carbon tax policy, a carbon emissions trading plan, and a large-scale rollout of renewable energy.

The impact of energy consumption and economic growth on CO2 emissions was investigated by Osobajo *et al* (2020). Granger causality, panel cointegration tests, and regression analysis (including pooled OLS regression and fixed effects approaches) were used to evaluate the relationship between energy consumption, economic growth, and CO2 emissions. Data from 70 nations were examined between 1994 and 2013. Granger causality tests showed that whereas energy consumption has a unidirectional link with CO2 emissions, the research variables (population, capital stock, and economic growth) had a bidirectional relationship. Similarly, the results of the cointegration tests demonstrated that there is a long-term correlation between the research variables (economic growth and energy use) and CO2 emissions. However, energy consumption and economic growth have a large beneficial impact on CO2 emissions, as demonstrated by both the pooled OLS and fixed approaches. Hence, this study supports the necessity for a worldwide transition to a low carbon economy primarily through climate finance, which refers to local, national, or transnational financing, that may be taken from public, private and alternative sources of financing. This will encourage major renewable energy investments, which are necessary to drastically cut CO2 emissions.

Using simultaneous equation models, Abdouli and Hammami (2018) examined the connections between economic growth, FDI inflows, environmental quality, and financial development for Middle Eastern nations between 1980 and 2014. There is a unidirectional causal relationship between financial development and CO2 emissions, according to empirical findings. However, the findings are consistent with the existence of bidirectional causality between economic growth and CO2 emissions, as well as a bidirectional causal relationship between FDI inflows, economic growth, and financial development for the global panel. According to the study, financial systems in these nations should currently operate with an awareness of environmental issues. Furthermore, Middle Eastern nations must implement effective financial, foreign, and economic policies in order to safeguard the environment, encourage economic growth, attract significant FDI inflows, and advance financial development.

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Aye and Edoja (2017) used the dynamic panel threshold framework to study how economic expansion affects CO2 emissions. The data used in the analysis came from a panel of 31 developing nations. The findings show that while economic expansion has a positive influence in high growth regimes and a negative effect in low growth regimes on CO2 emissions, the marginal effect of economic growth is larger in high growth regimes. The study's findings demonstrate a U-shaped association rather than supporting the Environmental Kuznets Curve (EKC) hypothesis. It was also shown that population growth and energy consumption had a favorable and notable impact on CO2 emissions. The model's conclusion on the EKC hypothesis remained unchanged with inclusion of the financial development indicator. There is proof of a substantial causal association between CO2 emissions, economic growth, energy consumption, and financial development using panel causality methodologies. The results highlight how low-carbon technologies must change if emissions are to be reduced and sustainable economic growth is to be achieved. This could involve switching from nonrenewable to renewable energy sources and improving energy efficiency.

Mesagan (2015) concentrated on the correlation between Nigeria's economic expansion and carbon emissions between 1970 and 2013. In order to conduct the analysis, the research used trade openness, capital investment, real gross domestic product, and carbon emissions. The study employed an error correction model, and the findings unambiguously demonstrated that economic expansion has a positive impact on carbon emissions during the initial period and a negative impact during the lagged term. It also showed that capital investment and trade openness have a beneficial effect on Nigeria's carbon emissions. It is advised that while lowering GDP (in an effort to reduce carbon emissions) may impede the nation's economic development, it is more practical to look for strategies to encourage green growth in the nation.

Theoretical Framework

The paper's theoretical framework is the Environmental Kuznets Curve (EKC), which links CO2 emissions to economic growth. Simon Kuznets (1955) examined the relationship between economic growth and income inequality and first confirmed the EKC hypothesis. Kuznets (1955) came to the conclusion that early economic growth is linked to a rise in income disparity up to a certain point, beyond which inequality is reduced by ongoing economic growth (Saba, 2023).

Growth in the early phases is linked to rising emissions. However, increased productivity becomes environmentally sustainable when economies of scale, money, and innovation rise. As a result, a negative U-shaped relationship was found between economic expansion and environmental deterioration. The environmental Kuznets curve (EKC) hypothesis has gained widespread acceptance based on this discovery.

In general, there is a direct correlation between pollution and economic growth. The connections between these two, however, can be lessened by a number of measures, such as switching to ecologically friendly technology and advancing technological advancements that ensure overall gains in economic production and, more especially, in the reduction of pollution. Notwithstanding the skepticism surrounding the possibility of limitless substitution or technological advancement, there might be constraints on the degree to which these connections can be further loosened in the future.

The functional relationship, as used by David Stern in 2003, can be stated as follows:

$$(E/P)_t = f(GDP/P)_t \tag{1}$$

Equation (1) can be explicitly written as:

$$\text{In}(E/P)_t = \alpha + \gamma_t + \beta_1 In(GDP/P)_t + \beta_2 (In(GDP/P))^2{}_t + \varepsilon_t \tag{2}$$

Where E is carbon emissions, P is population, and ln indicates natural logarithms. The first two terms on the RHS are intercept parameters, while subscript, ‘t’ is the number of years. It is assumed that, while emissions per capita may vary throughout nations at a given income level, income elasticity is constant across nations at a given income level.

Nevertheless, the real gross domestic product will be used to represent the explanatory variable, output growth (GDP), and environmental degradation (E) will be represented by carbon (CO2) emission for the purposes of empirical modelling in this paper. This is so that the research could determine how Nigeria's economic growth affects environmental degradation. Equation (2) can now be written in a functional form as:

$$CO2 = f(\text{RGDP}) \tag{3}$$

Where CO2 stands for carbon emissions and RGDP stands for real gross domestic product as a measure of economic growth.
Explicitly, equation (3) can be written as:

$$CO2 = \alpha + \beta(\text{RGDP}) + \varepsilon \tag{4}$$

III. Methodology

The ex-post facto design is the chosen research design for this work. The inability of the researcher to alter the data being studied is what distinguishes this method. The ex-post facto, also known as "causal comparative research," was defined by Kerlinger (1973) and refers to the process of determining possible cause-and-effect links between independent and dependent variables. The principal aim is to definitively establish a causal relationship between them. This design was chosen for the current paper due to its relevance, particularly in identifying these links.

Model Specification

The model used in this paper is based on the Environmental Kuznets Curve (EKC) theoretical framework and a modified version of Khan (2023) model, who investigated the connection between economic growth and carbon emissions in some selected ECOWAS member states between 1991 and 2022. The form of the Khan (2023) model is:

CO2 = F (GDP, EXP, EXCRT, ENRGCON, ELECTRCON, GCF, POPGRO, INDUSTGRO) (5)

Where, GDP = Gross Domestic Product, Exp = Exports, ExcRt = Exchange Rate, EnrgCon = Energy Consumption, ElectrCon = Electricity Consumption, GCF = Gross Capital Formation, PopGro = Population Growth Rate, IndustGr = Industrial Growth Rate. Equation 5 is modified for the purpose of this paper in order to include two indicators of economic growth such as trade openness and capital investment, which is captured with gross fixed capital formation. The modifications and extensions are as follows:

$$C02_t = \beta_0 + \beta_1 RGDP_t + \beta_2 TOP_t + \beta_3 GFCF_t + \varepsilon_t \tag{6}$$

To ensure consistency among all the variables, we take the log of the dependent and explanatory variables.

$$InC02_t = \beta_0 + \beta_1 InRGDP_t + \beta_2 InTOP_t + \beta_3 InGFCF_t + \varepsilon_t \tag{7}$$

Where, In: Natural logarithm, β_0 is the intercept, $\beta_1 to \beta_3$ are slope parameters, CO2 represents carbon emissions as a measure of environmental degradation, RGDP represents real gross domestic product as a measure of economic growth, TOP represents trade openness, GFCF represents gross capital formation as proxy for capital investment, and ε_t is the error term. Trade openness and capital investment are set of controlled variables in the model.

Building equations (7) into a Fully Modified Ordinary Least Squares (FMOLS) model, we have:

$$C02_t = \beta_0 + \sum_j^p(\beta_1 RGDP_t) + \sum_j^p(\beta_2 TOP_t) + \sum_j^p(\beta_3 GFCF_t) + \varepsilon_t \tag{8}$$

Equation (8) represents the long-run relationship between environmental degradation and economic growth using the FMOLS methodology. The coefficients $\beta_1 - \beta_3$ give insights into how each of the explanatory variables impacts carbon emissions in Nigeria.

With its increased resilience against endogeneity, the FMOLS methodology eliminates the need for tools such as the instrumental variable approach or 2-stage least squares. To ensure unbiased long-run estimates, FMOLS corrects for potential endogeneity resulting from the feedback effects among the variables. The method by which the FMOLS takes into consideration serial correlation in the error terms and possible endogeneity in the independent variables is what makes it unique. Adjustments for possible biases and serial correlation in the error terms are provided by this method, which frequently befalls OLS in non-stationary environments. Whether the variables being studied are integrated of order one, I(1), mixed, or even fractionally integrated, FMOLS can still be employed.

In contrast to several econometric methods that require time series variables to be integrated of order one, or I(1), FMOLS permits thorough analysis without requiring prior knowledge about the integration characteristics of the series being studied. Because of its adaptability, FMOLS is a better option, particularly when examining the connections between economic growth and environmental degradation in a country with an evolving economy like Nigeria. The necessary data are trade openness (net export divided by GDP), real gross domestic product, gross capital formation (a proxy for capital investment), and carbon emissions (C02), a proxy for environmental degradation. The World Development Indicators and the Central Bank of Nigeria Statistical Bulletin were the sources of the data.

IV. Results

Descriptive Statistics

Table 1 presents the descriptive statistics for the paper.

Table 1: Descriptive Statistics

	C02	RGDP	TOP	GFCF
Mean	0.695735	41917.84	0.431062	13.14885
Std. Dev.	0.127209	20860.22	0.133434	5.582212
Skewness	0.173954	0.354535	-0.141753	0.706530
Kurtosis	1.678786	1.487590	2.541555	2.661749
Jarque-Bera	2.877748	4.301503	0.447926	3.254694
Probability	0.237195	0.116397	0.799345	0.196450
Observations	37	37	37	37

Source: Authors Computation, 2024 (Eviews-12)

For CO2, the standard deviation is 0.127209 and the mean is 0.695735. The standard deviation and mean for RGDP are 20860.22 and 41917.84, respectively. In contrast, the corresponding mean and standard deviation for GFCF and TOP are 13.14885 and 5.582212, respectively, and 0.431062 and 0.133434, respectively. Table 1's standard deviation values reveal a notable departure of the variables from their mean values; nonetheless, their kurtosis suggests that the policy variables follow a normal distribution. Specifically, kurtosis values < 3 were shown by CO2, RGDP, TOP, and GFCF, indicating that these variables cause less extreme and less frequent outliers than those observed in the normal distribution. All of the variables are positively skewed, with the exception of TOP, as indicated by the skewness values in Table 1 which display the asymmetry of the data. The skewness and kurtosis of sample data are measured using the Jarque-Bera statistics to determine how well they fit a normal distribution. As evidenced by the probability values of each variable's corresponding Jarque-Bera statistics, the null hypothesis is firmly supported for all variables in their nominal form. Since the accompanying Jarque-Bera probability values of these variables have a significance level larger than 5%, it may be concluded that they have a normal distribution.

Unit Root Test

Time series data frequently display trends that can be addressed with differencing, mainly for the purpose of determining the data's stationarity. Table 2 therefore displays the results of the Augmented Dickey-Fuller (ADF) unit root test, a fundamental step in time series analysis to determine the stationarity of the series.

Table 2: Unit Root Test Result

Variable	**ADF Test Statistics**		
	ADF	Critical Value	Order of Integration
C02	-6.011120	-4.243644*	I(1)
RGDP	-3.367551	-3.204699***	I(1)
TOP	-7.263564	-4.243644*	I(1)

GFCF	-7.296912	-4.252879*	I(1)

*Note: *, **, *** significant at 1%, 5% and 10%*
Source: Authors Computation, 2024 (Eviews-12)

The ADF test statistic is bigger than the critical value, which indicates that all of the variables under examination were stationary at first difference but none at second difference. As a result, all of the variables in Table 2 have integrated of order one, or I(1), indicating that after taking their initial differences, each variable becomes stable. This suggests that the non-stationarity in these variables will need to be addressed in any modeling or forecasting that involves them, usually using methods like differencing or cointegration.

Cointegration Test
Table 3 summarizes the findings of the Co-integration test utilizing the Engle and Granger (Residual Based) Cointegration Test, building on our continuing discussion of time series analysis and the investigation of the links between environmental degradation and economic growth in Nigeria.

Table 3: Results of Engle and Granger (Residual Based) Cointegration Test

Variable	ADF Test Statistic	99% Critical ADF Value	Remarks
Residual	-4.000388	-2.630762*	Co-integrated

*Note: * significant at 1%*
Source: Authors Computation, 2024 (Eviews-12)

The ADF Test Statistic for the residuals in "Table 3: Results of Engle and Granger Residual Based Cointegration Test" is -4.000388, exceeding the critical value at the 1% significance level of -2.630762, showing co-integration. This is crucial because it shows that environmental degradation captured by carbon emissions and economic growth in Nigeria are in a long-term equilibrium. Fully Modified Least Squares regression estimation was the next step in the paper's process.

FMOLS Regression Results and Test of Hypotheses
The FMOLS estimation findings for the model are shown in Table 4 to provide some intriguing insights into the direct influences of economic growth on environmental degradation in Nigeria.

Table 4: Fully Modified Least Squares (FMOLS) Result
Dependent Variable: LOG(C02)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LOG(RGDP)	-0.294999	0.062204	-4.742455	0.0000
LOG(TOP)	0.016527	0.083579	0.197736	0.8445
LOG(GFCF)	0.035049	0.072437	0.483861	0.6318
C	2.650434	0.571030	4.641496	0.0001
R-squared	0.791595			
Adjusted R-squared	0.772057			
Long-run variance	0.011350			
Wald-F-Statistic	19.78711			
Wald-F-Statistic (p-value)	0.0000			

Source: Authors Computation, 2024 (Eviews-12)

It is evident from the individual relationships between the explanatory variables and the dependent variable that there is a substantial negative association between Nigeria's environmental degradation and economic growth as measured by real gross domestic product (RGDP). The variable passes the significance level of 5%, indicating that it might have a significant impact on Nigeria's economic growth in the long run. On the other hand, the negative sign indicates a -0.295% drop in economic growth as carbon emissions, a proxy for environmental degradation rise.

However, although the link is not statistically significant, the coefficients of trade openness (TOP) and gross fixed capital formation—a proxy for capital investment—are positively correlated with environmental degradation in Nigeria across the research period. It is sufficient to state that the two variables—GFCF and TOP—are significant contributors to environmental degradation.

With the explanatory variables accounting for nearly 79% of the variation in the environmental degradation, the model appears to be well-fitting, as indicated by the R-squared value of 0.791595. The model appears to be quite good even after accounting for the impact of unimportant estimators, as indicated by the modified R-squared value of 0.772057. To evaluate the joint significance of the model's coefficients, a Wald (p-value) of 0.0000 is used in conjunction with a Wald-Statistic of 19.78711. The p-value being less than 0.01 suggests that the coefficients of real gross domestic product (RGDP), trade openness (TOP) and gross capital formation (GFCF) in the model are jointly significant at the 1% level. This indicates that the model economic indicators collectively contribute significantly to the explanation of variations in environmental degradation.

The residual test findings, which are displayed in Table 5, shed light on the reliability and validity of the regression model used in the investigation.

Table 5: Results of Residual Test

Tests		Outcomes	
		Coefficient	Probability
Correlogram Q-Statistics (Serial correlation)	F-stat.	2.178336	0.2672
Normality Test	Jarque-Bera	2.704788	0.2586

Source: Authors Computation, 2024 (Eviews-12)

A regression model's residuals can be examined for potential serial correlation using the Correlogram Q-Statistics test. The presence of serial correlation in the regression estimates may indicate that the model is not fully capturing the relevant data, which might be problematic. An F-statistic of 2.178336 with a probability of 0.2672 is noted in this test. There is no significant serial correlation in the residuals, as indicated by the probability value being bigger than the traditional significance thresholds (e.g., 0.05 or 0.01). This is a good result, meaning that this part of the FMOLS regression model's specification is well-defined. Next, the normality test evaluates whether the model's residuals are normally distributed using the Jarque-Bera statistic. 2.704788 is the Jarque-Bera value, and the probability is 0.2586. The likelihood value exceeding the traditional significance thresholds suggests that there is no substantial deviation from a normal distribution in the residuals.

As a result, Table 5 residual tests indicate that the regression model used to investigate how Nigeria's economic growth directly affects environmental degradation appears to be well-fitted, with residuals that are roughly normally distributed and show no signs of a strong serial correlation.

V. Discussion

The investigation began with a preliminary analysis in the form of basic descriptive statistics and an examination of the time series features of the variables to comprehend the relevant properties of the data. This is required because time series analysis needs to do the unit root test, which determines whether the variables are stationary, to confirm which approach to use and avoid choosing the wrong method. To determine whether the data series are normally distributed and appropriate for regression analysis, the pre-estimation analysis described the primary characteristics of the variables in the model, giving rise to a basic understanding of the nominal data set.

Descriptive statistics show that the average nominal value of carbon emissions (CO_2) is 0.695735, with a standard deviation of 0.127209. The standard deviation and mean for RGDP are 20860.22 and 41917.84, respectively. Although the kurtosis values for CO_2, RGDP, TOP, and GFCF were less than 3, this suggests that the outliers produced by these variables are less extreme and less common than those seen in the normal distribution. Furthermore, all variables in their nominal form strongly support the null hypothesis, as indicated by the probability values of the corresponding Jarque-Bera statistics. Since the accompanying Jarque-Bera probability values of these variables have a significance level larger than 5%, it may be concluded that they have a normal distribution. Additionally, since the ADF test statistic is higher than the critical value, the findings of the Augmented Dickey-Fuller (ADF) unit root test demonstrate that all variables under investigation were stationary at first difference. All variables are therefore integrated of order one, or I(1).

Thereafter, the paper determined the existence of a long-run cointegration relationship between economic growth and environmental degradation in Nigeria from 1986 to 2022 using the Engle and Granger (residual-based) Cointegration Test. Based on the Engle and Granger Residual Based Cointegration Test findings, co-integration is suggested by the residuals' ADF Test Statistic of -4.000388, which is larger than the critical value at the 1% significance level of -2.630762. Thus, the null hypothesis—that there is no long-term relationship—is rejected at the 1% significance level. Consequently, it is possible to conclude that the variables are cointegrated.

The impact of economic growth on environmental degradation in Nigeria from 1986 to 2022 was then examined by the paper using the Fully Modified Ordinary Least Squares (FMOLS) model. The estimated FMOLS shows a significant negative association between Nigeria's environmental degradation and economic growth, indicating that environmental degradation represented by carbon emissions has a major impact on the country's economic growth over time. On the other hand, the negative sign indicates that economic growth falls by about -0.295% as carbon emissions rise. Although the association is not statistically significant, the coefficients of trade openness (TOP) and gross fixed capital formation—a proxy for capital investment—are positively correlated with environmental degradation in Nigeria throughout the investigation period. It is sufficient to state that the two variables—GFCF and TOP—are significant contributors to environmental degradation.

In Nigeria, real gross domestic product—a measure of economic growth—has been found to have a long-term, significantly negative relationship with carbon emissions. This is contrary to theoretical predictions because an increase in RGDP is expected to lower carbon emissions in Nigeria in light of the environmental Kuznets curve, which shows that in the early stages of development, environmental degradation will rise with income but then fall as economies become wealthier and possess the means to use environmentally friendly machinery in production to prevent environmental degradation.

To be more precise, a one percent increase in real gross domestic product will eventually result in a -0.295% decrease in environmental degradation. This research outcome is corroborated by Aye and Edoja (2017) and Raihan et al. (2022) who found a significant inverse relationship between environmental degradation and economic growth in Nigeria and Bangladesh respectively. The research findings, however, conflict with those of Osobajo *et al* (2020), Olubusoye and Musa (2020), Osadume and Edih (2021), Espoir and Sunge (2021), Raihan *et al* (2022), Abdulkarim (2023), and Espoir *et al* (2023), who found that environmental degradation has a significant and positive impact on economic growth in their respective studies, supporting the existence of the EKC hypothesis.

Additionally, although the effect is statistically insignificant, Table 4 evidence indicates that trade openness has a long-term positive impact on environmental degradation. Consequently, a one percentage point increase in trade openness will cause environmental degradation to rise by 0.0165 percent. Trade openness's statistically insignificant impact on environmental degradation could be the result of the manufacturing sector's struggles in Nigeria, which are now plaguing the country's manufacturing sector due to unreliable power supplies, uncertain political environments, and structural rigidities.

Similarly, gross fixed capital formation, a substitute for capital investment, is predicted to have a positive but then statistically insignificant impact on environmental degradation in Nigeria. More specifically, Nigeria's environmental degradation will rise by 0.035% for every percentage increase in gross fixed capital formation. It follows that capital investment plays a significant role in contributing to environmental degradation. The very low level of capital investment in Nigeria may be one reason for the statistically insignificant relationship between gross fixed capital formation and environmental degradation.

VI. Conclusion and Recommendations

The ecosystem and the people who live in it, in both developed and developing countries, have been severely impacted by CO2 emissions' negative environmental effects. It is worrisome that several environmental risks have emerged as a result of temperature variations. The economic sector's susceptibility to frequent droughts, floods, and cyclones is one of the risks; others include a decline in the populations of some plants and animals, the spread of disease vectors such as malaria, the freezing and breaking up of ice on rivers and lakes, a decrease in food production and agricultural productivity, a rise in the death rate, and a threat to sustainable development. Therefore, using the Fully Modified Ordinary Least Squares (FMOLS) model, the research investigates the impact of economic growth on environmental degradation in Nigeria from 1986 to 2022.

Based on the estimated FMOLS, there is a significant negative relationship between Nigeria's GDP (real gross domestic product) and environmental degradation, indicating that environmental degradation has a major impact on the country's economic growth over time. On the other hand, the negative sign indicates that economic growth falls by about -0.295% as environmental degradation rise. Although the link is not statistically significant, the coefficients of trade openness and gross fixed capital formation variables show a positive correlation with environmental degradation in Nigeria over the investigation period. It is sufficient to state that during the investigation period, trade openness and gross fixed capital formation were the two variables that propelled environmental degradation in Nigeria.

This paper establishes a significant negative link between Nigeria's environmental degradation and actual gross domestic product. In light of this, the paper recommended the Federal Ministry of Petroleum Resources and Energy create environmental regulations that lower CO_2 emissions as a measure of environmental degradation without endangering economic growth. Additionally, the research paper calls on the Nigeria Customs Service to implement policies that prohibit the importation of ecologically harmful goods, as the results of the research indicate that trade openness plays a significant role in Nigeria's environmental degradation. Finally, the Federal Government, acting through appropriate agencies like the Ministry of Environment, can use its infrastructure deficit to leapfrog to greener investments by utilizing ecologically sound technologies and innovations that are currently available in order to ensure that capital investments do not contribute to environmental degradation in Nigeria.

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